Effects of Geohelminthiases on Academic Performance in Primary School Children in Nairobi County, Kenya

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ABSTRACT

The purpose of this study was to determine the effects of geohelminths on academic performance of school children living in slums of Nairobi County, Kenya. A longitudinal study was carried out in children aged 6-18 years in classes 2-7 from schools within 2 slums in Nairobi County. Household socio-economic status questionnaires were administered to cater for potential confounders. Stools were collected and analyzed by modified Ridley and Kato-Katz Thick Stool Smear techniques. Infection intensity was defined by World Health Organization criteria and 3 terms pre- and 2 terms post-treatment academic records were collected for analysis; data were coded and entered in the Microsoft Excel. Data was analyzed using Statistical Analysis Software, Version 9.4 M8 (2023) for descriptive statistics and Analysis of variance (ANOVA); t-test was used to detect significant differences in pre-treatment, post-treatment academic performance.

Pearsons Product Moment Correlation analysis was used to show associations between intensity of geohelminthiases and academic performance. The highest prevalence occurred with Ascaris lumbricoides (37.4%) and Trichuris trichiura (33.2%). Highest number of light and moderate infections (16.5%) and (10.4%), respectively, occurred in 11-14 years age-group, pre-treatment. No Strongyloides stercoralis larvae were seen in stools. There was significant difference in infection intensities with T. trichiura and A. lumbricoides between males and females, $p < 0.05$, with females having higher infections. Geohelminthiases adversely affected Academic performance) $r = - 0.879$; $p<0.05$). Treatment with albendazole was more effective with A. lumbricoides than T. trichura. We recommend that effective control of geohelminths required periodic, regular mass deworming with benzimindazoles (broad-spectrum athelminthics). In addition, stake holders need to be properly informed on the importance of maintaining proper environmental sanitation and effective health education campaign strategies.

Key words: Academic performance, geohelminths, geohelminthiases, confounders, albendazole

INTRODUCTION

Geohelminthiases and Academic Performance:

Geohelminthiases constitutes a group of infections caused by roundworms in the class Nematoda. These worms consist of five species commonly called geohelminths, namely: Ascaris lumbricoides (large round worm), Trichuris trichiura (Whipworm). Strongyloides stercoralis (Thread worm) and the hookworms (Ancylastoma duodenale and Necator americanus). Adults of geohelminths live in the gastro-intestinal tract. However, although the adults of Enterobius vermicularis (Pin worm) also live in the lumen of the gastro-intestinal tract, it is not considered as a geohelminth (1, 2, 3). Several investigators have shown that geohelminths can cause light, moderate and heavy infections, especially in school-age children. These

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infections can lead to oedema, iron-deficiency, protein-energy malnutrition, electrolyte derangement, endocrine upsets and cardio-vascular failure (4, 5).

Depending on species, humans become infected with geohelminths by ingesting embryonated (infective eggs) of geohelmniths (A. Lumabricoides and T. trichiura) of through penetration of skin by filarifom (infective) larvae from the soil (3, 4). Investigators have reported that almost 2 billion people are currently infected with geohelminths, world-wide; the greatest number of these infections occur in Asia, Sub- Sahara Africa, Central and South America (2, 4). Further, geohelminthic infections affect all members of the population. However, the most vulnerable groups are the pre-school and school age children with severe consequences on their physical and mental health; the ensuring sequelae impair academic performance, leading to failure of realization of full human potential (5, 6).

Children are prone to geohelminthic infections because of their less developed immunity, toilet habits, tendency to wall bare feet poor personal hygiene and poor hand washing practices (4). Geohelminthic infections usually result in malnutrition, iron-deficiency anaemia mal-absorption syndrome and intestinal and biliary obstruction. Further, these infections also cause intestinal bleeding, chronic dysentery, rectal prolapse, respiratory complications and impaired cognitive development in children (4). Thus, all those conditions negatively affect children’s growth and impede their ability to excel in educational development and academic performance; these pathological manifestations have long-term consequences on individuals social and professional development (3, 7).

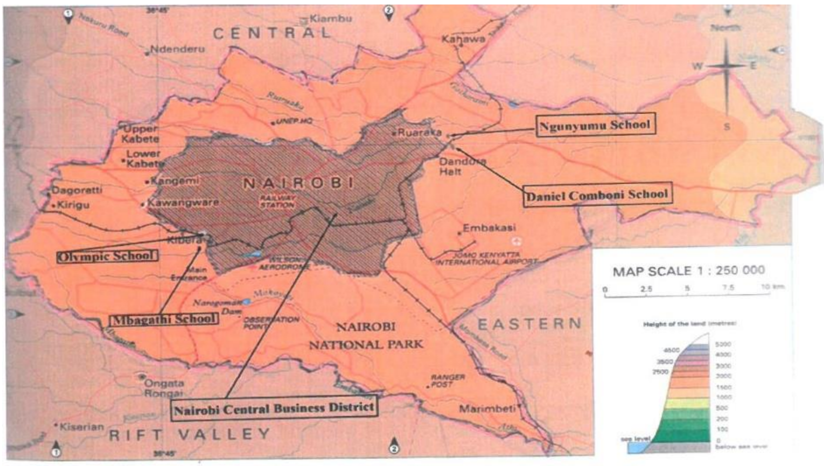
MATERIALS AND METHODS

The study site:

This study was carried out within Kasarani, Lang’ata and Dagoretti Districts of Nairobi County; the three Sub-counties were purposefully selected because a large population lives in over-crowded slum conditions. The County has 9 sub-counties, namely: Kasarani, Lang’ata, Dagoretti, Starehe, Kamukunji, Makandara, Westlands, Njiru and Embakasi. Further, Kasarani Sub-county is located at the Northern end of Nairobi County while Lang’ata Sub-county is located at the South Western area and Dagoretti Sub-county in the Western area of the County. Nairobi County is the capital and largest city in Kenya (Latitude 1^0 30’ S and 1^0 45’ S) and (Longitude 36^0 E and 38^0 E). In addition, Nairobi County is about 1,700 metres above sea level and covers an area of approximately 696 square Kilometers **(Fig.1)**. The schools selected for the study are Daniel Comboni, Ngunyumu, Mbagathi and Olympic primary schools; Daniel Comboni and Ngunyumu are located in Kasarani Sub-County while Mbagathi school is located in Dagoretti Sub-County and Olympic school in Lang’ata Sub-County.

Map of Nairobi County

Fig.1. Map of Nairobi showing location of sampled schools (Philip’s Atlas, 2002)



Inclusion Criteria:

Only children whose parents /guardians signed and returned issued informed consent forms were included in the study. Further, informed consent authorization was obtained from the Director of Nairobi City Education Department Moreover, the Chief Medical Officer of Health issued the Research Permit allowing the Principal Investigator to access school Head teachers, Parents /Guardians and pupils from whom analytical specimens would be collected.

Exclusion Criteria:

Children where parents/guardians refused to sign and return informed consent forms were excluded from the study population.

Study population:

The study population consisted 470 children, 235 of whom were infected with one or more species of helminths while 235 children were controls, matched for age and class.

Study design:

This was a longitudinal study conducted in 2 purposefully selected, large slums in Nairobi County (Korogocho slums in Kasarani sub-county and Kibera slums in Lang'ata and Dagoretti Sub-Counties) where the 4 schools are located. The 4 schools which were purposely selected included Daniel Comboni and Ngunyumu in Kasarani Sub-county, Mbagathi in Riruta Sub-county and Olympic in Lang'ata Sub-county, based on previous reports in these schools. All available children (1,283) in 4 schools in class 2-7 were screened for geohelminths (Ascaris lumbricoides, Trichuris trichiura, hookworms and Strongyloides stercoralis). In addition, stools were also screened for Entamoeba histolytica, Giardia lamblia, Taenia saginata and Taenia solium, Hymenolepis nana and Schistosoma species (Schistosoma mansoni, S. haematobium and S. japonicum) using Modified Ridley's Method (8). Further, blood samples were screened for malaria parasites (Plasmodium falciparum, P. malariae, P. vivax and P. ovale) using Giemsa staining method (9). Stool egg counts were performed on 235 children using Kato-Katz quantitative technique (10) to determine infection intensity for geohelminths in stool samples. School Academic performance records for 3 preceeding terms were collected. The selected children were treated with 400 mgs, single-dose albendazole while Socio-economic status (SES) was assessed using a structured Questionnaire. Three months after treatment, academic performance records for 2 immediate terms were collected.

Sample size Determination:

Kasarani, Lang'ata and Dagoretti Sub-Counties with a population of 265,221 primary school children (2010) were purposely selected because scarce data exists on such a study. The study sample was drawn at random from children attending 4 schools in purposefully selected. The pupils were selected based on the basis of proportional probability, where Kasarani Sub-County had the highest number of children compared to the rest of the Sub-Counties in the study. In addition, every third child in the register in class 2-7 was selected for the study after the results of the stool were obtained. The slum school children live in extremely unsanitary, unhygienic environments and majority do not gain access to sanitation facilities. The level of sanitation, personal and communal hygiene is also poor and this status coupled with soil texture and rainfall patterns can lead to a high transmission of geoheminthiases within the selected Sub-Counties. The method of Fisher et al. (11) was used to determine the sample size.

The minimum sample size calculated in this study was 384 school-age children. However, the study population stated with 470 children, 235 of whom were infected while 235 non-infected children served as controls. The higher population was to cater for loss of subjects to follow-up, migration and school transfers; Systematic probability method was used to select the study population subjects.

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Academic Performance Records:

End of term examination scores for 3 preceding and 2 immediate post-treatment terms were collected for analysis of academic performance **(Fig.2).**

Data Analysis:

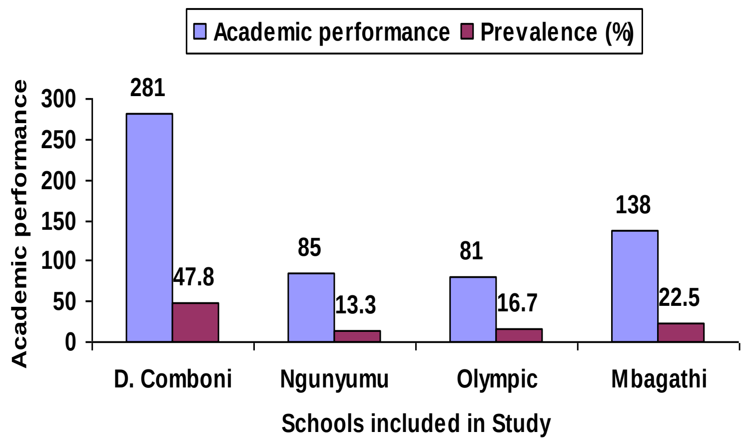
Data collected were entered in the Microsoft Office excel and analyzed using statistics Analysis software version 9.4 M 8 (2023) for descriptive statistics. The t-test statistic was used to test for differences Academic performance, pre and post-treatment. Correlation analysis was used to show associations between intensity of geohelminthiases and academic performance test scores in infected children. Linear Regression analysis was used to detect multiple factors (co-variates / confounders) that had significant adverse effects on Academic performance.

RESULTS

Correlation showed significant inverse correlation between prevalence and academic performance, pre-treatment **(Fig. 2**; **r = 0.879;** P<0.05). This showed that geohelminthiases had significant adverse effect on Academic performance, pre-treatment; further, intensity of infections (moderate & heavy) with Ascaris lumbricoides significant adversely affected Academic performance (P<0.05). Linear Regression analysis on socio-economic factors influencing, Academic performance showed that school (P<0.001), Class (0.028) sub-county (0.002) and village (0.049) significantly adversely affected Academic performance **(Table 1)** Furthermore, Trichuris trichiura infections (p<0.027), hookworms (p<0.007) failure to wear shoes (0.049) and lack of latrine (p<0.048) also significantly adversely affected academic performance. Moreover, fathers casual employment status (0.043) lack of milk (p<0.52) and inability to concentrate on school work (p<0.007) also significantly, adversely affected Academic performance **(Table 1).**

The Pearson's product Moment correlation showed significant inverse correlation between Prevalence and Academic performance, pre-treatment (Fig. 2; r=-0.879; p< 0.05). This showed that geohelminthiases had significant adverse effect on Academic performance, pre- treatment. Intensity of infections (moderate and heavy) with A. lumbricoides significantly adversely affected Academic performance (p<0.05). Linear regression on socio-economic factors influencing Academic performance showed: school (p< 0.028), class (p< 0.0001), district (p<0.002) and village (p<0.049) significantly adversely affected Academic performance. T. trichiura infections (p<0.027), hook works (p< 0.007), failure to wear shoes (p<0.049) and lack of latrine (p<0.048) also significantly adversely affected Academic performance.

Fig. 2: Infected children's academic performance pre-treatment (n = 182)



Academic performance was assessed using arbitrary score values for each grade, for example: A = 5, B = 4, C = 3, D = 2 and E = 1. The final score for each school was obtained by multiplying each arbitrary score with each grade (A-E) to get the sum total score. Results showed that father's casual employment status (p<0.043),

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lack of milk (p< 0.502) and inability to concentrate on school work (p<0.007) also significantly adversely affected Academic performance **(Fig. 2).**

The factors that were found to affect Academic performance in this study were as indicated below **(Table 1).**

Table 1: Factors that affect academic performance

Factors	**pValue**
School	< 0.0001
Class	< 0.028
District	< 0.002
Village	< 0.049
T. trichiura infections	< 0.027
Hook worms (A. duodenale or N. americanus)	< 0.007
Failure to wear shoes	< 0.049
Lack of latrine	< 0.048
Father’s casual employment status	< 0.043
Lack of milk	< 0.052
Problems with concentration on school work	< 0.007

The original study population consisted of 470 pupils; 235 pupils were infected with one or more species of geohelminths while 235 pupils were controls, matched for age and class. However; 106 pupils were lost to follow-up, before data collection period ended. This meant that data analyzed was for remaining 364 children [(182 controls (non- infected) and 182 infected children (n = 182)] Out of those infected, three groups were identified, based on infection intensity (light, moderate and Heavy infections). Overall, there were 114 (62.6 %) light infections, 60 (33.0%) moderate and 8 (4.4%) heavy infections pre-treatment while 26 (14.3%) light infections, 1 (0.5%) moderate and 2 (1.1%) heavy infections persistently occurred, post-treatment (Fig. 2). Overall, results showed significant reduction in parasite load intensity, after treatment (p < 0.05).

DISCUSSION

Results in this study showed that geohelminthiases had significant adverse effects on academic performance of school-age children, pre-treatment (r = - 0.879; P<0.05). However, similar observation have been reported in other parts of the world such as India (21), Nigeria (22), Vietnam (23), Ethiopia (14, 15, 20, 24), Africa (25) China and South America (25). Moreover, several investigators have shown that, besides impairment of Academic performance, geohelminthiases are also associated with other moderate to severe morbidities. These include Cognitive dysfunction (13, 14, 16) school Absenteeism Malnutrition, Growth and Mental retardations and (16, 17) Iron-deficiency anaemia, among myriad pathological manifestations (18, 19, 20).

The precise mechanisms by which geohelminthic infections impair academic performance and cognitive functions are still ill-understood. This is despite spectacular advances in research in Biotechnology, Pharmaceutical technologies, Medicine, (16, 17, 18, 24) Immunology-haematology, Biochemicstry and Laboratory technological innovations (4, 10, 13, 16). Nevertheless, the World Health Organization continued to drive de-worming initiatives coupled with Health-educational policy framework, especially in poor third-world countries (1, 4, 10) within the Tropics and Sub-Tropics (1, 4).

The primary World Health Organization geohelminthiases control strategy remains Morbodity Control (4, 10). This is achieved through periodic large-scale preventive chemotherapy in at-risk populations. This is integrated with improved water sanitation and hygiene (W.A.S.H.). Effective control of geohelminthiases is based on periodical de-worming to eliminate infecting worms. This is coupled with Health education to prevent re-infection and improved sanitation (4, 25).

Improved sanitation reduces soil-contamination with infective eggs (4). The effective control of trichuriasis (infection with Trichuris trichiura) has been impeded by resistance to treatment with single dose of 400 mgs albemdazole administration (4, 21, 22, 24). Moreover, physicians in tropical countries have reported incidences of rectal prolapse ceased by trichiurasis, especially in pregnant women. Furthermore, patients with moderate to severe infections with Trichuris trichiura often develop faecal incontinence following vaginal childbirth (4, 16, 19). However, treatment and tricuriasis with three daily consecutive doses of albendazole 400gs tablets taken on empty stomach helps adult worm expulsion from the gastro-intestinal tract (17, 20, 22).

Assumptions / Limitations made in the Study:

There are several problems associated with accurate evaluation of results from longitudinal neuro-psychological studies (4, 6) These include lack of knowledge and information on onset of disease and their natural histories; for example, it was not known when children were initially infected with geohelminths in the study. Moreover, neither duration of geohelminthiases nor the pathological state (acute or chronic) were known at baseline, all of which may contribute to poor academic performance, especially in school-age children (6).

Furthermore, it was also assumed that treatment with albendazole 400 mgs, single does would clear the infection, which was not the case with some parasites. The study was based on assumption that three months would be sufficient for the recovery of Academic performance following treatment; this was not necessarily true for some subjects. It was assumed that besides the presence of geohelmninths and other parasites, children were healthy. However, there are other factors that can affect Academic performance, for example diabetes, hypertension, anaemia, pulmonary oedema, renal insufficiency, fever and diarrhoea. It was also assumed that poor academic performance was largely, due to ill-health contributed by geohelminthiases. However, other factors such as lack of school fees, school uniform and other statutory financial requirements may have contributed to poor academic performance.

CONCLUSIONS AND RECOMMENDATIONS

Geohelmnianthiases adversely affected academic performance of school-age children in Kenya. The most prevalent geohelminths were A. lubric (37.4%) and T.trichiura (33.2%). Prevalence and intensily of infections with A. L****., T. trich., N*** were Aduodenale significantly reduced post-treatment with albendazole 400mgs single oral dose. However, infections with T. trichiura showed some resistance complete expulsion. The highest prevalence and intensity of infections occurred in class 2.4 and 5 and most affected children were in 6-10 year and 11-14 age groups; females had higher infections compared to males.

This conclusion has socio-economically important implications for both Ministry of Health and Education. Thus, although the ongoing National School Based De-worming Programme (N.S.B.D.P) was launched in 2012-2018 in Kenya, unacceptably high level of worm prevalence still persists, especially in pastoralism communities. This findings of this study, indeed, support these observation: Moreover, the resistance of T. trichiura to expulsion of adult worms using singledose Albadazole tablets poses significant control drawbacks. However, treatment of children with three consecutive doses of albendazole 400 mgs tabs on empty stomach effectively ex** adults worms. Thus, further research on chemotherapy of T. trichiura is recommended.

Therefore, information obtained from this study can greatly improve school-based health interventions and long-term educational goals in Kenya if well implemented.

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RECOMMENDATIONS

Regular population-based (mass-chemotherapy) with broad-spectrum and specific anthelminthics in schools can drastically reduce disease prevalence and intensity Three, consecutive oral doses of albendazole, 400 mgs single dose should be recommended for expulsion of Trichiura trichiura. Health benefits and economic costs of treatment of various population groups that could result from chemotherapy programmes should be regularly assessed. Sensitization campaigns on Health Education programmes on Hygiene and effects of geohelminths on child development and Academic performance should be encouraged and supported. Regular counselling and motivation talks should be given to address environmental factors affecting academic performance and County Government should address sanitation issues. Testing of chemotherapy of Trichuris trichiura in school-age children should also be proposed.

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Contributors

Dr. Benedict M. Mwenji, the principal investigator in the study also provided editorial skills and standardized the scientific protocols. Prof. Ethan Karuri and Michael M. Gicheru provided intellectual guidance and material support.

Sources of Finance

This study was funded through a private grant.

Conflict of Interest

There is no conflict of interest in this study. Data from this study can be shared with other scientists and institutions.

Ethical Approval

Ethical approval for this study was obtained from the Ethics Committee of the Kenyatta University, Kenya.

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