



Incidence of *Ascaris* infection among primary school children in Ogun State, Nigeria: A generalised linear model approach

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Abstract

To estimate the effect of community soil (location) on the incidence and prevalence of *Ascaris* infection in school children, the model assumptions of the Generalised Linear Model (GLM) in a linear relationship between independent (X_i 's) and dependent variable (Y), where $\hat{a}(Y) = \beta_0 + \beta_1 X_{i1} + \beta_2 X_{i2} + \dots + \beta_p X_{ip}$ was adopted. Of the 1,519 pupils, 30% (225/759) male and 28% (210/760) female pupils were infected with *Ascaris lumbricoides* but it was not sex-specific ($p > 0.05$). Male pupils voided higher number of worms (1,090, $\bar{X} = 2.2$) than female pupils (879, $\bar{X} = 1.7$). Intensity of infection rates was inversely related to body weight of pupils. The model observed a significant probability of < 0.05 even with an Adjusted R Squared of 0.033. Of the three variables considered, only weight was significant in explaining the variation in the dependent variable (worm count). Thus, it could be inferred that the weight for age of the child is an important indicator for determining the incidence and intensity of ascariasis in school-age children.

Keywords: general linear model, *ascaris*, school children, Ogun State, Nigeria.

Introduction

Parasitic helminth disease and malnutrition among children are two of the most important health problems affecting developing countries. Crompton [1] had stressed that intestinal worm infections are pervasive and, indeed, thrive in communities in need of better housing, sanitation, water supplies, health-care, education and parental earnings. However, only through quantitative estimates, can a measure of the burden of disease and disability caused by these infections, always

superimposed in malnourished bodies, be truly appreciated and recognised for the magnitude of resource consumption and wastage they cause in affected tropical communities.

Modelling the determinants of parasitic helminth disease is multi-faceted. While it is clear that parasitic disease manifestation is fundamentally related to inadequate dietary intake and the incidence, severity and duration of disease, these factors themselves are related to a large number of intermediate and basic causes operating at the household and community levels. These



include education, wealth and income situation of the parents, household size, birth order, religion, and sex of the child. Others are the availability of clean water, adequate sanitation, immunization and the level of disease prevalence in the surrounding community [2,3].

Studies in the Republic of Benin [4] identified these factors as causal determinants of parasitic helminth infections and use the graphical chain model for its analysis. However [5], had earlier applied a logistic regression approach in formulating a community-based integrated control program using similar determinants in Ghana. The model suggested an influence of health education that motivated community participation in the provision of facilities for the control programmes.

In this study, we investigated the incidence of helminth infection using a General Linear Model (GLM) for estimating effect of community soil-type (location) on the incidence and prevalence of ascariasis infection in school children; with Ogun State, Nigeria, as a case study. The model considers some underlying factors associated with parasitic helminth infection and models the relationship of association between them.

Materials and methods

Study area

Ogun State lies approximately between longitude 2°30' and 4°30'E and between latitudes 6°30' and 8°N. It is predominately populated by the Yoruba-speaking tribes of Nigeria whose traditional occupations are agriculture and commerce. The study-areas were mapped using the soil-geological map of Ogun State [6].

Ethical consideration for the survey were also observed, consent and approval were obtained from the State Primary Education Board. Letters were thereafter issued to officials of the Local Government Education Authority in the local government areas, as well as to the head teachers in the selected primary schools for cooperation and assistance during the research study. Parental consents were obtained through the schools. In the four primary schools selected from each of the local government areas, consent was also sought from the Parent/Teachers Association and the school children through interactive sessions facilitated by the head teachers of each school.

Demographic information

The study population of 1,519 pupils were made up of children four years of age and above (i.e. Primary One to Primary Five pupils). Data on the pupils collected from 2003-2005 included names, age, sex, weight, and

occupation of parent among others. The weights of pupils were determined using a floor weighing scale with a range of 1 kg to 100 kg

Worm examination

Levamex (containing 40 mg of Levamisole and manufactured by UNIBIOS Laboratories Ltd, India) a broad-spectrum antihelminthic was administered to all participants in the study according to manufacturer's instructions. The pupils who took the drugs in our presence, were each given a labelled screw cap plastic container, about 1.5 litres with an instruction to pass all stools for the next 48 hours. Stool passed within 48 hours of treatment was collected, preserved with 10% formalin and transported to the University of Agriculture, Abeokuta. Examination of *Ascaris* was by flushing the stool with running water through a sieve. The worms present were then sorted into sexes and counted.

Study design

Let the observed value for *Y* be y_i and the observed values for the explanatory variables X_1, X_2, X_3 be X_{i1}, X_{i2}, X_{i3} for the *i*-th hundred value in the sample.

- Where Y = number of worms voided.
- X_1 = age of pupils.
- X_2 = weight of pupils.
- X_3 = sex of pupils.

The Y_i are independent random variable sharing the same form of distribution from the exponential family.

The linear predictor for the *i*-th observation is³

$$\varepsilon(Y_i) = \mu_i = \beta_1 X_{i1} + \beta_2 X_{i2} + \dots + \beta_p X_{ip} \dots(1)$$

$i = 1, 2, \dots, n$

our response variable Y_i is binomial. The relationship between response means μ and the linear predictor is determined by a link function:

$$g(\mu_i) = X^T \beta \dots(2)$$

where $g(n)$ is known as the link function. The regression model that represents the mean response is here given by:

$$\mu_i = g^1(X^T \beta) \dots(3)$$

for invertible g .

The canonical link function associated to the binomial distribution can be shown to be:

$$\mu = b^1(\theta) = \frac{ne^\theta}{1 + e^\theta} \dots(4)$$

The canonical link is found by making θ the subject of

the formula. Now⁴ implies that:

$$\mu = (1 + e^\theta) = ne^\theta$$

$$\rightarrow \mu = (n - \mu) e^\theta$$

$$\rightarrow e^\theta = \frac{\mu}{n - \mu}$$

hence $g(\mu) = \log = \left(\frac{\mu}{n - \mu} \right)$

$$\theta = \log = \left(\frac{\mu}{n - \mu} \right)$$

This is known as the logit link function.

All analyses were done using SPSS Version 10 and the results show that the model though with a low R-square value, was significant at probability of $p < .05$.

Results

Empirical results

Results obtained showed that 30% (225/759) male and 28% (210/760) female pupils were infected with *A. lumbricoides* (Table 1), however, student *t*-test analysis showed no significant difference between the infection rates in both sexes ($p > 0.05$). It was observed from the

data that male pupils voided higher number of worms (1,090, $\bar{X} = 2.2$) than female pupils (879, $\bar{X} = 1.7$) in the study areas. On the weight distribution of the pupils with respect to infection status, the study observed that the intensity of infection rates was inversely related to the body weight with mean body weight of 14.23 ± 7.08 . The data also showed that pupils within the weight range of 5-10 kg had higher infection rates (10%, 154 of 1519), than 11-15 kg (6.5%, 99 of 1519), while the infection rates decreased considerably as the weights of the pupils increased.

From the direct prevalence and intensity of *Ascaris*, results showed that pupils within the age range of 6-10 years had the highest prevalence of positive cases of worm infection (Table 1); when compared with the other age groups. The prevalence values were lower in age range ≤ 5 years, rose in the 6-10 years old, and showed a decline in the older age class with a mean age of 9.26 ± 2.57 . *Chi*-square interaction analysis revealed no significance differences in the age prevalence status.

Regression model results

The result of fitting the Generalised Linear Model Using the Univariate Regression Analysis is shown in Table 2. In this Table the criterion of goodness of fit was analysed

Table 1: The age-sex distribution of the pupils by their weights and the number of worms expelled.

		Age (Yrs)					No. of Worms				
		1-5	6-10	11-15	16 and above	No worms expelled	1-5	6-10	11-15	16-20	21 and above >
Sex	Male	25	492	237	5	534	176	28	10	7	4
	Female	24	529	202	5	550	169	26	12	1	2
	Total	49	1,021	439	10	1,084	345	54	22	8	6
Weight (kg)	5-10	42	569	26	0	465	122	20	7	3	2
	11-15	7	283	166	0	344	89	7	2	1	0
	16-20	0	61	103	1	128	58	8	2	0	0
	21-25	0	80	47	2	75	40	6	4	3	1
	26-30	0	21	49	2	39	18	9	3	0	3
	31-35	0	5	30	3	19	14	2	3	0	0
	36-40	0	2	11	1	9	4	0	0	1	0
	41-45	0	0	2	0	2	0	0	0	0	0
	46-50	0	0	5	1	3	0	2	1	0	0
Total	49	1,021	439	10	1,084	345	54	22	8	6	

which is in sum of squares of Y about the fitted relation. The smaller the sum of squares (SS), the better the fit. One approach to the problem was the construction of an analysis of variance (ANOVA) table sharing the reduction in the SS due to fitting X_1 , then the additional

reduction due to fitting X_2 (after X_1), then the additional reduction due to fitting X_3 (after X_1 and X_2). The additional reduction caused by a regressor variable may be tested by an F test and if it is not significant then the idea is that this variable may be omitted.

Table 2: Result of the model test among the variables.

Dependent variable: No. of worms.

Source	Type III sum of squares	<i>df</i>	Mean Square	<i>F</i>	Sig.	Eta squared
Corrected Model	640.489	16	40.031	4.270	.000	.044
Intercept	33.567	1	33.567	3.581	.059	.002
Age* weight	640.489	16	40.031	4.270	.000	.044
Error	14,079.382	1,502	9.374			
Total	16,736.000	1,519				
Corrected total	14,719.871	1,518				

a R squared = .044 (adjusted R squared = .033).

The estimated coefficient for the two variables – age and weight over the number of worms – which is the dependent variable, is shown in Table 2. The model is significant at the 0.05 level for the effect of the number of worms over age and weight. Sex did not correlate with prevalence of infection; since the results showed no significant difference; and therefore do not present a factor in the effects due to ascariasis.

The results in Table 3 indicated that weight for age of pupils had significant effect on the prevalence of *A. lumbricoides*, that is, as an individual become older, the probability that individual would be infected would be reduced.

Discussion

The study observed that the different locations examined showed different prevalence levels which may be attributed to the foci of the study that comprised of urban and semi-rural communities where the housing nature at the communal level are compact and could predispose healthy individuals to level of infections with *A. lumbricoides*. Applying the Generalised Linear Regression Model on locations, age, sex and weight; showed that weight for age of the school pupils was an important factor in intestinal parasitic infections irrespective of location.

From the direct prevalence and intensity of *Ascaris*,

results showed that pupils within the age-range of 6-10 years had the highest prevalence of infection with *A. lumbricoides*; when compared with the other age-groups. This observations confirmed reports by [7,8] which attribute the trend to be influenced by changes in behaviour and hence exposure to infection. The sex prevalence ratio from the study indicated no significant correlation relationship between percentage of male pupils infected and female pupils at the 0.05 levels. Kightlinger *et al* [9]; had earlier inferred that results of male: female could be influenced by gender related behavioural and environmental factors that may contribute to exposure. Anderson [10] had opined that vertebrate hosts mount responses to parasitic invasions which may be immunological in nature, and if successful, these responses may either eliminate the parasite or constrain its population size within the host to a low level.

A high degree of heterogeneity in body sizes of *Ascaris* were observed within population recovered following the initial anthelmintic treatment of the pupils in the study-areas. The data examined from the study did show a direct influence of worm density (total worm burden or worm bulk) on the size of individual worms, which may largely be host-weight and age-related that appear to represent different worm population within individual hosts. Some worms recovered measured up to 47 cm and 49.5 cm. There was equal distribution where most

Table 3: Parameter estimates.*Dependent variable:* No. of worms.

Parameter	B	Std. error	t	Sig.	95% Confidence Interval Lower Bound	Upper Bound	Eta Squared
Intercept	-.408	.216	-1.892	.059	-.831	1.492E-02	.002
[Age=2] * Weight	.391	.218	1.796	.073	-3.595E-02	.818	.002
[Age=4] * Weight	8.069E-02	.183	.440	.660	-.279	.440	.000
[Age=5] * Weight	.150	.056	2.694	.007	4.084E-02	.260	.005
[Age=6] * Weight	.166	.031	5.390	.000	.106	.226	.019
[Age=7] * Weight	.134	.023	5.902	.000	8.918E-02	.178	.023
[Age=8] * Weight	.109	.022	5.024	.000	6.626E-02	.151	.017
[Age=9] * Weight	.121	.020	6.035	.000	8.177E-02	.161	.024
[Age=10] * Weight	.104	.019	5.484	.000	6.691E-02	.141	.020
[Age=11] * Weight	.116	.020	5.705	.000	7.628E-02	.156	.021
[Age=12] * Weight	8.998E-02	.016	5.753	.000	5.930E-02	.121	.022
[Age=13] * Weight	7.308E-02	.018	3.983	.000	3.709E-02	.109	.010
[Age=14] * Weight	8.947E-02	.023	3.865	.000	4.406E-02	.135	.010
[Age=15] * Weight	6.730E-02	.019	3.609	.000	3.072E-02	.104	.009
[Age=16] * Weight	1.862E-02	.037	.506	.613	-5.357E-02	9.081E-02	.000
[Age=17] * Weight	5.111E-02	.076	.670	.503	-9.842E-02	.201	.000
[Age=18] * Weight	1.237E-02	.093	.133	.894	-.170	.195	.000

worm populations were within the length ranges of 20-29 cm and weight ranges of 1.0-6.9 gm. The weak positive association observed in the study, between worm size and hosts' weight might reflect an enhancement of worm growth in individuals with large intestines or those who consume more food, or may simply reflect variability with host's age. It has been reported [11] that host immune responses may directly limit the growth or life expectancy of worms, despite the importance of host's age on the size profiles. Older children with a longer exposure to *Ascaris* infection were observed in the study to harbour smaller worms than younger pupils. This could be that acquired immunity stunts, worm growth, or that turnover of the worm population was more frequent perhaps due to more constant and intense exposures.

Documented observation by Stephenson *et al* [12] have shown that infections with intestinal nematodes and other parasites can negatively influence individual's nutritional status, physical, cognitive, educational and societal development. They further observed that intestinal parasitic infections lead to decreased food intake which is the consequence of a combination of

appetite inhibition due to infections and of food withdrawal as misguided therapy for children which invariably leads to reduced intake of essential micro-nutrients, low weight and height in teenagers, low birth-weight babies, small adult women, etc.

Taking into consideration the different assumptions, the study had therefore shown how well an independent variable both separately or together [13] could explain the variation in a single dependent variable. It therefore becomes fundamental to note that the weight for age of the child is an important indicator when providing antehelminthic treatment to pupils with intestinal helminth infections during any helminthiasis prevention and control programme among school children.

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