

**PREVALENCE OF GEOHELMINTHIASES AND ITS EFFECTS ON GROWTH  
AND COGNITIVE FUNCTIONS IN PUPILS IN KIBERA AND KOROGOCHO  
SLUMS, NAIROBI COUNTY, KENYA**

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PARASITOLOGY IN THE SCHOOL OF PURE AND APPLIED SCIENCES OF  
KENYATTA UNIVERSITY**

**MAY, 2017**

**DECLARATION**

I hereby declare that this thesis is my original work and has not been presented for degree or other awards in any other University

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## **DEDICATION**

This work is dedicated to my father Lazarus Mwenji Mugo and my late mother, Priscilla Wangechi Mugo whose commitment towards educational goals provided me with the inspiration to pursue the learning experience to the highest level that is possibly attainable

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**ABBREVIATIONS AND ACRONYMS**

ADEK	Fat-soluble vitamins (A, D, E, K)
ANOVA	Analysis of variance
BMI	Body Mass Index
BIP	British Institute of Psychology
Ca <sup>++</sup>	Calcium ion
CLM	Cutaneous Larva Migrans
Cl <sup>-</sup>	Chloride ion
CNS	Central Nervous System
Cod-B	Coding-B
DALYs	Disability adjusted life years
DSP	Digit Span (Forwards and Backwards)
DSB	Digit Span Backwards
DSF	Digit Span Forwards
epg	Eggs per gramme
g	Unit of expression of centrifugal force used in centrifugation
GIT	Gastro-Intestinal Tract
gms	Grammes
IDA	Iron Deficiency Anaemia
IQ	Intelligence Quotient
K <sup>+</sup>	Potassium ion
LM	List Memory
Mg <sup>++</sup>	Magnesium ion

mgs	Milligrammes
MUAC	Mid-Upper Arm Circumference
Na <sup>+</sup>	Sodium ion
NEPSY	Neuropsychology
OLM	Ocular Larva Migrans
pH	Negative logarithm (-log) of Hydrogen ion concentration
RPM	Revolutions per minute
SAS	Statistical Analysis Software
SES	Socio-economic Status
SOLs	Space occupying lesions
SPM	Standard Progressive Matrices
STH	Soil-Transmitted Helminths
SS-B	Symbol Search-B
VLM	Visceral Larva Migrans
WGI	Word Generation Initial
WGS	Word Generation Semantic
WHO	World Health Organization
WISC	Wechsler Intelligence Scale for Children
yrs	Years

**DEFINITION OF OPERATIONAL TERMS**

Absenteeism	The practice of being purposely away from attending classes
Administrator	The person trained to administer the cognitive function tests
Anthelminthics	Drugs used to treat diseases caused by helminths
Auto-infection	Infection resulting from either ingestion of embryonated eggs of nematodes in infected individuals or by transfer of infective larvae from one part of the body to another in the same person
Cercariae	The infective stages of parasites commonly called schistosomes
Cestodes	Flat worms commonly known as Tape worms
Cognitive function	A series of mental processes carried out on a person's memory resulting in a motor response
Cyanocobalamin	Vitamin B <sub>12</sub>
Cysticercoid larvae	The infective stages of some cyclophyllidean tape worms
Cysticercosis	Disease caused by <i>Taenia solium</i> larvae in the human brain
Cysticercus larvae	The infective stages of <i>Taenia</i> species (Tape worms)
Diarrhoea	Frequent bowel evacuation or passage of abnormally soft or liquid faeces
Ether	A hydrocarbon solution used to extract fats from stool
Dysfunction	Abnormal functioning of any organ or part of the body
Electrolyte	A liquid or solution of a substance which is capable of conducting electricity
Embolism	The condition in which an embolus becomes lodged in an artery and obstructs its blood flow
Encephalopathy	Inflammatory state of brain tissue caused by various disease agents
Epilepsy	A group of conditions resulting from disordered electrical activity of the brain

Filariform larvae	Infective stage of hookworms ( <i>A. duodenale</i> & <i>N. americanus</i> ) and <i>Strongyloides stercoralis</i>
Formol saline	A fixative solution (10%) used to kill living parasites in stool
Geohelminthiases	A group of diseases caused by intestinal round worms commonly known as geohelminths
Geo-helminths	Soil-transmitted helminths (Round worms)
Glycerol (50%)	An organic solution used for clearing stool debris during processing using the Kato-Katz Thick stool technique
Haemoglobin	The molecule found in erythrocytes which is responsible for transportation of oxygen in blood
Helminths	A group of organisms that move by creeping (worms)
Helminthiases	A group of diseases caused by worms commonly known as helminths
Hygiene	The science dealing with preservation and maintenance of health
Hyperinfection	Infection greater than or above normal levels
Hypermotility	Increase in the peristaltic movement of food in the intestine
Hypochloraemia	Depletion of chloride ions in blood
Hypokalaemia	Depletion of potassium ions in blood
Hypernatraemia	Increase of sodium ions in the blood
Hyponatraemia	Depletion of sodium ions in blood
Immuno-suppress	To reduce the immunological responsiveness in the body
Inflammatory response	Reaction of living tissues to injury, infection or irritation characterized by pain, swelling, redness and heat
Intensity	Measure of the degree of infection
Kwashiorkor	A disease caused by dietary deficiency of protein
Lethargy	A heavy, unnatural or morbid drowsiness

Lugol's iodine	A stain used in parasitology laboratory to stain stool films for microscopic examination
Malnutrition	The condition caused by an improper balance between what a Person eats and what is required to maintain health
Morbidity	The state of illness produced by a disease
Mortality	Death, usually in reference to death caused by a particular disease
Neuro-transmitters	A chemical substance that is released by a transmitting neuron at the synapse and that alters the activity of a receiving neuron
Oviparous	Gravid female nematodes that produce eggs
Ovi-viviparous	Gravid female nematodes that produce eggs which hatch out almost immediately to larvae
Palinaesthesia	spontaneously occurring abnormal tingling sensation, described sometimes as 'pins' and 'needles'
Parthenogenesis	Reproduction in which an organism develops from an unfertilized ovum as occurs with <i>Strongyloides stercoralis</i>
Percutaneous	Denotes introduction of a drug or disease-agent through the skin
Peri-anal area	Area surrounding the anus
Peristalsis	Normal contractile waves of a hollow organ
Polyparasitism	Infection of the host with more than one parasite
Prevalence	The proportion of persons in a given population that has a particular disease
Protozoa	Unicellular members of the animal kingdom
Pteroylglutamic acid	Folic acid
Rhabditiform larvae	The non-infective larvae of hookworms ( <i>A. duodenale</i> & <i>Necator americanus</i> ) and <i>Strongyloides stercoralis</i>
Splenomegaly	Enlargement of the spleen
Trematodes	Flat worms commonly known as flukes

**ABSTRACT**

Geohelminthiasis are infections caused by *Ascaris lumbricoides*, *Ancylostoma duodenale*, *Necator americanus*, *Strongyloides stercoralis* and *Trichuris trichiura* leading to oedema, iron-deficiency, protein-energy malnutrition, electrolyte derangement, endocrine upsets and cardio-vascular failure. Resulting sequelae lead to poor health, physical fitness and anaemia. Geohelminthiasis is widespread in areas with poor sanitation but empirical data on prevalence and its effects on growth, academic performance and cognitive functions is scanty. The current study aimed at determining effects of geohelminthiasis on growth, Cognitive functions and academic performance of children in Kibera and Korogocho slums, Nairobi County. Kasarani (Korogocho slum), Lang'ata (Kibera slum) and Dagoretti (Kibera slum) sub-Counties were purposefully selected. Four schools were selected purposefully using cluster random sampling method: 2 from Kasarani, 1 from Dagoretti and 1 from Lang'ata sub-Counties. Sample size of 470 children in class 2-7 were selected by systematic random sampling method. Kato-Katz technique was used to estimate infection intensity. Point prevalence was determined by comparing total number of infected children against total number of sampled children, expressed as percentage. Information on Cognitive functions was obtained using Word Generation Semantic (WGS), Word Generation Initial (WGI), List Memory (LM), Standard Progressive Matrices (SPM), Coding-B (Cod-B), Symbol Search-B (SS-B) and Digit Span (DSP) tests. Anthropometric measurements were used for computing BMI. Data on absenteeism and academic performance was deduced from class records for 3 terms pre-treatment (400 mgs albendazole) and immediate 2 terms, post-treatment. Stool examination was repeated 3 months after treatment. Questionnaire was administered to collect information on family background to cater for confounders influencing cognitive functions. Pearson's Product moment correlation was used to determine associations. t-test was used to determine differences between means of infected and non-infected children. ANOVA was used to determine relationships. Linear Regression was used to identify the confounders influencing Cognitive functions. Highest prevalence of geohelminths (51.9%) occurred in Dagoretti sub-County (Kibera slum). Highest prevalence occurred with *A. lumbricoides* (37.4%) and *T. trichiura* (33.2%). Highest light and moderate infections (16.5%) and (10.4%), respectively, occurred in 11-14 years-old children. Heavy infections (1.1%) occurred in 6-10 and 11-14 year-old children. Highest absenteeism (44.3%) was in Mbagathi school (Kibera slums) and highest prevalence (51.7%) in Olympic school (Kibera slum). Significant differences in infection intensities occurred between males and females ( $p < 0.05$ ), with females having higher infections than males. Geohelminthiasis negatively affected Growth ( $r = - 0.809$ ;  $p < 0.05$ ). Children with low BMI had high infection rates ( $p < 0.05$ ). Geohelminthiasis inversely correlated with Cognitive performance as measured in WGS, WGI, LM, SPM, Cod-B and DSP tests ( $p < 0.05$ ). Infections positively correlated with Absenteeism ( $r = 0.971$ ;  $p < 0.05$ ) and adversely affected Academic performance ( $r = - 0.879$ ;  $p < 0.05$ ). Interestingly, chemotherapy with albendazole improved BMI, Cognitive functions and Academic performance. Data generated will support policy on control of geohelminthiasis. It is recommended that regular mass-chemotherapy programmes be applied in schools and slum communities to improve children's general health, growth, school attendance and academic performance.

## CHAPTER ONE: INTRODUCTION

### 1.1 Background information

Geohelminths constitute a group of intestinal round worms (nematodes) commonly called soil-transmitted helminths (STH) (Bentony *et al.*, 2006; WHO, 2011). The group includes various species of clinical concern, specifically *Ascaris lumbricoides*, *Ancylostoma duodenale*, *Necator americanus*, *Trichuris trichiura* and *Strongyloides stercoralis* (WHO, 2012). However, there are other less frequently encountered nematodes which cause disease in man but are closely related to geohelminths. These include *Strongyloides fuelleborni*, *Ascaris suum*, *Toxocara canis*, *Toxocara cati*, *Toxascaris leonina*, *Capillaria hepatica* and *Capillaria philippinensis*. Also included in this group are *Baylisascaris procyonis*, *Lagochilascaris sprenti*, *Angiostrongylus cantonensis* and *Nippostrongylus muris* (WHO, 1987; Katz and Hotez, 2004; Knopp *et al.*, 2008).

Further, *A. lumbricoides*, *T. trichiura*, *A. duodenale*, *N. americanus* and *S. stercoralis* are the most clinically important soil-transmitted helminths (WHO, 2006; Hotez *et al.*, 2008). Geohelminths produce their pathogenic effects through two main processes. There are those processes leading to iron-deficiency anaemia (IDA) and oedema which are caused by hookworms and to a lesser extent by *T. trichiura* (Nokes *et al.*, 1998) and *S. stercoralis* infections (Katz and Hotez, 2004; Olsen *et al.*, 2009). There are those processes relating to intestinal malfunction, especially impairment of fat and protein absorption and impaired absorption. Moreover, other processes lead to the loss of Vitamin B<sub>12</sub> (Cyanocobalamin), Folic acid (pteroylglutamic acid) and Vitamin A (Katz and Hotez, 2004; Albonico *et al.*, 2008). These processes are caused by *S. stercoralis* which specifically impairs digestion, absorption of fats and proteins (Barnish and Ashford, 1989; Olsen *et al.*, 2009; Mejia and Nutman, 2012).

*A. lumbricoides* impairs protein digestion and absorption, heavy infections were associated with stunting, malnutrition, avitaminosis-A and Kwashiorkor. Heavy worm burdens with *S. stercoralis* (Olsen *et al.*, 2009) and *T. trichiura* (Nokes *et al.*, 1992; Nokes *et al.*, 1998) result in malnutrition, accompanied with wasting of muscle mass. Infections with *S. stercoralis*, *A. duodenale* and *N. americanus* modify the motility (peristalsis) of the intestines, affecting normal gastro-intestinal tract (GIT) movement (Hotez *et al.*, 2008). The prevalence and intensity of geohelminths results in morbidity, malnutrition and growth deficits (WHO, 2012). These were attributed to *A. lumbricoides* and *T. trichiura* (Nokes *et al.*, 1998), iron-deficiency anaemia (IDA), impaired cognitive functions and educational under-achievements; general ill-health is frequently encountered in infected persons (Simeon *et al.*, 1994; Katz and Hotez, 2004).

Heavy geohelminthic infections cause drowsiness, lassitude, lethargy, mental and muscle fatigue, decreased mental proficiency, decreased judgement and poor attention (WHO, 1987; Behrman *et al.*, 2004). This situation leads to impaired growth, cognitive functions, school attendance and poor academic performance (Nokes and Bundy, 1994; Nokes *et al.*, 1998). Geohelminthic infections continue to wreak havoc on children's physical, social, sexual and psychological development. Current evidence suggests that geohelminthiases have a detrimental effect on educational achievements in children. This was the situation for many years and still remains unchanged (WHO, 2012; Lustigman *et al.*, 2012). Literature shows prevalence level, intensity of infection and absenteeism patterns of children (Nokes and Bundy, 1993; de Paula *et al.*, 2015; Addisu and Asmamaw, 2015) adversely influence educational performance (Simeon *et al.*, 1994); this is associated with loss in personal development and productivity (Nokes *et al.*, 1991; Kvalsvig *et al.*, 1994; Nokes and Bundy, 1994).

The purpose of this study is to determine the prevalence, intensity of geohelminths and its effects on growth, cognitive functions, school attendance and academic performance in school children in Kibera and Korogocho slums in Nairobi County.

## **1.2 Statement of the problem**

School-age children living in slums perform poorly in education partly due to exposure to unhygienic environments and lack of proper sanitation facilities (Drake *et al.*, 2000; Bieri *et al.*, 2013). This pattern has been observed especially in countries located within the tropics and subtropics (Ezeamama *et al.*, 2005; Taylor-Robinson *et al.*, 2012; Hürlimann *et al.*, 2014). Moreover, personal and communal hygienic standards are poor and are compounded by harmful socio-cultural traditions, norms and practices (Richardson *et al.*, 2011). Most children living in such areas report poor health, which may adversely affect growth and cognitive development (Nokes *et al.*, 1991; Nokes and Bundy, 1994; Jardim-Botelho *et al.*, 2008). Although geohelminthiasis is widespread in areas with poor sanitation, empirical data on prevalence, their effects on growth, cognitive functions and academic performance is scanty (Chunge *et al.*, 1995; Brooker *et al.*, 2000; DVBD, 2000; Odiere *et al.*, 2011). This direly needed data would inform policy in Ministries of Health and Education on control of geohelminthiasis. This data should be generated in areas where geohelminthiasis is prevalent which formed the basis of the study.

## **1.3 Study justification**

Infections with geohelminths have been associated with mental and muscular fatigue, lethargy, ill-health and listlessness in infected persons. Geohelminthiasis continue to wreak havoc on children's physical, social, sexual, psychological and educational development (WHO, 2012).

This may adversely affect school attendance, academic performance, personal development and productivity of school-age children (Simeon *et al.*, 1994). These effects are insidious, indirect and ill-understood and have been under-estimated for many years. Data and information on effects of geohelminths on growth, cognitive functions, school attendance and academic performance is scanty (Nokes *et al.*, 1992). Therefore, it is necessary to study the effects of geohelminths on growth, cognitive functions and academic performance in school children. There is necessity to examine whether chemotherapy reverses the adverse effects of geohelminths in school children. Based on available literature, there is limited data in Kenya which has examined the pathological effects of geohelminths on growth, cognitive functions and school absenteeism (Ngonjo *et al.*, 2012) and related these variables to academic performance in the same population (Stephenson *et al.*, 1993; Adams *et al.*, 1994; Odiere *et al.*, 2011). The results obtained can be used to influence National policy decisions in the Ministries of Health and Education in Kenya to reduce the prevalence and transmission of geohelminthic infections.

#### **1.4 Research Questions**

- (i) What are the prevalence rates of geohelminths in the study population?
- (ii) What are the infection intensities of geohelminths in the study population?
- (iii) What are the effects of geohelminthiases on growth in the study population?
- (iv) What are the effects of geohelminthiases on cognitive functions in the study population?
- (v) What are the effects of geohelminthiases on school attendance in the study population?
- (vi) What are the effects of geohelminthiases on academic performance in the study population?

## **1.5 Hypothesis**

Geohelminthiases do not affect growth, cognitive function, school attendance and academic performance of pupils from selected schools in Nairobi County.

## **1.6 Objectives**

### **1.6.1 General Objective**

To determine the prevalence of geohelminthiases and its effects on growth and cognitive functions among pupils of Kibera and Korogocho slums of Nairobi County, Kenya

### **1.6.2 Specific Objectives**

- (i) To determine prevalence rates of geohelminths in the study population
- (ii) To determine infection intensities of geohelminths in the study population
- (iii) To determine the effects of geohelminthiases on growth in the study population
- (iv) To determine the effects of geohelminthiases on cognitive functions in the study population
- (v) To determine the effects of geohelminthiases on school attendance in the study population
- (vi) To determine the effects of geohelminthiases on academic performance in the study population

## **1.7 Significance of the study and anticipated output**

There is a current huge increase of school-age children in Kenyan schools in the free primary education programme initiated by the government in 2003.

All these children are likely to be exposed to the pathologically damaging effects of geohelminthic parasites. The study will generate empirical data on prevalence rates of geohelminths among school children in the slums of Nairobi County. Data will be available on effects of geohelminthiasis on school attendance and academic performance of school children living in slums of Nairobi County. Further, data will be generated on cognitive functions which impact on academic performance of school children in slums. This data will benefit Ministry of Health and Ministry of Education mainly for policy formulation for control and management of geohelminthiasis. The school children will benefit from this data in terms of better management of the disease complex. The schools, teachers and parents will also benefit from this study since the disease will be managed and controlled in slum communities; this will be done for the improvement of health and academic performance of school children.

### **1.8 Assumptions made in psychological testing of study population**

Anastasi and Urbina (1997) showed there are several problems associated with accurate evaluation of results from longitudinal neuro-psychological studies (Bever *et al.*, 1995; Camp *et al.*, 2005). These include lack of knowledge and information on onset of diseases and their natural histories; for example, it was not known when children were initially infected with geohelminths in the study. Moreover, neither duration of geohelminthiasis nor the pathological state (acute or chronic) were known at baseline, all of which may contribute to the severity of cognitive dysfunction, especially in children (Camp *et al.*, 2005; Wade and Tavis, 2011). Due to the vulnerable nature of administration of neuro-psychological tests, it was found necessary to make several assumptions to reduce performance bias in this study, which included the following, viz.:

The psychological tests used were developed on British school children; this study assumed that the tests would have the same performance when applied to African children. Further, these tests had been administered on British children for whom English was their native language. However, tests in this study were administered in English and Kiswahili on Kenyan children who spoke many different languages as their mother tongue. It was assumed that data from these different groups of children would be comparable.

Furthermore, it was also assumed that treatment with albendazole 400 mgs, single dose 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 cognitive function following treatment. This was not necessarily true for some subjects. It was also assumed that besides the presence geohelminths and other parasites, children were healthy. There are many other factors that can affect cognitive functions, for example, diabetes, hypertension, anaemia, pulmonary oedema, fever and diarrhoea. It was also assumed that absenteeism was largely due to ill health contributed by helminthes, however, other factors such as school fees and other statutory financial requirements may have contributed to absenteeism.

## CHAPTER TWO: LITERATURE REVIEW

### 2.1: Distribution of geohelminths

#### 2.1.1 Global distribution of geohelminths

The commonest geohelminths of great clinical concern world-wide are *Ascaris lumbricoides*, *Trichuris trichiura* and human hookworms (*Necator americanus* and *Ancylostoma duodenale*) (Knopp *et al.*, 2008; Parker and Allen, 2011). However, *Strongyloides stercoralis* is a relatively uncommon geohelminth. Current evidence indicates that geohelminths are rare in the northern hemisphere, especially North America, Alaska, Canadian Arctic and Greenland. However, global estimates of geohelminths (van Riet *et al.*, 2007; Walker *et al.*, 2011; WHO, 2012) show the worms are common in Ceylon, India, Uttar Pradesh, (Yajima *et al.*, 2009), Malaysia, Singapore, Timor, Papua New Guinea and Equador (Andrade *et al.*, 2001). Further, geohelminths are common in Western Hemisphere, China, South-east Asia, Indonesia and Pacific islands (Ndyomugenyi *et al.*, 2008).

Geohelminths were reported in Poland, Portugal, Greece, Italy (Behrman *et al.*, 2004; Ellis *et al.*, 2007; Ndyomugenyi *et al.*, 2008), Russian Republic (Ezeamama *et al.*, 2005), Australia, North, Central and South America (Yajima *et al.*, 2009). Hookworms have cosmopolitan distribution (Uneke *et al.*, 2006) and were reported in south-eastern USA, Texas, Puerto Rico, Cuba and Costa Rica. Hookworms were reported in Mexico, Chile, Peru, tropical South America, Surinam, Pernambuco (Brazil) and Colombia (Behrman *et al.*, 2004; Hotez *et al.*, 2008). Hookworms were reported in Yemen, Iran, Iraq, Lebanon, Western Turkey, West Pakistan, Portugal and Italy (Behrman *et al.*, 2004; Ellis *et al.*, 2007). Hookworms were also reported in Australia, among aborigines of Queensland and Northern Territory (Knopp *et al.*, 2008).

Further, hookworms have also been reported in Cambodia (Schär *et al.*, 2011) and Vietnam (Yajima *et al.*, 2009). Further, *A. duodenale* predominates in India, Bangladesh and China (Schär *et al.*, 2013). *A. duodenale* is the major parasite in South American countries, Honduras, El Salvador and Western Australia (ten Hove *et al.*, 2009; Yajima *et al.*, 2009). *N. americanus* is the predominant hookworm in the world, especially in Western Hemisphere, China, South-east Asia, Indonesia and Pacific islands (Ndyomugenyi *et al.*, 2008). *A. lumbricoides* and *T. trichiura* often co-exist and occurred in Poland in early sixties (Parker and Allen, 2011). However, *T. trichiura* has also been reported in Rofrano, Italy (Katz and Hotez, 2004); currently *A. lumbricoides* and *T. trichiura* infections co-occur in South Pacific, Marshall Islands and sub-tropical areas of the United States (Yajima *et al.*, 2009).

*A. lumbricoides* and *T. trichiura* infections are relatively common in Eastern Europe and the Russian Republic (Ezeamama *et al.*, 2005) and Vietnam (Yajima *et al.*, 2009). Currently, *A. lumbricoides* is highly prevalent in Guatemala and Mexico (Ellis *et al.*, 2007). Strongyloidiasis is focally endemic in North America (south-eastern United States) and Appalacia (Stothard *et al.*, 2008; Khieu *et al.*, 2013; de Paula *et al.*, 2015). Strongyloidiasis is also endemic in Jamaica, Caribbean islands (Ellis *et al.*, 2007), Puerto Rico (Stothard *et al.*, 2008) and Cambodia (Khieu *et al.*, 2013). *Strongyloides stercoralis* was also reported in Greece and Turkey (Stothard *et al.*, 2008). In addition, *Strongyloides fuelleborni* is endemic in Papua New Guinea, sub-Saharan Africa (Stothard *et al.*, 2008) and Cambodia (Schär *et al.*, 2011).

### **2.1.2: Regional distribution of geohelminths**

Geohelminths are widespread in Africa (Katz and Hotez, 2004), especially in Angola, Mozambique, Ivory Coast (Hürlimann *et al.*, 2014) and Nigeria (Unke *et al.*, 2006). Geohelminths are also common in Malawi, Zimbabwe and Kenya (Ellis *et al.*, 2007). Thus, *A. duodenale*, *N. americanus* were reported in Morocco, Madeira islands, Yemen, Iran, Iraq, Lebanon, Ethiopia, Kenya and Egypt (Behrman *et al.*, 2004; Ellis *et al.*, 2007; Hotez *et al.*, 2008). *A. duodenale* is the major parasite in Egypt, Mediterranean region, Madeira islands and several other African countries (Behrman *et al.*, 2004; Ellis *et al.*, 2007; ten Hove *et al.*, 2009; Yajima *et al.*, 2009). *N. americanus* is thought to be the predominant hookworm in Uganda (Ndyomugenyi *et al.*, 2008) and Côte d'Ivoire (Righetti *et al.*, 2012). Currently *A. lumbricoides* and *T. trichiura* infections are highly prevalent in Africa (Katz and Hotez, 2004). Indeed, *A. lumbricoides* and *T. trichiura* infections are highly prevalent in Cameroon (Richardson *et al.*, 2011), Nigeria, South Africa, Sudan, Egypt and Ethiopia (Katz and Hotez, 2004). *S. stercoralis* is relatively prevalent in Kenya, Mozambique, Principe islands (Stothard *et al.*, 2008), Côte d'Ivoire (Glantz *et al.*, 2010), Uganda (Stothard *et al.*, 2011) and Zanzibar island, East Africa (Knopp *et al.* (2008).

### **2.1.3: Distribution of geohelminths in Kenya**

Geohelminths are widespread in Kenya ((Behrman *et al.*, 2004; Hotez *et al.*, 2008) and currently *A. duodenale*, *N. americanus*, *A. lumbricoides* and *T. trichiura* are highly prevalent in many Counties (Ngonjo *et al.*, 2012). Further, *A. duodenale*, *N. americanus*, *A. lumbricoides* and *T. trichiura* worms have been reported in Western Kenya (Odiere *et al.*, 2011). Further, *A. duodenale* and *N. americanus* are prevalent in Kenya (Behrman *et al.*, 2004; Ellis *et al.*, 2007).

However, *N. americanus* is more predominant according to Ndyomugenyi *et al.* (2008); *S. stercoralis* is relatively prevalent (24%) in Kenya, (Stothard *et al.*, 2008; Olsen *et al.* (2009).

## **2.2 General epidemiology of geohelminthiasis**

Geohelminthiasis is a common term denoting diseases acquired by infection with geo-helminths which are commonly known as soil-transmitted helminths (STH). Cooper (2004), Katz and Hotez (2004) and WHO (2012), defined geo-helminths as intestinal nematodes transmitted to man through ingestion of food or drink contaminated with soil or by skin penetration of the infective-stage larvae. These worms were specifically named: *A. duodenale*, *N. americanus*, *A. lumbricoides*, *T. trichiura* and *S. stercoralis* (de Paula *et al.*, 2015). These nematodes all complete their life-cycle in man in 3 weeks to 6 months (Ellis *et al.*, 2007). Although *Enterobius vermicularis* is an intestinal nematode, it is not considered a geohelminth because it is mostly transmitted through inhalation of embryonated eggs.

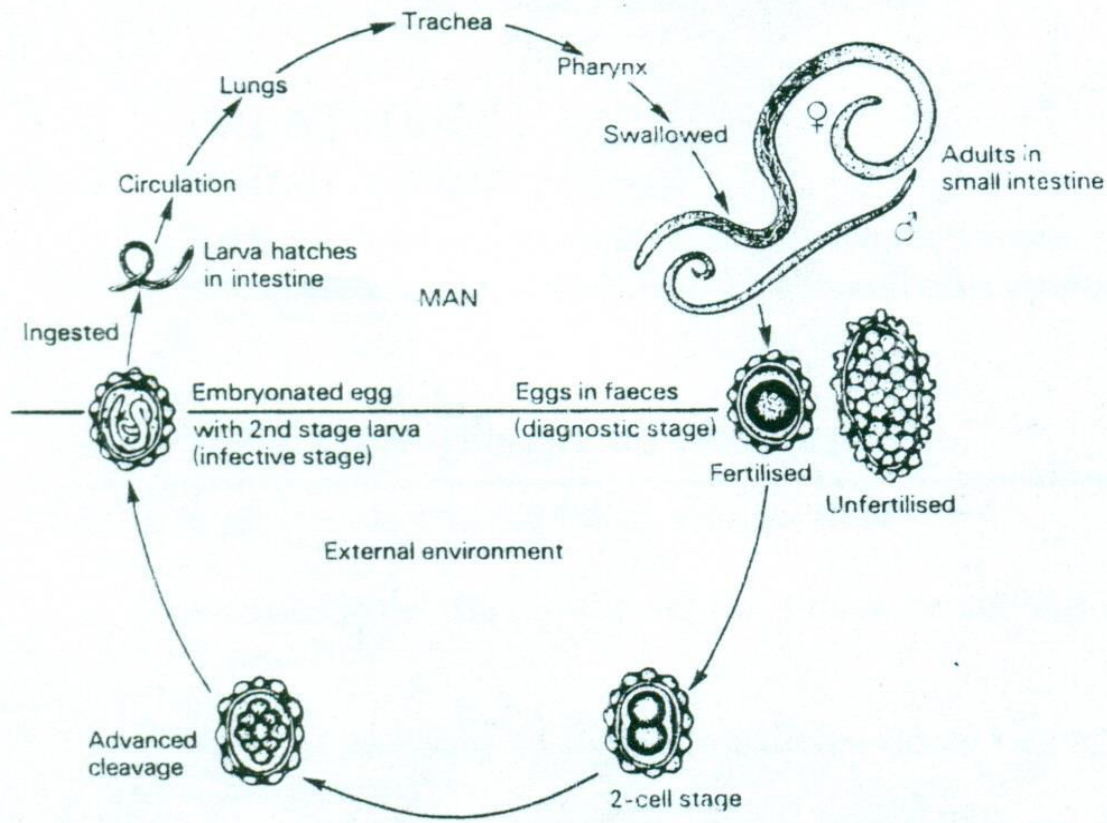
Mature adults and larvae are found within the gastro-intestinal tract of infected individuals (Knopp *et al.*, 2008; Matthys *et al.*, 2011). This has been attributed to its mode of transmission in humans which is different from the rest of the soil-transmitted nematodes (Yajima *et al.*, 2009). *Ancylostoma caninum* (dog hookworm), *Ancylostoma braziliense* (cat hookworm), *Ascaris suum* (pig ascarid), *Toxocara canis* (dog ascarid) and *Toxocara cati* (cat ascarid) do not complete their life-cycles in man but are also considered as geohelminths (Katz and Hotez, 2004). Although *Trichinella spiralis* (WHO, 2006) has an intestinal phase, it is considered a tissue nematode and not a geohelminth (WHO, 2012).

*Baylisascaris procyonis* and *Lagochilascaris sprengi* which are rare nematodes related to *A. lumbricoides* have been incriminated with causing cutaneous larva migrans (Parker and Allen, 2011). Environmental factors play a major role in the epidemiology of soil-transmitted helminths; these factors include rainfall, temperature, humidity, soil type and altitude and socio-cultural determinants (Raso *et al.*, 2005; Ellis *et al.*, 2007). Current literature shows that these factors have not been adequately investigated in slum school children in Kasarani, Lang'ata and Dagoretti sub-Counties, Nairobi County. Data on prevalence and associated pathological effects of geohelminths on cognitive performance is currently scanty (Brooker *et al.*, 2000; Ngonjo *et al.*, 2012). Excessive over-crowding in school classrooms and close contact during play, coupled with poor sanitation standards contribute to the spread of geohelminths in slum school children (Raso *et al.*, 2005; Walker *et al.*, 2011). This situation was compounded by introduction of free primary education programme in Kenya in 2003, resulting in admission of thousands of children into overcrowded school environments. The situation, in turn, created conducive conditions for transmission of geohelminths (Parker and Allen, 2011).

### **2.2.1 Ascariasis**

Ascariasis is caused by intestinal nematodes called *A. lumbricoides*, through ingestion of the embryonated eggs in food or soil contaminated with infected faeces; eggs hatch in small intestine releasing larvae which follow a heart-lung migration. The larvae are coughed and swallowed and mature to adults in 2-3 weeks in duodenum; adults copulate and eggs are passed out in stools (Stephenson *et al.*, 1993). The pathological manifestations in patients are caused by both adults and immature larvae (Walker *et al.*, 2011). It is estimated that *A. lumbricoides* infects 1.47 billion people world-wide, including 4 million Americans (Katz and Hotez, 2004).

This worm is ubiquitously present in both temperate and tropical zones; its highest prevalence is in warm countries with poor sanitation and affects all ages (WHO, 2006). Young children who are exposed more often to the contaminated soil are affected most frequently (Ellis *et al.*, 2007). Children usually harbour greater numbers of adult worms in their intestine than adults living under similar conditions (van Riet *et al.*, 2007) (Fig. 2.1).



**Fig. 2.1: Life cycle of *Ascaris lumbricoides* in man (Jenson and Baltimore, 2002)**

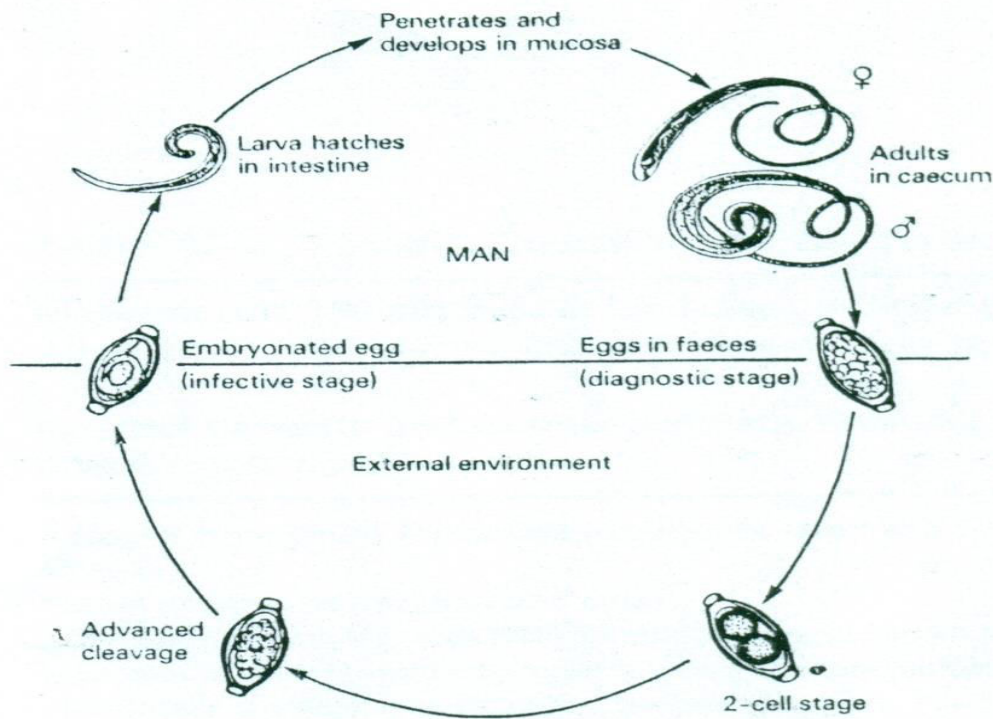
*A. lumbricoides* is extremely hardy and relatively resistant to extremes of temperature. High rates of ascariasis are found in impoverished, urban environments in Guatemala and Mexico Cities. Ascariasis is also encountered in cities located in temperate zones of developed countries; eggs can survive the ordinary freezing temperatures of winter months (Ellis *et al.*, 2007).

Eggs of *A. lumbricoides* (Fig. 2.1) and those of *T. trichiura* (Fig. 2.2) are resistant to chemical disinfectants and are not destroyed readily by sewage treatment (WHO, 2006). Pigs have been shown to serve as reservoir hosts for zoonotic *A. lumbricoides* infection (van Riet *et al.*, 2007). Global estimates show that infected individuals pass 25,000 tons of *A. lumbricoides* eggs into the environment annually (Walker *et al.*, 2011). Ascariasis (Ezeamama *et al.*, 2005) occurs in warm climates with poor sanitation. It is transmitted and maintained by indiscriminate defaecation of children in the immediate vicinity of the homestead; children pick infectious eggs on their hands during periods of play (Brooker *et al.*, 2000). Ascariasis is also acquired through inhalation and ingestion of egg-contaminated foods by the host (van Riet *et al.*, 2007). The adult *A. lumbricoides* is a short-lived worm (6 to 18 months) and is the largest and commonest of the intestinal helminths (van Riet *et al.*, 2007). Gravid females lay 200,000 eggs per worm per day, whether they are fertilized or not. Eggs are highly resistant to environmental conditions and may remain viable for up to 6 years in mild climates (Raso *et al.*, 2005; Yajima *et al.*, 2009). Estimates of annual worldwide deaths associated with ascariasis range from 8,000 to 100,000 persons (Parker and Allen, 2011).

### **2.2.2 Trichuriasis**

Trichuriasis is an infection caused by an intestinal nematode called *T. trichiura*. It is acquired through ingestion of embryonated eggs found in food or soil contaminated with infected faeces (Nokes *et al.*, 1992). The eggs hatch in small intestine releasing larvae which migrate to the caecum and mature to adult worms in 3 months. Adults embed their anterior ends in the mucosal wall, copulate and eggs are passed out in stools (Nokes *et al.*, 1992) (Fig. 2.2).

The pathological manifestations are caused by adults and immature larvae. It is estimated that *T. trichiura* infects 1.3 billion people worldwide (van Riet *et al.*, 2007; WHO, 2012). These parasites are most commonly found in tropical regions but are also detected in sub-tropical areas of USA. The distribution of *T. trichiura* closely parallels *A. lumbricoides*. Like ascariasis, children with trichuriasis usually harbour greater numbers of worms than adults living under similar conditions (Yajima *et al.*, 2009). Children suffer greater morbidity from trichuriasis than adults; these observations were reported by van Riet *et al.* (2007) and WHO (2012).



**Fig. 2.2: Life cycle of *Trichuris trichiura* in man (Jenson and Baltimore, 2002)**

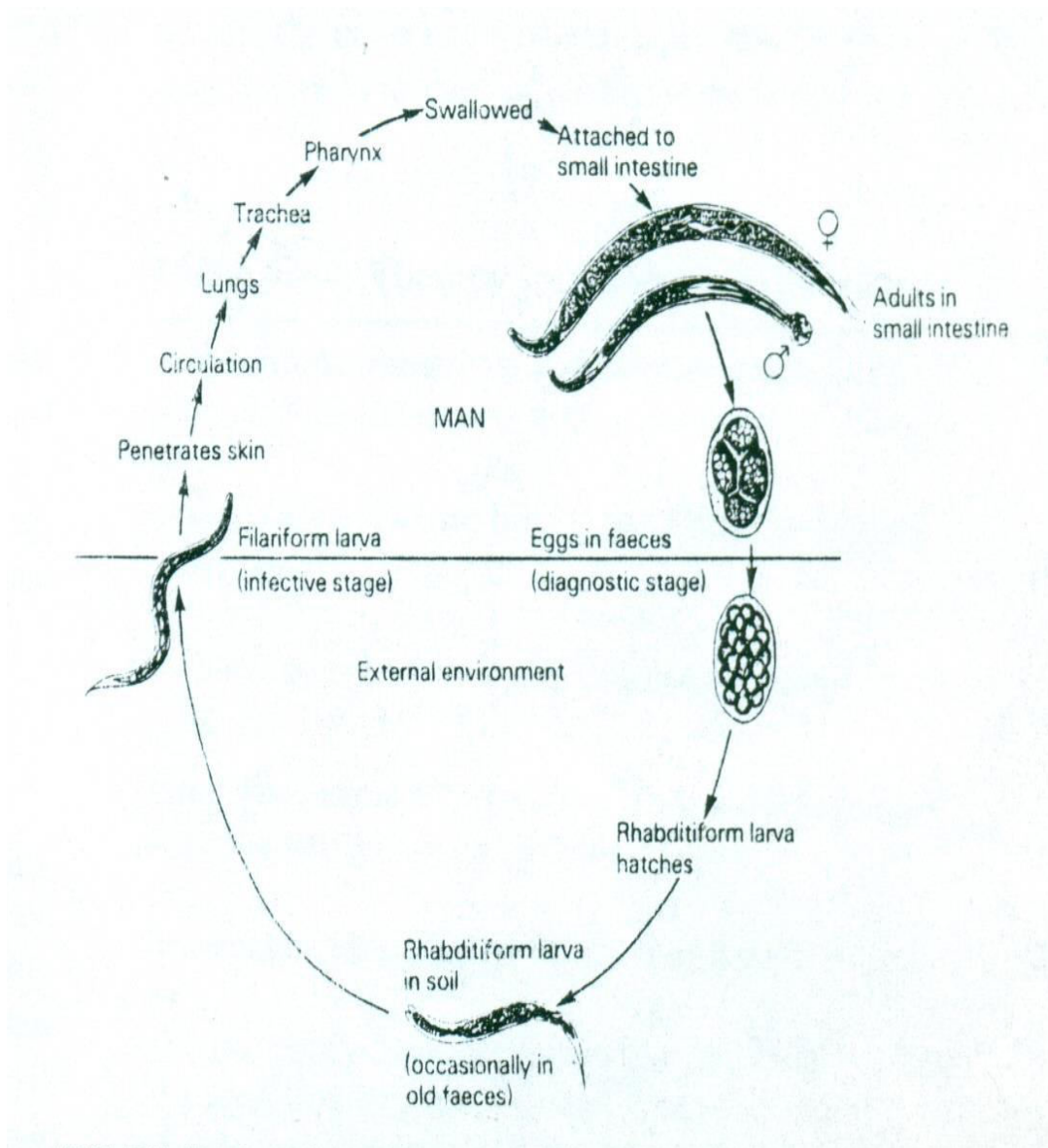
The mechanistic basis of added worminess in children is unknown. Infections with *T. trichiura* (Anuar *et al.*, 2014) are aggregated, with a minority of children suffering from particularly heavy infections (Walker *et al.*, 2011). It was shown that heavily infected children apparently have a genetic or immunologic predisposition to *T. trichiura* infection (Ellis *et al.*, 2007).

Children are, therefore, the major source of *T. trichiura* eggs in the environment. Eggs deposited in soil (Fig. 2.2), become infective after one month and remain viable for several months (Rosenthal, 2009). *T. trichiura* eggs are killed by exposure to temperatures exceeding 40° C within 1 hour; freezing temperatures below -8 °C destroy the eggs (WHO, 2006). Like *A. lumbricoides* eggs, *T. trichiura* eggs are resistant to chemical disinfectants. *T. trichiura* are concentrated in areas where indiscriminate defecation and warm, humid environments produce extensive seeding of soil with infectious eggs. *T. trichiura* often co-exists with *A. lumbricoides* (Ezeamama *et al.*, 2005; Walker *et al.*, 2011). Infection rates in tropical climates may reach 80% but incidence is lower in family and institutional clusters found in temperate climates (Rosenthal, 2009). Adult *T. trichiura* worms can live 4 to 8 years and fertilized females produce 3,000 to 10,000 oval eggs per worm per day (Unke *et al.*, 2006; Knopp *et al.*, 2008).

### **2.2.3: Ancylostomiasis / Necatoriasis (Hookworm infection / disease)**

Hookworm infection in man is caused by two species called *A. duodenale* and *N. americanus* (Hotez, 2008). Infection is acquired by the penetration of filariform larvae through the exposed skin. Larvae penetrate small blood vessels, begin a heart-lung migration and are coughed and swallowed into the small intestine; adults attach to mucosal lining, suck blood, copulate and eggs are found in stools in 6 weeks (Katz and Hotez, 2004) (Fig. 2.3). The pathological manifestations in patients are caused by both adults and immature larvae. It has been shown that although hookworms (Unke *et al.* 2006) had world-wide distribution in ancient times, these parasites are currently most prevalent in tropical and sub-tropical zones. Hook worms affect over 900 million people worldwide (Yajima *et al.*, 2009) and are found in temperate climates (Ndyomugenyi *et al.*, 2008).

Investigators have shown that *A. duodenale* predominates in India, Bangladesh and China (Schär *et al.*, 2013). *A. duodenale* is the major parasite in Egypt, Mediterranean region, Africa and South American countries, Honduras, El Salvador and Western Australia (ten Hove *et al.*, 2009; Yajima *et al.*, 2009). *N. americanus* is the predominant hookworm in the world, especially in Western Hemisphere, Africa, China, South-east Asia, Indonesia and Pacific islands (Ndyomugenyi *et al.*, 2008).



**Fig. 2.3: Life cycle of *A. duodenale*, *N. americanus* in man (Jenson & Baltimore, 2002)**

The distribution human hookworms is not absolute; small numbers of either *N. americanus* or *A. duodenale* are present where the other predominates and mixed infections with hookworm species are common (Hotez, 2008). *A. ceylonicum* occurs in endemic areas of southern Asia (Walker *et al.*, 2011) whereas *A. caninum* (dog hookworm) was reported to cause human eosinophilic enteritis in Australia (Schär *et al.*, 2013). Hookworm larvae survive in soil for 6 weeks and are destroyed by drying, freezing temperatures and heat in excess of 45° C (Walker *et al.*, 2011). Hookworm infections occur in areas with high agricultural intensity; they are not found frequently in urban areas where *A. lumbricoides* and *T. trichiura* predominate (Katz and Hotez, 2004). Shade and moisture have been shown to be essential for the survival of the infective (filariform) larvae. Like other soil-transmitted helminths, hookworm infections are aggregated in certain persons (Hotez, 2008). Most persons harbour light worm-burdens whereas minority harbour moderate or heavy infections (Unke *et al.*, 2006). Moreover, even after specific anthelmintic chemotherapy, re-infections often occur (Parker and Allen, 2011).

Moderately and heavily infected persons appear to be predisposed to the re-acquisition of heavy infections (Walker *et al.*, 2011). Predisposition to hookworm infection may have genetic or immunologic basis (Ellis *et al.*, 2007). Unlike other geohelminths, high rates of hookworm infection occur in both adults and children (Ezeamama *et al.*, 2005). Hookworms show age-associated prevalence and intensity increases linearly, with heaviest infections occurring in elderly populations (Katz and Hotez, 2004). Hookworm infection is commonly transmitted through skin penetration of filariform larvae. Infections are particularly intense in densely populated communities such as tea and coffee plantations (Ellis *et al.*, 2007); recent estimates show that *A. duodenale* and *N. americanus* extract over 7 million litres of blood each day.

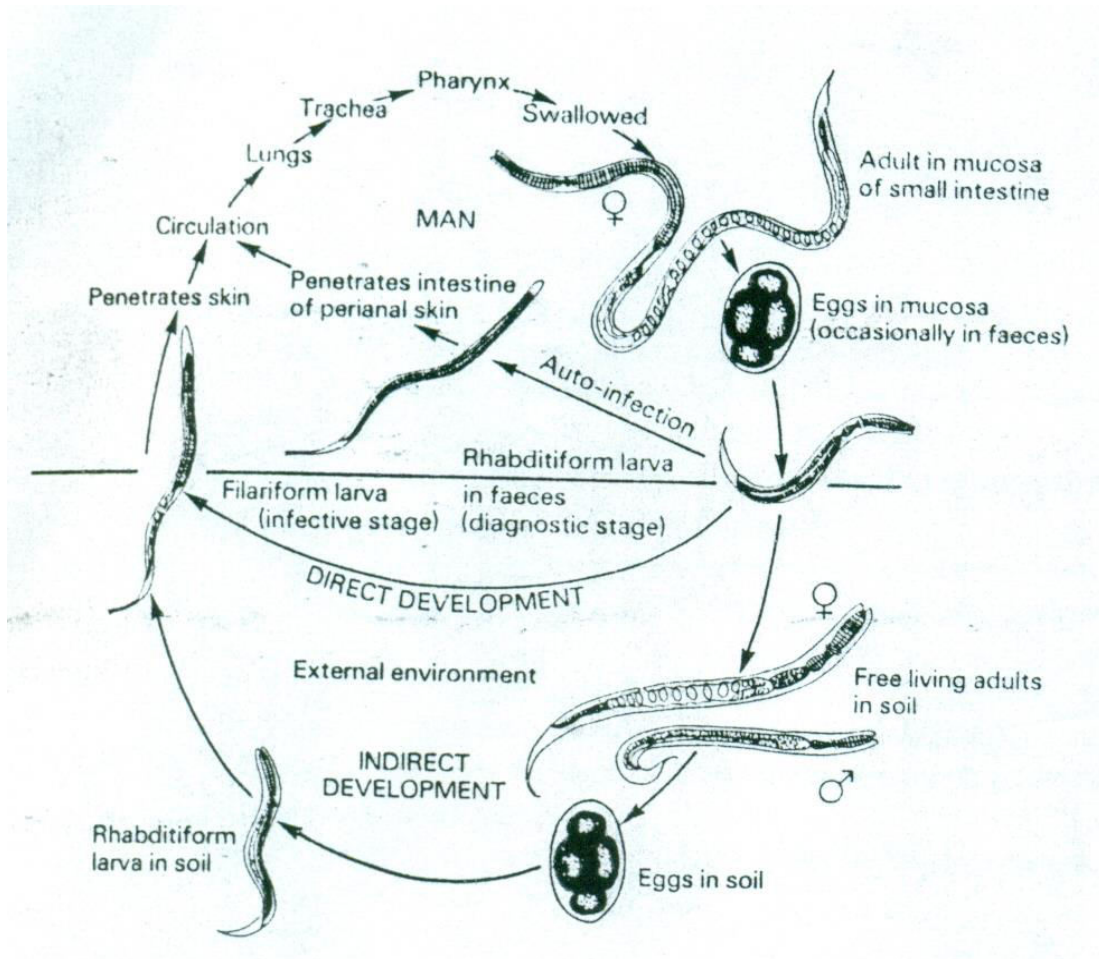
This amount of blood comes from 7 million individuals scattered worldwide; both species cause 50,000-60,000 deaths annually (Walker *et al.*, 2011). Fertilized females release 10,000- 20,000 eggs per worm per day; adults may live in infected hosts for 2-14 years (Schär *et al.*, 2013).

#### **2.2.4: Strongyloidiasis**

Strongyloidiasis is an infection caused by an intestinal nematode called *Strongyloides stercoralis*. Infection is acquired through the penetration of filariform larvae through the exposed skin and by auto-infection (Barnish and Ashford, 1989). The filariform larvae penetrate the outer skin and smaller blood vessels and begin heart-lung migration. Filariform larvae, especially in heavy infections, can similarly penetrate the mucosal wall and blood vessels of the small intestine, leading to dissemination of filariform larvae to extra-intestinal foci (Mejia and Nutman, 2012) (Fig. 2.4). The pathological manifestations in infected individuals are caused by both adults and immature larvae. Distribution of *S. stercoralis* infection is world-wide and parallels that of hookworms, although it is less prevalent than hookworms (de Souza *et al.*, 2007).

Infections with *S. stercoralis* are most prevalent in tropical and sub-tropical regions and currently, this worm infects 90 million individuals worldwide (Knopp *et al.*, 2008). Strongyloidiasis is focally endemic in North America and Appalachia (Khieu *et al.*, 2013; de Paula *et al.*, 2015); it is also common in South-east Asian immigrants. One study showed 76.6% of Kampuchean immigrants and 55.6% of Laotian immigrants were sero-positive for *S. stercoralis* infection (Fig. 2.4) (Schär *et al.*, 2013). Strongyloidiasis is endemic in Jamaica and Caribbean islands. Because of auto-infection, strongyloidiasis is highly prevalent in mental hospitals, prisons and homes for mentally retarded children (Ellis *et al.*, 2007).

Dogs and anthropoid apes may serve as reservoir hosts for *Strongyloides stercoralis*. In addition, *S. fuelleborni* is endemic in Papua New Guinea and sub-Saharan Africa (Stothard *et al.*, 2008).



**Fig. 2.4: Life cycle of *Strongyloides stercoralis* in man (Jenson and Baltimore, 2002)**

Infections with *S. stercoralis* and *S. fuelleborni* (Barnish and Ashford, 1989) are acquired by direct contact of the skin with filariform larvae. Infections may follow ingestion of food contaminated with filariform larvae (Buonfrate *et al.*, 2013). Transformation of rhabditiform larvae to filariform stage within the GIT results in seeding of peri-anal area with infectious organisms (Fig. 2.4); larvae may be passed to persons through direct physical contact or auto-infect the original host (de Souza *et al.*, 2007; Walker *et al.*, 2011).

In debilitated and immuno-suppressed patients, transformation of rhabditiform larvae to filariform stage occurs within the GIT, producing massive auto-infection or hyper-infection (Katz and Hotez, 2004). Males of *S. stercoralis* and *S. fuelleborni* are seldom seen and some authorities believe females conceive parthenogenetically (Knopp *et al.*, 2008); gravid female is ovi-viviparous and its eggs hatch into rhabditiform larvae almost immediately; auto-infection is common with *S. stercoralis* (Knopp *et al.*, 2008; Khieu *et al.*, 2013).

### **2.3 Transmission of geohelminthiases**

The main routes of entry of the commonest geohelminths into the human body include ingestion, skin penetration, inhalation and auto-infection (Schär *et al.*, 2013; de Paula *et al.*, 2015) (Fig. 2.1-2.4).

#### **2.3.1 Ingestion**

Ingestion of viable, infective embryonated eggs eaten with contaminated food or drink occurs in ascariasis (Fig. 2.1) (Walker *et al.*, 2011). Ingestion is also the commonest mode of infection with trichuriasis (Fig. 2.2) (Hotez *et al.*, 2009; WHO, 2012). Enterobiasis is occasionally transmitted through ingestion (ten Hove *et al.*, 2009; Schär *et al.*, 2013). The two major species of hookworms (*A. duodenale* and *N. americanus*) cause different clinical syndromes in children (Ezeamama *et al.*, 2005). *A. duodenale* which is larger, generally causes greater blood loss, can infect humans orally and is more virulent than *N. americanus* (Fig. 2.3; Knopp *et al.*, 2008; Schär *et al.*, 2013; de Paula *et al.*, 2015).

### **2.3.2 Skin penetration**

Skin penetration is the commonest method of infection by the infective-stage (filariform) larvae of *A. duodenale* and *N. americanus* (Fig. 2.3) and those of *S. stercoralis* and *S. fuelleborni* (Fig. 2.4) is common (Schär *et al.*, 2013). The penetration process leads to hookworm and strongyloides infection (Vadlamudi *et al.*, 2006; Ndyomugenyi *et al.*, 2008).

### **2.3.3. Inhalation**

Inhalation of viable embryonated eggs of *A. lumbricoides* (Fig. 2.1), *T. trichiura* (Fig. 2.2) and *E. vermicularis* results in ascariasis, trichuriasis and enterobiasis, respectively (WHO, 2012).

### **2.3.4 Auto-infection**

Auto-infection is a common mode of infection with *S. stercoralis* (Fig. 2.4) (de Paula *et al.*, 2015); auto-infection is also common with *E. vermicularis* (Khieu *et al.*, 2013). Transmission of intestinal helminthic infections in endemic areas is dependent on many factors (Ezeamama *et al.*, 2005). These include the species of helminths in the area, seasonality of transmission and infection rate (Knopp *et al.*, 2008). The process of transmission involves three major life cycles for intestinal nematodes: the direct, direct modified and percutaneous (Schär *et al.*, 2013). The direct life cycle involves transmission from the soil into the digestive system where maturation of the worm occurs with *Trichuris trichiura* (Fig. 2.2). The indirect life cycle is similar to the direct life cycle but involves migration of larvae through the circulatory and respiratory systems; with *A. lumbricoides*, final migration into the digestive system occurs followed by maturation (Fig. 2.1) (Yap *et al.*, 2013). The percutaneous life cycle involves penetration of filariform larvae through the skin and migration through the circulatory and respiratory systems.

These larvae finally enter the digestive system where maturation occurs as shown for hookworms (de Paula *et al.*, 2015). Excessive clustering of eggs of *A. lumbricoides* and *T. trichiura* suggests that concurrent infection with these species occurs at a greater frequency than would be expected by chance (van Riet *et al.*, 2007). This is further demonstration that *A. lumbricoides* and *T. trichiura* have a common transmission route (ten Hove *et al.*, 2009). Evidence from Panama (Andrade *et al.*, 2001), Malaysia (Walker *et al.*, 2011) and Madagascar (WHO, 2012) showed that even within a given locality, prevalence of intestinal helminthiases varies from one household to another. This occurs due to differences in socio-cultural, behavioural and economic backgrounds (Khieu *et al.*, 2013).

Majority of intestinal infections occur among people living in overcrowded areas, especially city slums (Olsen *et al.*, 2009); children growing in such endemic communities are prone to infections after weaning and are constantly re-infected. Multi-parasite infections are common and children harbouring such intestinal infections suffer from exacerbated morbidity; this makes them even more vulnerable to other infections (de Paula *et al.*, 2015). Investigators showed that parasitic worms may be the commonest agents of chronic intestinal infection in humans (ten Hove *et al.*, 2009). Investigators have shown that there are several factors which contribute to persistence of geohelminthiases worldwide. These include poverty, illiteracy and social inequality (WHO, 2012), low status of women in most cultural contexts and communities and increasing emergence of benzimidazole (broad-spectrum anthelmintics) drugs resistance (Jamaiah and Rohela, 2005; Al-Mekhlafi *et al.*, 2007; Ngui *et al.*, 2011). Other identified factors include inadequate nutrition, poor sanitation, inadequate housing, rapid urbanization and failure to implement known preventive strategies.

Also included are changing life-styles, limited access to health care and inadequate surveillance systems (de Paula *et al.*, 2015). Periodic mass deworming, proper sanitation and effective health education are three major and vital interventions for the long-term control and elimination of geohelminthiases (Kobayashi *et al.*, 2006).

## **2.4 The pathogenesis of geohelminthiases**

### **2.4.1 Pathological disease processes caused by adult geohelminths**

Geohelminths exert their pathogenic effects by producing multi-faceted disease processes. These processes lead to various clinico-pathological manifestations and considerable morbidity and mortality (Hürlimann *et al.*, 2014). These include: cognitive dysfunction, anaemia and oedema caused by *A. duodenale* and *N. americanus* and to a lesser extent by *T. trichiura* and *S. stercoralis* (Hartgers *et al.*, 2008; Conteh *et al.*, 2010). Other disease processes relate to intestinal malfunction by *A. lumbricoides*, *A. duodenale*, *N. americanus*, *S. stercoralis* and *T. trichiura* (de Paula *et al.*, 2015).

However, the mechanism by which mental processes are affected is uncertain but available evidence suggests that the mechanism is indirect (Khieu *et al.*, 2013). A causal link exists between parasitic infections and impaired cognitive function or delayed cognitive development (Ezeammama *et al.*, 2005). Treatment of infected children is shown to have therapeutic and beneficial effects (de Paula *et al.*, 2015). Consensus has emerged that iron-deficiency impairs cognitive development and contributes to loss of productivity. Learning abilities of children provide the skills for development (Ezeamama *et al.*, 2005). Gabrielli *et al.* (2005) studied cognitive development in relation to iron-deficiency caused by hookworms.

The authors concluded that iron-deficiency was associated with impaired educational performance. Available evidence suggests the existence of a direct association between academic performance and intestinal geohelminthiases (Ellis *et al.*, 2007). School-age children with multiple geohelminthiases produce poorer academic performance than uninfected children or those infected with a single species of geohelminths (van Riet *et al.*, 2007). About 20% of disability adjusted life years (DALY's) lost due to disease among school children is a direct result of geohelminthic infections (WHO, 2012). Taylor-Robinson *et al.* (2012) showed iron-deficiency anaemia in children is associated with significantly lower scores on psychological tests. The effects of iron-deficiency during infancy were associated with lower developmental test scores at 5 years of age (Schär *et al.*, 2013). Recent studies in Tanzania showed that school children infected with helminths achieved significantly lower scores in some tests of cognitive ability; the degree of deficit was related to intensity of infection (Bieri *et al.*, 2013).

Intestinal helminthic infections in Kenya rank fifth as major cause of out-patient attendance after malaria, pneumonia, dysentery and skin disease (Sang *et al.*, 2014). The most plausible mediators of cognitive dysfunction are common sequelae of infection which include iron-deficiency anemia (IDA) and malnutrition (decreased neuro-transmitter amounts) (Ezeamama *et al.*, 2005). Rosenthal (2009) reported that iron-deficiency anemia in infants and young children is associated with significantly lower scores on psychological tests. During infancy, these effects are associated with lower developmental test scores at 5 years of age (Jardim-Botelho *et al.*, 2008; Hürlimann *et al.*, 2014).

Other geohelminth-related pathological manifestations include intestinal malfunction and malabsorption; these are characterized by impairment of fat and protein digestion, protein and fat absorption (Katz and Hotez, 2004). Other observable manifestations include loss of Iron, Folic Acid and Vitamin B<sub>12</sub> from the bowel due to hookworm infections (Joardim-Botelho *et al.*, 2008). Hookworm infection is also associated with alterations of gastric motility and acidity (Amara *et al.*, 2005) while *A. lumbricoides* infection causes avitaminosis-A and marked intoxication with toxins (Behrman *et al.*, 2004). Electrolyte derangement, especially of potassium (K<sup>+</sup>), sodium (Na<sup>+</sup>), calcium (Ca<sup>++</sup>), magnesium (Mg<sup>++</sup>) and chloride (Cl<sup>-</sup>) ions (WHO, 2012) is common in ascariasis. Infections with geohelminths have been shown to cause electrolyte derangement especially in diarrhoeic episodes and hyper-motility of the gastrointestinal tract (Profumo *et al.*, 2014). Heavy electrolyte losses occur during diarrhoeic states with serious patho-physiological consequences in school-age children, pregnant women and elderly persons. Pronounced electrolyte disturbances are clinically dominated by associated hypokalaemia, hyponatraemia and hypochloraemia (WHO, 2006).

Other important disturbances include dehydration or even over-hydration states, among others (Katz and Hotez, 2004). Flaccid paralysis secondary to hypokalaemia was associated with severe paediatric malnutrition (Ezeamama *et al.*, 2005). Further, van Riet *et al.*, (2007) showed that cognitive function is potentially adversely affected by electrolyte disturbances. These disturbances present as hyponatraemia and hypernatraemia (Minciullo *et al.*, 2012). Loss of weight also occurs in infections with *A. lumbricoides* and *T. trichiura* (Taylor-Robinson *et al.*, 2012). Other pathogenic effects inducing physiological changes include stunted growth and impairment of intellectual development and function (WHO, 2006).

Geohelminthiases are also shown to cause cardiac dilatation and cardiac-failure (Katz and Hotez, 2004), endocrine upsets, parotid gland enlargement and allergic states (de Paula *et al.*, 2015). However, many of the mechanisms underlying the production of these states have wide common frontiers with malnutrition (Hartgers *et al.*, 2008). Geohelminths also produce enzymic and anti-enzymic secretions that interfere with protein digestion (WHO, 2011). Various allergic states in geohelminthic infections are frequently encountered in man (Profumo *et al.*, 2014).

#### **2.4.2 Pathological disease processes caused by larval geohelminths**

Current evidence shows that three recognized types of human disease are caused by the migrating larvae, specifically cutaneous larva migrans (WHO, 2012), visceral larva migrans and ocular larva migrans (WHO, 2006; Hartgers *et al.*, 2008). The disease processes result from normal migration of larvae of geohelminths that commonly occur in man and from some species that are rare. The filariform larvae of *A. duodenale*, *N. americanus*, *S. stercoralis*, *S. fuelleborni*, *A. caninum* of dogs and *A. braziliense* of cats (Katz and Hotez, 2004) infect humans by penetrating the skin exposed to the external environment (Fig. 2.3 & 2.4), causing cutaneous larva migrans. The penetration of filariform larvae is facilitated by release of parasite-derived hydrolytic enzymes. The larvae release eicosanoids that elicit a vigorous host-inflammatory response (de Paula *et al.*, 2015). The inflammatory response leads to the development of dermatitis known as “ground itch” (Rosenthal, 2009). The infective-stage larvae of *A. lumbricoides*, *A. duodenale*, *N. americanus* and *S. stercoralis* have a heart-lung migration phase (Ezeamama *et al.*, 2005) (Fig. 2.1-2.4). Some of these larvae occasionally follow abnormal pathways and migrate into unusual body locations, especially *S. stercoralis* and *S. fuelleborni* (Vadlamudi *et al.*, 2006).

These infective-stage larvae can be disseminated to many organs of the body such as the kidneys and the central nervous system (CNS) (WHO, 2006). Current evidence shows that infective larvae trapped in brain tissue produce space occupying lesions (SOLs) which raise the intracranial pressure. This results in serious clinical manifestations which occasionally lead to death of the patients (Schär *et al.*, 2013; de Paula *et al.*, 2015). Geohelminthic larvae chiefly responsible for cutaneous larva migrans (CLM) are *A. caninum* (dog hookworm) and *A. braziliense* (cat hookworm) (Ezeamama *et al.*, 2005). Visceral larva migrans is caused by larval ascarids of dogs (*Toxascara canis*) and cats (*T. catis*) (WHO, 2012). These are widespread in distribution; static encephalopathy from *T. canis* has been described (Ezeamama *et al.*, 2005). *Toxascaris leonina* which partly or entirely replaces *Toxocara* species in some regions of the world can cause visceral larva migrans (Ezeamama *et al.*, 2005). *Baylisascaris procyonis* from raccoons was also shown to cause (VLM) visceral larva migrans (Katz and Hotez, 2004).

Severe eosinophilic meningitis has been attributed to infections with *Baylisascaris procyonis* (Schär *et al.*, 2013). This ascarid was found parasitizing raccoons in USA (Katz and Hotez, 2004). *Baylisascaris procyonis* (raccoon ascarid) and *Lagochilascaris sprengi* (opossum ascarid) cause ocular larva migrans (OLM), especially in USA (Hotez, 2008). Infective-stage larvae causing visceral larva migrans can localize in any organs of the body including liver, kidneys and central nervous system (brain lobes and spinal cord) (WHO, 2006). Pathological disturbances caused by parasitic lesions in the frontal, parietal, temporal or occipital lobes can lead to hearing or visual impairment and concurrent hearing and visual impairments (Schwartz *et al.*, 2005). These dysfunctions have significant and marked effects on cognitive, physiological, psychological and functional health of infected persons (Schär *et al.*, 2013).

Dysfunction include the risk of mortality (Wade and Tavis, 2011); the presence of more than one sensory impairment increases morbidity risk relative to hearing impairment or visual impairment alone (Caban *et al.*, 2005). Infective-stage larvae in VLM were found localized in the Central Nervous System (CNS) and liver. However, larvae were occasionally reported in the spleen where they cause splenomegaly and in the eyes. In addition, damage to eyes can lead to palinopsia (WHO, 2011), visual impairment and blindness (Caban *et al.*, 2005). Myriad disorders of the CNS including hearing loss (Caban *et al.*, 2005), epilepsy (WHO, 2012), palinaesthesia (Schwartz *et al.*, 2005), convulsions and coma have been reported (Hotez, 2008). The clinico-pathological sequelae of these events lead to cognitive dysfunctions (Mejia and Nutman, 2012). Infective-stage larvae causing visceral larva migrans have also been reported in abscesses which occurred in the CNS as primary lesions; these have been shown to develop into oedema as space-occupying lesions (SOLs) causing epilepsy. Further, these lesions have been reported to severely disrupt cognitive functions (Minciullo *et al.*, 2012).

## **2.5 Cognitive Function expression in geohelminthiases**

Several investigators showed that normal cognitive function in children and adults is characterized with various manifestations of conscious awareness (Schwartz *et al.*, 2005). These include audio-visual and tactile alertness, awareness of events in ones external and internal environment, high mental proficiency and timely judgement. Also included among cognitive functions are memory and speed of information processing (Ezeamama *et al.*, 2005). Also included are perceptual speed in circumstances and situations that result in appropriate integrated motor, autonomic and neuro-endocrine output responses (Wade and Tavis, 2011). Cognitive dysfunctions are associated with several clinical manifestations (Crompton and Savioli, 2007).

Thus, for example, dizziness, drowsiness, lethargy, lassitude, mental and muscular fatigue when cognitive function is disrupted (Ojha *et al.*, 2014). Nausea and occasionally headache occur, accompanied by poor short-term memory leading to frequent forgetfulness, poor attention and low concentration power (Matthys *et al.*, 2011). Investigators showed that hookworm infections can have significant adverse effects on children's working memory, which may have severe consequences for a child's reasoning ability and reading comprehension (Schwartz *et al.*, 2005). Any disruptions to thinking processes in the brain caused by nutritional deficits and parasitic infections can disturb acquisition of both current and future thinking skills (Vadlamudi *et al.*, 2006). Geohelminthiasis may adversely affect memory, attention and speed of information processing in children (Ndyomugenyi *et al.*, 2008).

## **2.6 Anatomical and chemical-pathological changes observed in malnourished persons**

Geohelminthiasis in moderate and heavy episodes have been associated with malnutrition (Behrman *et al.*, 2004). Investigators reported that twenty-six adult *A. lumbricoides* worms deprived the human child of one-tenth of total protein content from the diet (Ezeamama *et al.*, 2005). Studies of animal models deprived of protein and calories *in utero* and/or in early extra-uterine life have shown a variety of patho-physiological changes (Hotez, 2008). These include growth retardation, failure to gain weight and less brain growth (Ojha *et al.*, 2014). Further, increase in water in the brain is also a patho-physiological change that was reported (Wade and Tavis, 2011). Other adverse effects may affect cell growth and replication (Zaiss *et al.*, 2013) and reduction in the number of synapses (WHO, 2012). Moderate to heavy hookworm infections produce iron-deficiency anaemia (Katz and Hotez, 2004). Iron is necessary for the biosynthesis of dopaminergic neurons and some neuro-transmitters such as serotonin and dopamine (Katz and Hotez, 2004).

Cognitive control of motor function requires complex processing of incoming sensory information signals in synapses in the soma, spinal cord and in cortices of the brain lobes (Ojha *et al.*, 2014). Loss of iron is associated with sub-optimal neuro-muscular functions (Katz and Horte, 2004). Malnutrition results in reduction in brain weight and increase in water content (Ojha *et al.*, 2014). Under-nutrition also alters the balance of synaptic neuro-transmitters in the developing brain (WHO, 2012). Taylor-Robinson *et al.* (2012) showed prolonged nutritional deprivation occurs during geohelminthiases (Katz and Horte, 2004). This may produce permanent deficits in humans in form of restricted skeletal growth and smaller head size. Katz and Horte (2004) reported that chronic, protein-energy deprived human populations often perform less well on IQ (Intelligent Quotient) tests given later in life. Investigators showed that substantial deficits in protein and/or calories have serious, permanent effect on developing brain, cognitive function and academic performance (Schär *et al.*, 2013).

## **2.7 Electrolytes and Cognitive dysfunction**

Investigators showed geohelminthiases cause electrolyte derangement, especially in diarrhoeic episodes and hyper-motility of the gastro-intestinal tract (WHO, 2012). Heavy electrolyte losses occur during diarrhoeic states with serious patho-physiological sequelae in school-age children, pregnant women and the elderly (Amara *et al.*, 2005; Müller *et al.*, 2011). Electrolyte disturbances are dominated by hypokalaemia (decreased  $K^+$ ), hyponatraemia (decreased  $Na^+$ ), hypocalcaemia (decreased  $Ca^{++}$ ), hypomagnesaemia (decreased  $Mg^{++}$ ), hypochloraemia (decreased-  $Cl^-$ ), dehydration or even over-hydration states (Hürlimann *et al.*, 2014). Flaccid paralysis secondary to hypokalaemia was reported in association with severe paediatric malnutrition (Behrman *et al.*, 2004).

Yap *et al.* (2012) showed that cognitive function in the brain is potentially adversely affected by electrolyte disturbances. These disturbances presented as hyponatraemia and hypernatraemia (Ojha *et al.*, 2014).

## **2.8 Clinical manifestations (features) observed in geohelminthiases**

Clinical manifestations of geohelminthiases relate to larval phase or adult phase of infection. Both phases apply in strongyloidiasis and ascariasis, often leading to hepatomegaly (Rosenthal, 2009; Hawkes, 2013). Symptoms of pulmonary migration of *A. lumbricoides* larvae range from mild dry cough to severe dyspnoea, cyanosis, wheezing pneumonitis and haemoptysis (de Paula *et al.*, 2015). During migratory phase of ascariasis, there may be urticarial or scaly rashes and peripheral eosinophilia (Katz and Hotez, 2004). Heavy worm burdens with *A. lumbricoides* produce lumbar lordosis and a large abdomen related to stunting, sub-nutrition, avitaminosis-A and kwashiorkor (Zhou *et al.*, 2007; Schär *et al.*, 2013).

Other patho-physiological manifestations occur, including marked intoxication, electrolyte derangement and dehydration. Also included are obstructive appendicitis, abdominal obstructions and invasion of the biliary system (WHO, 2006). These manifestations often occur in ascariasis and result in cholecystitis, acute cholangitis, acute pancreatitis or hepatic abscesses (Katz and Hotez, 2004). Eustachian and fallopian tubes or pancreatic duct perforations are other complications (Matthys *et al.*, 2011). Symptomatology in trichuriasis (WHO, 2006) is related to the number of worms present in the bowel. Light infections cause either no symptoms or mild ones while heavy infections are characterized by abdominal pain, loss of weight and failure to thrive and gain weight (Katz and Hotez, 2004).

Typical patients infected with *T. trichiura* present with under-nutrition with wasting of muscle mass (Schär *et al.*, 2013). Massive trichuriasis may play a role in the pathogenesis of kwashiorkor, rectal prolapse and combined blood loss from *Trichuris* dysentery and poor iron absorption from intestinal hypermotility (Matthys *et al.*, 2011). The main clinical feature in infections with *A. duodenale* and *N. americanus* is associated with iron-deficiency anaemia (IDA), hypo-albuminaemia and protein malnutrition. Mal-absorption and loss of Folic Acid (pteroylglutamic acid) and Vitamin B<sub>12</sub> (cyanocobalamin) may occur in moderate to heavy infections (WHO, 2012). The worm burden that produces IDA also depends on age, sex, physiological status (menstruation, pregnancy, lactation) and nutritional status of the host (Jardim-Botelho *et al.*, 2008).

Other symptoms in hookworm disease include severe diarrhoea, abdominal pain simulating gastro-duodenal ulcer or cholecystitis and production of hyper-motility of gastro-intestinal tract (Katz and Hotez, 2004; Vadlamudi *et al.*, 2006). Strongyloidiasis may present as a mild form of infection characterized by catarrhal enteritis, with mucous secretion and sometimes haemorrhage and micro-ulceration (Knop *et al.*, 2008). It may also present as intermediate forms of oedematous enteritis, with atrophy of the mucosa and oedema of submucosa (Ezeamama *et al.*, 2005). Oedematous enteritis may constitute a serious form of enteritis characterized by ulcerative enteritis (WHO, 2012). Young children develop anorexia, vomiting, chronic diarrhoea with fat mal-absorption leading to steatorrhoea (fatty diarrhoea). This leads to subsequent loss of fat-soluble vitamins (ADEK) (Schär *et al.*, 2013). These events lead to serious clinico-pathological manifestations; protein mal-absorption results in hypo-albuminaemia, peripheral oedema, cachexia and abdominal distention (Jardim-Botelho *et al.*, 2008).

Growth restriction, mal-absorption syndromes, deficiencies of vitamin B<sub>12</sub> and Folic Acid may also occur in strongyloidiasis (Schär *et al.*, 2013). An exaggerated form of strongyloidiasis (swollen belly syndrome) has been reported in infants with *S. fuelleborni* infection (Knop *et al.*, 2008). There is an inverse relation between the number of firariform larvae in faeces and severity (intensity) of the infection in strongyloidiasis. *S. stercoralis* infection causes abdominal pain and severe diarrhoea (Jardim-Botelho *et al.*, 2008).

Rapid deterioration of general condition, anorexia and extreme cachexia are reported, ending in death; fatal cases of strongyloidiasis are reported in endemic areas (Schär *et al.*, 2013). Light, moderate and heavy infections in children increase the risk of developing deficits in physical growth, cognition, cognitive functions and intellectual development (Taylor-Robinson *et al.*, 2012). The mechanisms and causative pathways involved in geohelminthiasis which manifest as cognitive dysfunctions and poor academic performance remain obscure and ill-understood (Jardim-Botelho *et al.*, 2008). There is currently no study that has demonstrated stunted growth, cognitive dysfunction and poor academic performance in the same population.

## **2.9 Other parasites producing gastro-intestinal symptoms and Cognitive dysfunction**

Beside geohelminths, other common parasites cause clinically important GIT disease, symptoms and cognitive dysfunction. These include trematodes (flukes), cestodes (tapeworms) and protozoa. The most clinically important trematodes are *Schistosoma mansoni*, *S. haematobium*, *S. japonicum* and *S. intercalatum* (Sang *et al.*, 2014) causing schistosomiasis. Cestodes of clinical importance are *Taenia saginata*, *Taenia solium* (taeniasis), *Hymenolepis nana* (hymenolepiasis) and *E. granulosus* (echinococcosis or hydatid disease) (Turner, 2004).

Some of the most clinically important protozoa are *Plasmodium* species found in blood and tissues (*Plasmodium falciparum*, *P. malariae*, *P. vivax* and *P. ovale*) which cause malaria (Halliday *et al.*, 2012).

### **2.9.1 Schistosomiasis**

Schistosomiasis (Parker and Allen, 2011) denotes a group of diseases caused by helminthic parasites called *Schistosoma* species. These exist as separate male and female sexes, specifically *S. mansoni*, *S. haematobium*, *S. japonicum* and *S. intercalatum* (Sang *et al.*, 2014); humans are the definitive hosts in schistosomiasis. *S. mansoni* and *S. haematobium* are found in many countries worldwide, especially Africa, Middle East, South America and Caribbean islands (Ezeamama *et al.*, 2005). However, *S. intercalatum* occurs only in limited areas on the African continent (Mugono *et al.*, 2014). *S. japonicum* (Sang *et al.*, 2014) occurs in far eastern Asia. *S. mansoni* and *S. japonicum* cause hepato-splenic intestinal schistosomiasis (Ezeamama *et al.*, 2005) while *S. japonicum* causes hepato-splenic intestinal schistosomiasis (also known as Asiatic bilharziasis); schistosomiasis are associated with cognitive dysfunction (Müller *et al.*, 2011).

The adult *S. mansoni*, *S. japonicum* and *S. haematobium* may cause parasitic embolism (Lustigman *et al.*, 2012) in blood vessels. Adult worms do not always follow typical routes described for intestinal and urinary schistosomiasis (Bundy *et al.*, 2013); worms occasionally migrate to cerebral blood vessels causing headaches and seizures. Neurologic manifestations of schistosomiasis are often clinically dramatic (Sang *et al.*, 2014). *S. haematobium* causes urogenital schistosomiasis (urinary schistosomiasis) (Odiere *et al.*, 2011). *S. intercalatum* causes infection in the intestinal tract (Müller *et al.*, 2011).

Odiere *et al.* (2011) showed that infections with *S. mansoni* and *S. haematobium* cause pathophysiological complications when eggs are trapped in the CNS, especially brain and spinal cord. Eggs produced by adult *S. mansoni*, *S. japonicum* and *S. haematobium* do not always follow typical routes described for intestinal and urinary schistosomiasis (Fenwick, 2012). The presence of eggs in tissues leads to formation of inflammatory granulomas which may occlude blood flow leading to ischaemic tissue damage (Reichenberg *et al.*, 2001; Odiere *et al.*, 2011). The initial entry of cercariae into the skin produces an inflammatory hypersensitivity reaction and itching (swimmer's itch) (Odiere *et al.*, 2011). Schistosomiasis can adversely affect memory function, attention and speed of information processing, especially in school children (Lustigman *et al.*, 2012).

### **2.9.2 Taeniasis**

Taeniasis is a group of diseases caused by helminthic parasites of the genus *Taenia*; the clinically most important infections are taeniasis saginata and taeniasis solium (Lustigman *et al.*, 2012). *T. saginata* has a worldwide distribution but is especially common in Africa, USA, Middle East, Russian Republic and South America (Kinung'hi *et al.*, 2014). *T. solium* is cosmopolitan in distribution but is particularly common in India, Asia, Africa, Central and South American (Matthys *et al.*, 2011). Taeniasis saginata is acquired by ingestion of infected undercooked or raw beef or beef products, containing the larval stage of *T. saginata* called *Cysticercus bovis* (Turner, 2004). The strobilate adult *T. saginata* and *T. solium* proliferating in small intestine can cause clinically significant constipation and obstruction, especially in heavy infections (Matthys *et al.*, 2011); this may precipitate cognitive dysfunction and occasional surgical emergency (WHO, 2006).

Taeniasis solium is acquired by ingestion of infected under-cooked or raw pork containing larval stage of *T. solium* called *Cysticercus cellulosae* (Turner, 2004). The regurgitation of embryonated eggs of *T. solium* in the stomach was reported to lead to a clinical condition called neuro-cysticercosis (Sang *et al.*, 2014). The eggs of *T. solium* occasionally become disseminated by blood circulation into the brain and spinal cord. This leads to larval development in intracranial tissues resulting in clinical manifestations of neuro-cysticercosis (Fenwick, 2012).

### **2.9.3 Hymenolepiasis**

Hymenolepiasis (Dwarf tapeworm infection) is a disease caused by infection with Cyclophyllidean tapeworm called *Hymenolepis nana* (Lustigman *et al.*, 2012); *H. nana* occurs in several countries in South America, Asia, Africa and the Far East (Sang *et al.*, 2014). Hymenolepiasis is acquired by ingestion of food or drink contaminated with embryonated eggs of *H. nana* (Bundy *et al.*, 2013); auto-infection often occurs in clinical hymenolepiasis (Sang *et al.*, 2014). The presence of cysticercoid larvae of *H. nana* (Chero *et al.*, 2007) in the villi of small intestines causes mucosal irritation and diarrhoea. Mucosal irritation, especially in heavy infections, leads to clinically significant diarrhoeic episodes and electrolyte derangement (Matthys *et al.*, 2011; Fenwick *et al.*, 2012). Further, investigators have shown that heavy worm burdens with *H. nana* cause cognitive dysfunction. Thus, sustained diarrhoea can lead to metabolic acidosis which depresses neuro-transmission of nerve impulses from receptor cells to the brain for interpretation; this can disrupt the effector function of muscles and glands, causing cognitive dysfunction.

#### 2.9.4 Malaria

Malaria which is caused by *Plasmodium falciparum*, *P. malariae*, *P. ovale* and *P. vivax* has a worldwide distribution. The disease is endemic in Africa, South-East Asia, the Middle-East, Latin America, Central America, India, Pakistan and Iran (Fernando *et al.*, 2010). Africa bears overwhelming proportion of malaria burden, closely associating with distribution of *Anopheles gambiae* complex species. Female *A. gambiae* and *A. funestus* are among the most efficient vectors of *Plasmodium* species of man (Fernando *et al.*, 2010); malaria is imported by ever-increasing speed of travel worldwide (Righetti *et al.*, 2012). Pervasive morbidity and high mortality of malaria in Africa persist because of failed transactions between those at risk and available and preventive and curative health systems (Yapi *et al.*, 2014). Human infections with *Plasmodia* results from bites of infected female *Anopheles* species; during the feeding process, sporozoites resulting from sexual or sporogonic cycle (sporogony) in female *Anopheles* species are injected into human blood stream (Carter *et al.*, 2005; Yap *et al.*, 2013).

Sporozoites rapidly enter parenchyma cells of the liver (within 1 hour) (schizogony), where the first stage of development takes place (exo-erythrocytic phase) of the cycle. Thereafter, numerous asexual progeny (merozoites) rupture, leave the liver cells, enter the blood stream and invade erythrocytes. Parasites in red cells multiply in species-characteristic fashion, breaking out of cells synchronously (Halliday *et al.*, 2012). This is known as the erythrocytic cycle, with successive broods of merozoites appearing at 48-hour intervals (*P. vivax*, *P. ovale* and *P. falciparum*) or every 72 hours (*P. malariae*). Solid immunity does not develop and population suffers repeated seasonal epidemics, in all ages groups (Kinung'hi *et al.*, 2014). Half of malaria deaths worldwide occur in children younger than 5 years.

Investigators showed that untreated malaria caused by *P. falciparum* can progress to severe cognitive dysfunction, coma, renal-failure, pulmonary oedema and death. Nausea, vomiting and headaches are common, followed by prolonged febrile stage, characterized by fever reaching 40° C or more (Kinung'hi *et al.*, 2014). Cerebral malaria caused by *P. falciparum* frequently causes severe cognitive dysfunction in patients (Kirwan *et al.*, 2010).

## **2.10 Chemotherapeutic Drug regimens for geohelminthiasis**

Albendazole 400 mgs is the current drug of choice for treatment of ascariasis, trichuriasis, ancylostomiasis, necatoriasis, strongyloidiasis, enterobiasis, visceral larva migrans and cutaneous larva migrans (Rosenthal, 2009). It is also used to treat hydatid disease and cysticercosis and the active ingredient acts against nematodes by inhibiting microtubule synthesis. Albendazole has larvicidal effects in ascariasis, hookworm infections, hydatid disease and cysticercosis but has ovicidal effects in ascariasis, trichuriasis and ancylostomiasis (Bundy *et al.*, 2013). Adults and children older than 2 years infected with *A. lumbricoides* and hookworms are treated with albendazole 400 mgs, single oral dose. This dosage is repeated for 2-3 days for heavy ascariasis and 2 weeks for enterobiasis (Rosenthal, 2009).

Three 400 mg oral doses of albendazole are currently recommended for the treatment of trichuriasis (Albonico *et al.*, 2008; Rosenthal, 2009; Edelduok *et al.*, 2013). A recent meta-analytical study showed that albendazole was superior to mebendazole or pyrantel pamoate for the treatment of hookworm infection. Cure rates for trichuriasis with albendazole or mebendazole 400 mgs, single oral dose, were less than 30%. This suggested that three albendazole 400 mgs, single oral dose drug regimen might be superior (Rosenthal, 2009).

Recent reports indicate that when used for 1-3 days, albendazole is nearly free of significant adverse effects (Rosenthal, 2009). Mild transient epigastric distress, diarrhoea, headache, nausea, dizziness, lassitude and insomnia can occur in patients undergoing therapy (Taylor-Robinson *et al.*, 2007). Blood counts and liver function tests should be monitored during long-term therapy. Albendazole should not be given to patients with known hypersensitivity to other anthelmintic drugs or those with liver cirrhosis. The safety of albendazole in pregnancy and in children younger than 2 years of age has not been established (Albright and Basaric-Keys, 2006).

### **2.11 Cognitive Function Tests**

There are several psychological tests used to assess Cognitive function in human subjects. However, in this study, seven cognitive function tests developed by the British Institute of Psychology (BIP) were applied (Raven, 1958; Raven *et al.*, 1977; Korkman *et al.*, 2007; Harcourt Assessment, 2007). These tests were all designed for specific age-groups, except Standard Progressive Matrices (SPM), which is age-independent (Baddeley *et al.*, 1995). These tests are: Word Generation Semantic (WGS, 3-16 yrs), Word Generation Initial (WGI, 3-16 yrs), List Memory (LM, 7-12 yrs), Standard Progressive Matrices (SPM) (6-65 yrs, for all Age-groups), Coding-B (Cod-B, 8-16 yrs), Symbol Search-B (SS-B, 8-16 Yrs) and Digit Span (DSP, 6-16 Yrs). WGS, WGI and LM are language-dependent while SPM, Cod-B, SS-B and DSP are non-language-dependent.

### **2.12 The gap in Knowledge addressed by this study**

Overview of information on geohelminths in the current literature shows that data on prevalence rates and intensities of these worms in school-age children is scanty (Brooker *et al.*, 2000).

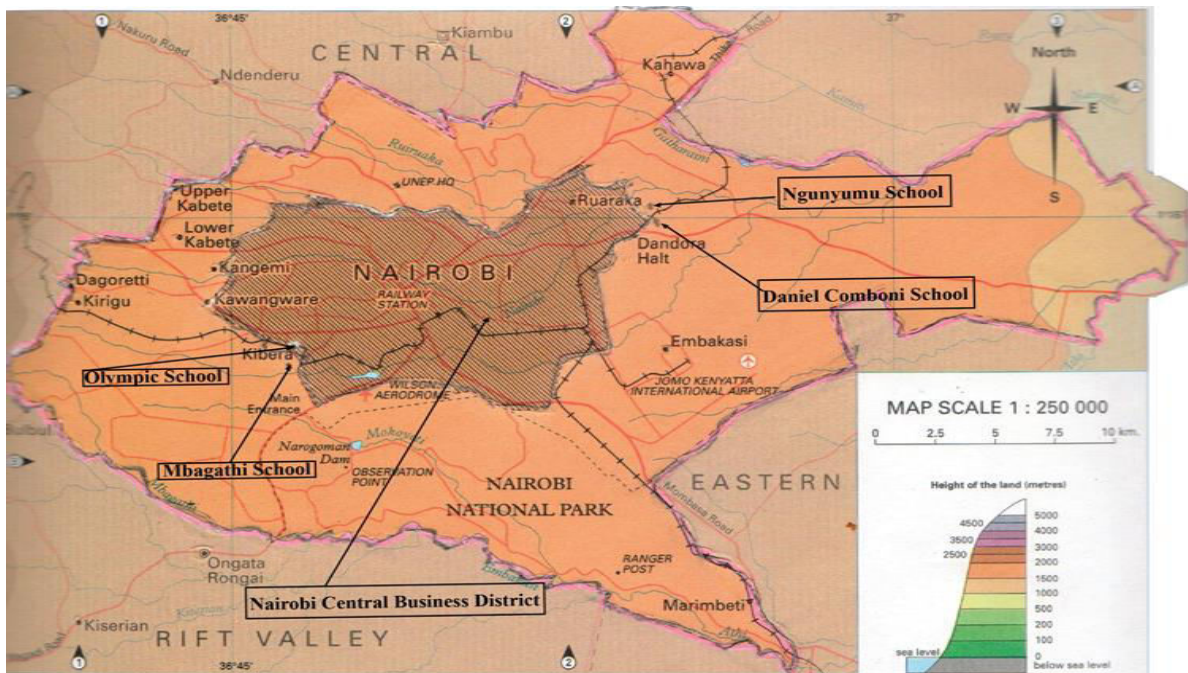
Data on prevalence and infection intensity is a dynamic phenomenon requiring frequent review and investigations. Studies on children infected with geohelminths in slum schools and the effects of the worms on cognitive function and academic performance are scanty in Kenya (Brooker *et al.*, 2000). Hence the relevance of this study to demonstrate and explain the miscellaneous factors that often contribute to poor academic performance in Nairobi slum schools annually. Most children living in such areas report poor health, which may adversely affect growth and cognitive development (Stephenson *et al.*, 1993). Although geohelminthiasis is widespread in areas with poor sanitation, empirical data on prevalence, their effects on growth, cognitive functions and academic performance is scanty (Ngonjo *et al.*, 2012). Thus, availability of this data would inform policy in the Ministries of Health and Education on effective control programmes for geohelminthiasis in Kenya.

Thus, this data needed to be generated in areas where geohelminthiasis is prevalent which formed the basis of the current study. The study sought to examine and illustrate the effect of geohelminthiasis on children's growth, cognitive functions and educational performance. The psychological tests used in this study are considered more culturally robust compared to other, mostly language-dependent tests used by investigators in related psychological studies. The simultaneous use of Kiswahili and English languages during administration of psychological tests constitutes a unique cultural adaptation. This type of adaptation in assessments of psychological tasks has not been applied before on African children, particularly using the current cognitive function testing battery.

## CHAPTER THREE: MATERIALS AND METHODS

### 3.1 The study site

This study was carried out within Kasarani, Lang'ata and Dagoretti sub-Counties of Nairobi County; three sub-Counties were purposefully selected because a large population lives in overcrowded slum conditions. The Nairobi County has 9 sub-Counties named: Kasarani, Lang'ata, Dagoretti, Starehe, Kamukunji, Makandara, Westlands, Njiru and Embakasi. Kasarani sub-County is located at the northern end of Nairobi County, Lang'ata at the south western and Dagoretti in the Western area of the County. Nairobi County is the capital and largest City in Kenya (Latitude  $1^{\circ} 30' S$  and  $1^{\circ} 45' S$ ) and (Longitude  $36^{\circ} E$  and  $38^{\circ} E$ ). Nairobi County is about 1,700 metres above sea level and covers an area approximately 696 square kilometers (Fig. 2.5). The schools selected for the study are: Daniel Comboni, Ngungumu, Mbagathi and Olympic primary schools; Daniel Comboni and Ngungumu schools are located in Kasarani sub-County, Mbagathi school is in Dagoretti sub-County while Olympic school is in Lang'ata sub-County.



**Fig. 3.1: Map of Nairobi showing location of sampled schools (Philip's Atlas, 2002)**

### 3.2 Study population

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

### 3.3 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 Dagoretti sub-County and Olympic in Lang'ata sub-County, based on previous reports in these schools. All available children 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 (Allen and Ridley, 1970) (Appendix 9). Blood samples were screened for malaria parasites (*Plasmodium falciparum*, *P. malariae*, *P. vivax* and *P. ovale*) using Giemsa staining method (Appendix 11; Baker *et al.*, 1998). Stool egg counts were performed on 235 children using Kato-Katz quantitative technique (Appendix 10; Ebrahim *et al.*, 1997; WHO, 2012). Cognitive function tests were administered (Appendix 1, 2 & 3) and anthropometric measurements taken to assess nutritional status of the pupils (Appendix 13, 14, 15 & 16). School attendance and academic performance records for 3 preceding 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 (Appendix 4).

Three months after treatment, cognitive function tests and anthropometric measurements were repeated and school attendance and academic performance records for 2 immediate terms were collected. The cognitive functions were assessed using a battery of seven tests (Appendix 1, 2 & 3) and the tests were administered to all 470 subjects, pre-treatment.

### 3.4 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 selected. The pupils were selected based on the basis of proportional probability, where Kasarani sub-County had the largest 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 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 geohemintiasis within the selected sub-County. The method of Fisher *et al.* (1998) was used to determine the sample size as shown below:

$$n = \frac{Z^2 pqD}{d^2} \text{ where:}$$

n = The desired sample size when the target population is greater than 10, 000.

Z = The standard normal deviate (1.96) at the 95 per cent level of confidence

p = 0.5 (Since the estimate of the target population with the characteristic under investigation is not known)

$$q = 1 - p$$

D = Design effect = 1

d = The level of statistical significance required

$$\text{Therefore: } n = \frac{1.96^2 \times 0.5 \times 0.5 \times 1}{(0.05)^2} = 384$$

Minimum sample size required in this study was 384 school-age children; however, the study population began 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, through migration and school transfers; systematic probability method was used to select the study population subjects, using class registers.

### **3.5 Screening for geohelminths**

Stool samples collected from school children were processed using Modified Ridley's method in which a pea-size stool was mixed with 4 mls of 10% formol-saline and emulsified; 3 mls of ether was added and shaken to mix, followed by centrifugation at 3g (1,800 rpm). The plug of debris was recovered using an applicator stick and the tube contents were decanted, leaving a button for microscopic examination at the bottom of the tube. Some small portion of the button was removed and mixed with 3% Lugol's iodine to provide background contrast; the preparation was examined using x 40 low power objective of the compound microscope. This was necessary for identification and quantification of geohelminthic eggs.

#### **3.5.1 Determination of infection Intensity**

Infection intensity for geohelminths, expressed in the number of eggs per gramme of stool (epg), was determined using the Kato-Katz Thick Stool Smear technique (Ebrahim *et al.*, 1997; WHO, 2012).

Approximately 2 gms of stool was placed on a sheet of disposable paper and pressed through the gauze square to obtain an estimated 50 mgs which was transferred onto a glass slide. A drop of 50% glycerol was added, mixed with the specimen and covered with a glass. Using another slide, the preparation was carefully pressed on the laboratory bench and left standing at room temperature for 45-60 minutes to clear faecal debris. The entire preparation was examined microscopically using x 40 objective; the number of eggs counted in a stool sample multiplied by a factor of 20 gave the number of eggs per gramme of stool. However, infection intensity of other helminths found in stool (*Taenia* species, *Hymenolepis nana* and *Schistosoma* species) was ignored in this study.

### **3.6 Screening for Other gastro-intestinal parasites**

Besides geohelminths found in stools screened, using Modified Ridley's method (*Ascaris lumbricoides*, *Trichuris trichiura* and hookworms (*A. duodenale* or *N. americanus*), other parasites were also found. These are: protozoa (*Entamoeba histolytica* and *Giardia lamblia*), cestodes (*Taenia* species and *Hymenolepis nana*) and blood flukes (*Schistosoma mansoni*). The eggs of hookworms and *Taenia* species are indistinguishable using ordinary compound microscope.

#### **3.6.1 Malaria**

Malaria parasites were screened using the Giemsa staining method; thin and thick blood films were prepared and fixed in absolute methanol for 3 minutes. Giemsa stain diluted (1 in 9) in buffered saline (pH 7-7.1) was flooded on slides and stained for 1 hour.

Blood films were washed and differentiated with buffered saline solution; differentiation with buffer solution improves the quality of staining and accuracy during the identification of malaria parasites (*Plasmodium* species). Stained slides were dried in air at room temperature for 30 minutes and examined microscopically, using x100 Oil immersion Objective (Baker *et al.*, 1998).

### **3.7 Cognitive Function testing**

#### **3.7.1 Description of Cognitive Function Tests Battery used pre- and post-treatment**

Cognitive function (Appendices 1, 2 & 3) was tested using a battery of 7 cognitive function tests (Raven, 1958; Raven *et al.*, 1977; Korkman *et al.*, 2007; Harcourt Assessment, 2007), which are designed for specific age-groups, except SPM which is age-independent (Baddeley *et al.*, 1995). These tests are: Word Generation Semantic (WGS, 3-16 yrs), Word Generation Initial (WGI, 3-16 yrs), List Memory (LM, 7-12 yrs), Standard Progressive Matrices (SPM, 6-65 yrs, for all Age-groups) and Coding-B (Cod-B, 8-16 yrs), Symbol Search-B (SS-B, 8-16 Yrs) and Digit Span (DSP, 6-16 Yrs). WGS, WGI and LM are language-dependent while SPM, Cod-B, SS-B and DSP are non-language-dependent. Raw scores were converted into standardized scores (age-dependent) and according to the percentile rank, cognitive description (performance) was given; tests were administered using Cognitive descriptions in the conversion Tables (Table 3.1).

**Table 3.1: Subtests Scaled Score equivalents of Cognitive Descriptions for all Cognitive Function Tests**

<b>Cognitive Description (Performance)</b>	<b>Sub-test Scaled Scores</b>
Very Superior	16 – 19
Superior	14 – 15
Bright Average	12 – 13
Average	8 – 11
Low Average	6 – 7
Significantly below Average	4 – 5
“Below 5 <sup>Th</sup> Percentile”	1 – 3

### **3.7.2 Cognitive Tests administration**

A battery of seven cognitive function tests, initially developed by British Institute of Psychology (BIP) (Raven, 1958; Raven *et al.*, 1977; Korkman *et al.*, 2007; Harcourt Assessment, 2007) was applied to determine cognitive functions for children with geohelminthiases. The tests are aimed at measuring different aspects of recognition and information processing in the human brain. Each of the cognitive function tests (Appendices 1, 2 & 3) was administered as follows:

#### **3.7.2.1 Word Generation Semantic (WGS) and Word Generation Initial (WGI) Tests**

This is a sub-test of Neuropsychology (NEPSY) designed to measure the child’s ability to generate either English or Kiswahili words within two specific Semantic categories (WGS - Item 1 = animals and Item 2 = foods or drinks) or two specific initial letters (WGI - Item 3 = “S” words and Item 4 = “F” words) (Appendix 1 i). The child is given Semantic category first and asked to produce as many words as possible in 60 seconds.

The administrator stops the test thereafter; each correct response is scored as 1 point. The raw score was obtained by adding the number of words the child gave correctly in each category; Word Generation (WGS) Semantic Total score was considered to be the sum of the correct responses for Items 1 and 2 while the Word Generation (WGI) Initial Letter Total score was considered to be the sum of the correct responses for Items 3 and 4 on the child's Record Form.

### **3.7.2.2 List Memory (LM) Test**

The List memory is a Sub-test of NEPSY) designed to assess several aspects of verbal learning and memory, including immediate and delayed recall, rate of learning and the role of interference from prior and new learning for children aged 7-12 years (Appendix 1 ii). The child was read a Word List by the sub-test administrator at a rate of one word every second and then the child was asked to recall all the words that can be remembered in any order; the responses were recorded verbatim; 1 point was given for each correct word said. The List Memory Total Correct score was considered to be the sum of correct words for Trials 1-5 on the child's Record Form.

### **3.7.2.3 Standard Progressive Matrices (SPM) Test**

The Standard Progressive Matrices test is a multiple-choice, non-verbal test designed to measure a person's mental ability or IQ (Intelligence Quotient) for all ages (Appendix 1 iii); the child's score was the total number of problems solved correctly; test design had no Time Limit and was meant for all ages (6-65 yrs). The consistency of a person's work was assessed by subtracting from a person's score, on each of the five sets (Sets A, B, C, D & E) the score normally expected on each set, for the same total score on a reference scale.

#### **3.7.2.4 Coding-B (Cod-B) Test**

This is a subtest from Wechsler Intelligence Scale for Children (WISC) designed to measure speed of information processing and administered to children aged 8-16 years (Appendix 1 iv). The total raw score was considered to be the number of correctly drawn symbols completed in 120 seconds.

#### **3.7.2.5 Symbol Search-B (SS-B) Test**

This is a subtest from the Wechsler Intelligence Scale for Children (WISC) designed to measure speed of information processing administered to children aged 8-16 years (Appendix 1 v). The total raw score was the number of correct responses minus the number of incorrect responses completed in 120 seconds.

#### **3.7.2.6 Digit Span (DSP) Test**

Digit Span (Backwards and Forwards) are sub-tests from Wechsler Intelligence Scale for Children (WISC) which measure working memory and attention skills in children aged 6-16 years (Appendix 1 vi). The total raw score for Digit Span is the sum of the item scores for both Digit Span Forwards and Digit Span Backwards.

##### **3.7.2.6.1 Digit Span Forwards**

The sub-test administrator told the child that some numbers would be said and when finished, the child should repeat and say the numbers; the sub-test was discontinued after the child scored 0 on both trials of an item (Appendix 1 vi).

### **3.7.2.6.2 Digit Span Backwards**

The child repeated numbers in reverse order of that presented by the administrator; the test was discontinued after the child scored 0 on both trials of an item. The Digit Span backwards was to be administered regardless of the child's performance on Digit Span Forwards (Appendix 1 vi).

### **3.8 Anthropometric measurements**

Anthropometric measurements were taken using the ordinary measuring tape for head circumference and height, MUAC (Mid Upper Arm circumference) tape and weighing balance for weight, pre- and post-treatment (Appendix 13, 14, 15 & 16). These measurements were taken for the determination of effects of geohelminthiases on growth.

### **3.9 Questionnaire administration**

Questionnaires were administered to collect data on children's family background to control for confounding covariates (Appendix 4).

### **3.10 Class Attendance and Academic performance records**

The class attendance records for 3 preceding and 2 immediate post-treatment terms were collected to determine the attendance patterns. End-of-term examination scores for 3 preceding and 2 immediate post-treatment terms were collected for analysis of academic performance.

### **3.11 Data analysis**

Data was collected, coded and entered in the Statistical Analysis Software (SAS), Version 9 (2002) for analysis.

The t-test statistic was used to test for differences in anthropometric measurements and BMI, cognitive function, absenteeism and academic performance, pre- and post-treatment. ANOVA was used to show differences between infection intensities and BMI (Appendices 13, 14, 15 & 16) and between infection intensities and absenteeism, between groups, pre- and post-treatment. Correlation analysis was used to establish associations between intensity of geohelminthiases and cognitive function test scores. Correlation analysis was used to show associations between intensity of geohelminthiases and absenteeism and associations between intensity of geohelminthiases and academic performance test scores in the infected children (Gordis, 1996). Linear Regression analysis was used to detect multiple factors (covariates/confounders) that had significant adverse effect on cognitive functions and academic performance.

### **3.12 Assessment units for Academic performance relating to geohelminthiases**

Academic performance was assessed using arbitrary unit score values for each grade, for example: A = 5, B = 4, C = 3, D = 2 and E = 1 scores. The final score for each school was obtained by multiplying each arbitrary score value with each grade (A-E) to get the sum total scores. Thus, for example, the arbitrary final academic score for Daniel Comboni school (281 scores) was calculated as follows: There were 7As, 22Bs, 32Cs, 30Ds and 2E grades in Daniel Comboni school. The final score in this school was equal to:  $7As \times 5 = 35 + 22Bs \times 4 = 88 + 32Cs \times 3 = 96 + 30Ds \times 2 = 60 + 2Es \times 1 = 2$ . Therefore, the total score for D. Comboni = 281 scores.

**3.13 Research authorization**

Research authorization was granted through Kenyatta University (Appendix 5 i & ii), Ministry of Higher Education Science and Technology (Appendix 6 i & ii), Directorate of City Education (Appendix 7) and Department of Health, Nairobi City Council (Appendix 8 i & ii).

## CHAPTER FOUR: RESULTS

### 4.1 Demographic profile of the sampled population

#### 4.1.1 Distribution of pupils by sub-County

Pupils were selected from the following three sub-Counties in Nairobi County: Kasarani, Lang'ata and Dagoretti: Majority of the sampled pupils came from Kasarani sub-County (65.5%) followed by Dagoretti (21.1%) and Lang'ata (13.4%) sub-Counties (Table 4.1).

**Table 4.1: Distribution of pupils by Sub-County and School (n = 469)**

Sub-County	Schools	No. of pupils	% Total
Kasarani	D. Comboni	232	49.5
	Ngunyumu	75	16.0
Lang'ata	Olympic	63	13.4
Dagoretti	Mbagathi	99	21.1
<b>Total</b>		<b>469</b>	<b>100%</b>

#### 4.1.2 Distribution of pupils by Classes

Majority of the pupils considered for the study were from the lower classes (2-4) (68.8%), while those in upper primary classes (5-7) were (31.2%) (Table 4.2).

**Table 4.2: Distribution of pupils by Class in 4 Schools (n = 469)**

<b>Class</b>	<b>No. of Pupils</b>	<b>%</b>
2	109	23.2
3	122	26.0
4	92	19.6
5	67	14.3
6	73	15.6
7	6	1.3
<b>Total</b>	<b>469</b>	<b>100%</b>

#### **4.1.3 Distribution of pupils by sub-County, School and Class (n = 469)**

Out of 469 pupils in the study population, (23.2%) were in class 2, (26.0%) class 3, (19.6%) class 4, (14.3%) class 5, (15.6%) class 6 and (1.3%) were in class 7. The largest number of pupils in class 2 (41.9%) were in Kasarani sub-County, followed by Dagoretti (25.3%) and Lang'ata (15.9%). The largest number of pupils in class 3 (59.4%) were in Kasarani sub-County, followed by Lang'ata (58.7%) and Dagoretti (8.1%). Further, the largest number of pupils in class 4 (36.4%) were in Kasarani sub-County, followed by Lang'ata (25.4%) and Dagoretti (21.2%). The largest number of pupils in class 5 (27.1%) were in Kasarani sub-County, followed by Dagoretti (23.2%). The largest number of pupils in class 6 (27.4%) were in Kasarani sub-County, followed by Dagoretti (22.2%). Kasarani sub-County had the largest number of pupils in class 7 (8.0%) (Table 4.3).

**Table 4.3: Distribution of pupils by sub-County, School and Class (n = 469)  
Classes (%)**

Sub-County	Sch. No. <sup>5</sup>	2	3	4	5	6	7	
Kasarani	1 <sup>1</sup>	232	63 (27.2)	48 (20.7)	41 (17.7)	35 (15.1)	45 (19.4)	0 (0.0)
	2 <sup>2</sup>	75	11 (14.7)	29 (38.7)	14 (18.7)	9 (12.0)	6 (8.0)	6 (8.0)
Lang'ata	3 <sup>3</sup>	63	10 (15.9)	37 (58.7)	16 (25.4)	0 (0.0)	0 (0.0)	0 (0.0)
Dagoretti	4 <sup>4</sup>	99	25 (25.3)	8 (8.1)	21 (21.2)	23 (23.2)	22 (22.2)	0 (0.0)
<b>% of Total</b>	<b>469</b>	<b>109 (23.2)</b>	<b>122 (26.0)</b>	<b>92 (19.6)</b>	<b>67 (14.3)</b>	<b>73 (15.6)</b>	<b>6 (1.3)</b>	

**Legend: 1<sup>1</sup> = Daniel Comboni; 2<sup>2</sup> = Ngunyumu; 3<sup>3</sup> = Olympic; 4<sup>4</sup> = Mbagathi; Sch. = School**

**No.<sup>5</sup> = No. of pupils in study**

#### 4.1.4 Distribution of pupils by Sex and Age-group

There was a total 168 (46.2%) males compared to 196 (53.8%) females among pupils sampled in all the four schools selected for the study. Majority (56.9%) were in the 11-14 year-age category, followed by 6-10 (36.5%) and 15 -18 (6.6%) year-age age categories (Table 4.4).

**Table 4.4: Distribution of pupils by Sex and Age-category (yrs) (n = 364)**

Age groups (yrs)	Sex		Total n (%)
	Male	Female	
6 – 10	98 (46.0%)	115 (54.0%)	213 (100.0%)
11 -14	57 (44.9%)	70 (55.1%)	127 (100.0%)
15 -18	14 (58.3%)	10 (41.7%)	24 (100.0%)
<b>Total =</b>	<b>169 (46.4%)</b>	<b>195 (53.6%)</b>	<b>364 (100%)</b>

#### 4.1.5 Distribution of pupils by Sub-County, School and Age-group

Among the 364 pupils sampled in all four schools included in the study, (54.9%) of the pupils aged 6-10 years were from Kasarani sub-County, (25.4%) from Lang'ata and (19.7%) from Dagoretti. Further, (74%) of pupils aged 11-14 years were from Kasarani sub-County, (3.9%) from Lang'ata and (22.0%) from Dagoretti. In addition, (66.7%) of pupils aged 15-18 years were from Kasarani sub-County and (33.3%) from Dagoretti sub-County (Table 4.5).

**Table 4.5: Distribution of pupils by sub-County, School and Age-group (n = 364)**  
Age-groups (yrs)

Sub-County	Schools	No. of Pupils	6-10	11-14	15-18
Kasarani	D. Comboni	173	94 (44.1%)	72 (56.7%)	7 (29.2%)
	Ngunyumu	54	23 (10.8%)	22 (17.3%)	9 (37.5%)
Lang'ata	Olympic	59	54 (25.4%)	5 (3.9%)	0 (0%)
Dagoretti	Mbagathi	78	42 (19.7%)	28 (22.0%)	8 (33.3%)
<b>Total</b>		<b>364</b>	<b>213 (58.5%)</b>	<b>127 (34.9%)</b>	<b>24 (6.6%)</b>

#### 4.1.6 Distribution of pupils by School, Age-group and Sex

Among the 364 pupils sampled in four schools, (58.5%) were aged 6-10 years, (34.9%) were aged 11-14 years while (6.6%) were aged 15-18 years. There were (46.0%) males and (53.6%) females in four schools (Table 4.6).

**Table 4.6: Distribution of pupils by School, Age-group and Sex (n = 364)**  
**Sex** **Age-groups (yrs) (%)**

Schools	Pupil No.	Sex		Age-groups (yrs) (%)		
		Male	Female	6-10	11-14	15-18
D. Comboni	173	73 (42.2%)	100 (57.8%)	94 (54.3%)	72 (41.6%)	7 (4.0%)
Ngunyumu	54	22 (40.7%)	32 (59.2%)	23 (42.6%)	22 (40.7%)	9 (16.7%)
Olympic	59	34 (57.6%)	25 (42.4%)	54 (91.5%)	5 (8.5%)	0 (0%)
Mbagathi	78	40 (51.3%)	38 (48.7%)	42 (53.8%)	28 (35.9%)	8 (10.3%)
<b>Total</b>	<b>364</b>	<b>169 (46.0%)</b>	<b>195 (53.6%)</b>	<b>213 (58.5%)</b>	<b>127 (34.9%)</b>	<b>24 (6.6%)</b>

#### 4.1.7 Distribution of pupils by Sub-County, Class and Sex

Among the 469 pupils sampled in four schools, (23.2%) were in class 2, (26.0%) in class 3, (19.6%) in class 4, (14.3%) in class 5, (15.6%) in class 6 and (1.3%) in class 7. Males constituted 220 (46.9%) while females were 249 (53.1%) of the study population (Table 4.7).

**Table 4.7: Distribution of pupils by sub-County, Class and Sex (n = 469)**  
**Classes (%)**

Sub-County	No. <sup>5</sup>	Sex		2	3	4	5	6	7
		M	F						
Kasarani	307	129	178	74 (24.1)	77 (25.1)	55 (17.9)	44 (14.3)	51 (16.6)	6 (2.0)
Lang'ata	63	36	27	10 (15.9)	37 (58.7)	16 (25.4)	0 (0.0)	0 (0.0)	0 (0.0)
Dagoretti	99	55	44	25 (25.3)	8 (8.1)	21 (21.2)	23 (23.2)	22 (22.2)	0 (0.0)
<b>% of Total</b>	<b>469</b>	<b>220</b>	<b>249</b>	<b>109 (23.2)</b>	<b>122 (26.0)</b>	<b>92 (19.6)</b>	<b>67 (14.3)</b>	<b>73 (15.6)</b>	<b>6 (1.3)</b>

**Legend: No.<sup>5</sup> = No. of pupils in study; M = Male; F = Female**

#### 4.1.8 Distribution of pupils by Class, Sex and Age-group

Among the 364 pupils sampled in four schools, those aged 6-10 years were (58.5%), 11-14 years were (34.9%) and 15-18 years were (6.6%). Among pupils aged 6-10 years, (46.0%) were male while (54.0%) were female; among pupils aged 11-14 years (44.9%) were male while (55.1%) were female. There were (58.3%) males and (41.7%) females among pupils aged 15-18 years. The largest number of pupils were in class 3 (51.1%), followed by class 2 (45.6%) and class 4 (40.7%) (Table 4.8).

**Table 4.8: Distribution of pupils by Class, Sex and Age-group (n = 364)**

Class	6-10 yrs			11-14 yrs			15-18 yrs			%
	No. <sup>1</sup>	M	F	No. <sup>1</sup>	M	F	No. <sup>1</sup>	M	F	
2	75	39	36	7	2	5	1	1	0	45.6%
3	78	38	40	15	2	13	0	0	0	51.1%
4	42	15	27	30	14	16	2	2	0	40.7%
5	16	6	10	33	17	16	3	3	0	28.6%
6	2	0	2	41	22	19	13	6	7	28.8%
7	0	0	0	1	0	1	5	2	3	2.5%
-----										
(%) 213(58.5) 98(46.0) 115(54.0) 127(34.9) 57(44.9) 70(55.1) 24(6.6) 14(58.3) 10(41.7)										
-----										

Legend: No.<sup>1</sup> = Number of pupils in each class; M = Male; F = Female

#### 4.1.9 Distribution of pupils by sub-County, Sex and Age-group

Among the 364 pupils sampled in four schools, (58.5%) were aged 6-10 years, (34.9%) were aged 11-14 years while (6.6%) were aged 15-18 years. Among pupils aged 6-10 years, (46%) were male while (54.0%) were female; among pupils aged 11-14 years, (44.9%) were male while (55.1%) were female.

There were (58.3%) males and (41.7%) females among pupils aged 15-18 years. The largest number of pupils 227 (62.4%) were from Kasarani sub-County, followed by Dagoretti sub-County 78 (21.4%) and Lang'ata 59 (16.2%) (Table 4.9).

**Table 4.9: Distribution of pupils by sub-County, Sex and Age-group (n = 364)**

S-C	6-10 yrs			11-14 yrs			15-18 yrs		
	No. <sup>1</sup>	M	F	No. <sup>1</sup>	M	F	No. <sup>1</sup>	M	F
1	117	51	66	94	35	59	16	9	7
2	54	33	21	5	1	4	0	0	0
3	42	14	28	28	21	7	8	5	3
(%) 213(58.5) 98(46.0) 115(54.0) 127(34.9) 57(44.9) 70(55.1) 24(6.6) 14(58.3) 10(41.7)									

**Legend: S-C = Sub-County; No.<sup>1</sup> = Number of pupils in each sub-County; M = Male; F = Female  
1 = Kasarani sub-County; 2 = Lang'ata Sub-County; 3 = Dagoretti sub-County**

## 4.2 Prevalence and Intensity of geohelminths in the study population

### 4.2.1 Prevalence of specific geohelminth species

The prevalence rates of geohelminths identified in stools showed *Ascaris lumbricoides* (37.4%), *Trichuris trichiura* (33.2%) and human hookworms (*Ancylostoma duodenale* or *Necator americanus*) (0.6%). Other pathogenic helminthic parasites found in stool samples were: *Hymenolepis nana* (1.1%), *Tinea* species (*Tinea saginata* or *Tinea solium*) (0.3%) and *Schistosoma mansoni* (0.3%). After treatment, most of the parasites were cleared except *Trichuris trichiura* (7.4%) and *A. lumbricoides* (0.5%). The prevalence was significantly reduced (Fig. 4.1;  $p < 0.05$ ). Representative slides of the stool samples for parasites identified are shown (Fig. 4.2).

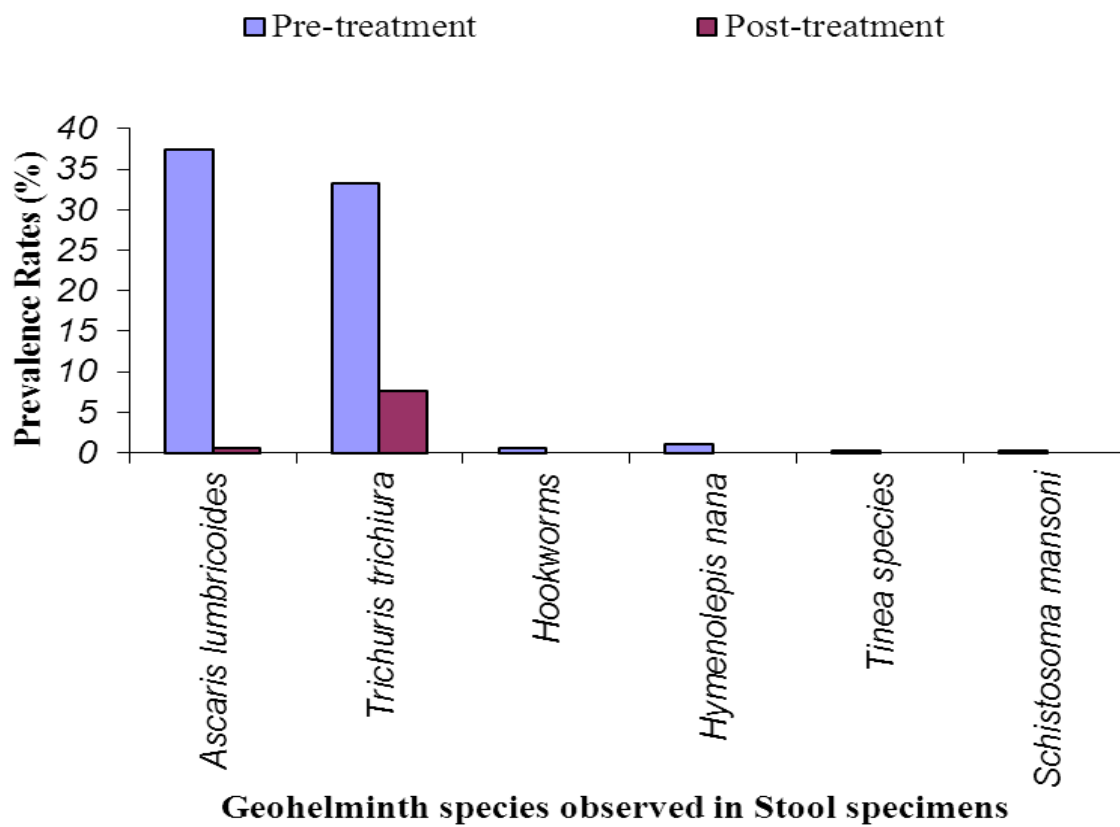
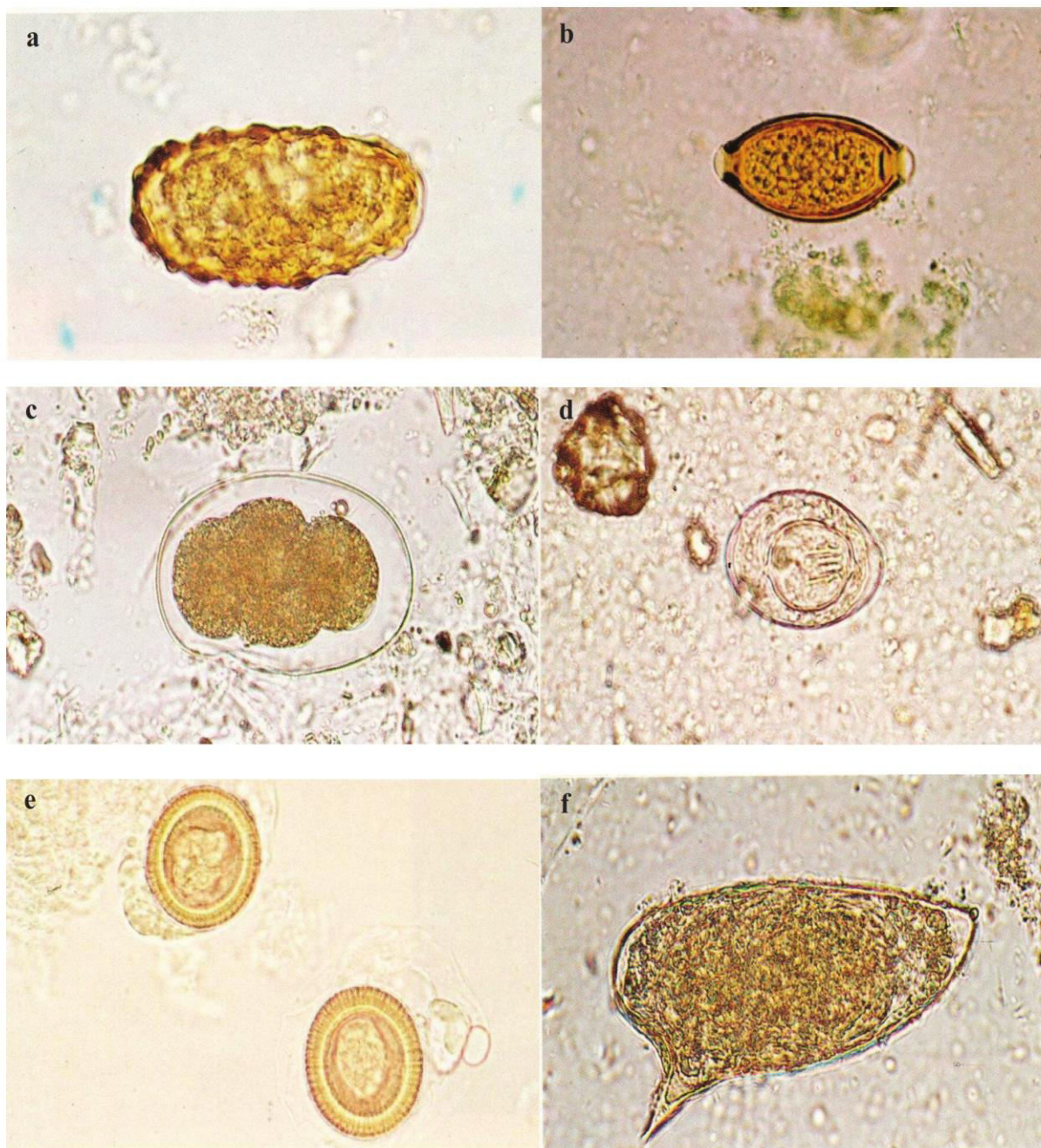


Fig. 4.1: Prevalence of geohelminths (n = 364)



**Fig. 4.2: Egg/Ova of each of the parasites identified in stool samples (x 40 magnification) stained with 1% Lugol's Iodine solution: a. *Ascaris lumbricoides*, b. *Trichuris trichiura*, c. *Ancylostoma duodenale* or *Necator americanus*, d. *Hymenolepis nana*, e. *Taenia* species (*Taenia saginata* or *Taenia solium*), f. *Schistosoma mansoni***

#### 4.2.2 Prevalence of geohelminths by sub-County

Demographic data was used to show the distribution of geohelminths in relation to prevalence by sub-County, school, class, sex and age-group of the pupils. The highest prevalence occurred in Dagoretti (51.9%) sub-County, followed by Lang'ata (51.7%) and Kasarani (48.9%), sub-Counties, respectively. There was no significant difference in prevalence in Dagoretti and Lang'ata sub-Counties compared to Kasarani sub-County ( $p > 0.05$ ).

#### 4.2.3 Prevalence of geohelminthiases by School

The highest prevalence of infections with *A. lumbricoides*, *T. trichiura* and (*A. duodenale* or *N. americanus*) was in Olympic school (51.7%), followed by D. Comboni (50.9%), Mbagathi (50.6%) and Ngunyumu school (44.4%), respectively (Table 5.0), pre-treatment. There was significant difference in prevalence in Mbagathi, Olympic and Daniel Comboni schools compared to Ngunyumu school ( $p < 0.05$ ). There was significant reduction in infections in all four schools (Table 5.0 & 5.1;  $p < 0.05$ ), post-treatment. There was significant difference in prevalence with *T. trichiura* in all schools, pre- and post-treatment ( $p < 0.05$ ).

**Table 5.0: Prevalence of geohelminthiases by School (n = 364)**

School	No. of pupils sampled	No. infected	Prevalence (%)
Daniel Comboni	173	88	<b>50.9</b>
Ngunyumu	54	24	<b>44.4</b>
Olympic	58	30	<b>51.7</b>
Mbagathi	79	40	<b>50.6</b>
Mean prevalence			<b>49.4</b>
<b>Total</b>	<b>364</b>	<b>182 (50%)</b>	

The highest prevalence of infections with *A. lumbricoides*, *T. trichiura* post-treatment, was in D. Comboni (9.8%), followed by Olympic school (8.6%), Ngunyumu (5.6%) and Mbagathi school (2.5%), respectively (Table 5.1).

**Table 5.1: Prevalence of geohelminthiases by School (Post-treatment) (n = 364)**

School	No. of pupils sampled	No. infected	Prevalence (%)
Daniel Comboni	173	17	<b>9.8</b>
Ngunyumu	54	3	<b>5.6</b>
Olympic	58	5	<b>8.6</b>
Mbagathi	79	2	<b>2.5</b>
Mean prevalence			<b>6.6</b>
Total	364	27	

#### 4.2.4 Prevalence of geohelminthiases by Classes

The highest prevalence of infections with geohelminths occurred in Class 2 (54.9%), followed by Class 4 and 5 (52.0%), Class 7 (50.0%), Class 3 (46.3%) and Class 6 (44.6%) pre-treatment. The highest prevalence of infections post-treatment occurred in Class 2 (12.2%) and Class 3 (11.6%) followed by Class 5 (6.0%) and Class 6 (1.8%), respectively. There was significant difference in prevalence between class 2 and class 3 compared to class 6 post-treatment ( $p < 0.05$ ). There was significant difference in prevalence in classes 2-6 pre- and post-treatment ( $p < 0.05$ ). The eggs of *A. duodenale* or *N. americanus*, *A. lumbricoides* and *T. trichiura* were seen in stool samples, pre-treatment. However, only eggs of *A. lumbricoides* and *T. trichiura* were seen post-treatment (Table 5.2).

**Table 5.2: Prevalence of geohelminthiases by Classes**

Class	Pre-treatment (n = 364)			Post-treatment (n =364)	
	No. sampled	No. infected	Prevalence (%)	Infected	Prevalence (%)
2	82	45	<b>54.9</b>	10	<b>12.2</b>
3	95	44	<b>46.3</b>	11	<b>11.6</b>
4	75	39	<b>52.0</b>	2	<b>2.7</b>
5	50	26	<b>52.0</b>	3	<b>6.0</b>
6	56	25	<b>44.6</b>	1	<b>1.8</b>
7	6	3	<b>50.0</b>	-	-
<b>Total</b>	<b>364</b>	<b>182</b>		<b>27</b>	

**Legend: (-) Denotes no data was available**

#### **4.2.5 Prevalence of geohelminthiases by Age-group and Sex**

The highest prevalence of infections pre-treatment occurred in pupils within the 11-14 years age-group (56.9%), followed by 6-10 years (36.5%) and 15-18 years age-group (6.6%) (Table 5.3). There was significant difference in prevalence between children aged 6-10 years and 11-14 years, pre-treatment and post-treatment ( $p < 0.05$ ). There was significant difference in prevalence between children aged 11-14 years compared to those aged 15-18 years pre-treatment ( $p < 0.05$ ).

**Table 5.3: Prevalence of geohelminthiases by Age-group and Sex (n =364)**

Age groups (yrs)	Sex		Prevalence (%)
	Male	Female	
6 – 10	62 (17%)	71 (19.5%)	133 (36.5.0%)
11 -14	92 (25.3%)	115 (31.6%)	207 (56.9%)
15 -18	14 (3.8%)	10 (2.7%)	24 (6.6 %)
<b>Total =</b>	<b>168 (46.2%)</b>	<b>196 (53.8%)</b>	<b>364 (100%)</b>

**Legend: (-) Denotes no data was available**

Overall, among the infected children, 53.8% were females while 46.2% were males. There were more infected females than males. However, when males and females infected with *T. trichiura* were compared, there was no significant difference in prevalence ( $p > 0.05$ ).

### 4.3 Intensity of geohelminthiases

Infection intensity was determined according to World Health Organization Reference Standard values in patients. Thus, geohelminthic infections were classified as light, moderate and heavy, depending on the number of eggs per gramme (epg) of the stool specimen examined, using the Kato-Katz Thick Stool Smear technique (Table 5.4; WHO, 1987).

**Table 5.4: WHO Reference Standard classification of geohelminthiases intensities (WHO, 1987)**

Geohelminth species	infection intensity categories (epg)*		
	Light (epg)*	Moderate (epg)	Heavy (epg)
<i>Ascaris lumbricoides</i>	< 5,000	5,000 - 50,000	> 50,000
<i>Trichuris trichiura</i>	< 1,000	1,000 - 10,000	> 10,000
<i>Ancylostoma duodenale</i>	< 2,000	2,000 - 5,000	> 5,000
<i>Necator americanus</i>	< 2,000	2,000 - 5,000	> 5,000

\*epg = eggs per gram of faeces

#### 4.3.1 Mean geohelminthiases intensities in four Schools

The highest Mean infection intensities with geohelminths, occurred in Mbagathi school (20,063 epg), followed by Daniel Comboni (11, 253), Ngunyumu (9,316) and Olympic (5,288), respectively. The highest Mean infection intensities for *A. lumbricoides* (moderate) occurred in Mbagathi school (19,835) while the highest Mean infection intensities for *T. trichiura* (light) occurred in Ngunyumu school (486). In addition, the highest Mean light infection intensities for Hookworms (*A. duodenale* or *N. americanus*) (20) occurred in Daniel Comboni (Table 5.5).

**Table 5.5: Mean geohelminthiases intensities in 4 Schools pre-treatment**

School	Mean infection intensities pre-treatment (epg)			
	<i>A. lumbricoides</i> (moderate)epg	<i>T. trichiura</i> (light)epg	Hookworms (light)epg	Total
Daniel Comboni	10,885	348	20	11,253
Ngunyumu	8,830	486	-	9,316
Olympic	5,045	243	-	5,288
Mbagathi	19,835	228	-	20,063

**Legend: (-) Denotes no eggs detected**

Results showed there was significant reduction in overall infection intensities in all schools, post-treatment ( $p < 0.05$ ) (Table 5.6). The highest Mean infection intensities with geohelminths, occurred in Ngunyumu school (1,640), followed by Daniel Comboni (1,306), Olympic (276) and Mbagathi (50), respectively, after treatment. The highest Mean infection intensities post-treatment for *A. lumbricoides* (light) occurred in Daniel Comboni school (320) while the highest Mean infection intensities for *T. trichiura* (light) occurred in Ngunyumu school (1,620). In addition, the highest Mean Light infection intensities for Hookworms (*A. duodenale* or *N. americanus*) (20) occurred in Daniel Comboni (Table 5.6).

**Table 5.6: Mean geohelminthiases intensities in 4 Schools pre- and post-treatment**

School	Mean infection Intensities (epg)				
	<i>A. lumbricoides</i> (light)epg	<i>T. trichiura</i> (light & moderate)epg	Hookworms (light)epg	Total Intensities(epg) pre-trt	post-trt
Daniel Comboni	320	966	20	11,253	1,306
Ngunyumu	20	1,620	-	9,316	1,640
Olympic	-	276	-	5,288	276
Mbagathi	-	50	-	20,063	50

**Legend: (-) Indicates there were no Means available for each worm  
(trt): Denotes treatment ; epg = eggs per gram of faeces**

#### 4.3.2 Geohelminthiases intensities by Sex

Out of 182 pupils, there were 62.6% light infections, 33.0% moderate and 4.4% heavy infections. There were 31.9 % males and 30.8% females with light infections, 13.2% males and 19.8% females with moderate infections and 0.5% males and 3.8% females with heavy infections. There were more infection intensities among females (55.0%) than males (45.6%). There were more females (3.8%) with heavy infection intensities than males (0.5%) (Table 5.7).

**Table 5.7: Geohelminthiases intensities by Sex (n = 182)**

Intensity category	Sex		Total
	Male (%)	Female (%)	
Light	58 (31.9 %)	56 (30.8%)	114 (62.6 %)
Moderate	24 (13.2%)	36 (19.8%)	60 (33.0%)
Heavy	1 (0.5%)	7 (3.8%)	8 (4.4%)
<b>Total</b>	<b>83 (45.6%)</b>	<b>99 (55.0%)</b>	<b>182 (100%)</b>

Out of 364 pupils, there were 19.8% light, 15.4% moderate and 2.2% heavy infections with *A. lumbricoides*. There were 9.6 % males and 10.2% females with light infections, 6.0% males and 9.3% females with moderate infections and 0.3% males and 1.9% females with heavy infections. There were more infection intensities among females (21.4%) than males (15.9%). There were more moderate infections (9.3%) in females than males (6.0%). There were more heavy infections in females (1.9%) than in males (0.3%). There was no significant difference in females compared to males (Table 5.8;  $p > 0.05$ ).

**Table 5.8: *Ascaris lumbricoides* infection intensities by Sex (n = 364)**

Intensity category	Sex (%)		Total
	Male	Female	
Light	35 (9.6%)	37 (10.2%)	72 (19.8%)
Moderate	22 (6.0%)	34 (9.3%)	56 (15.4%)
Heavy	1 (0.3%)	7 (1.9%)	8 (2.2%)
<b>Total</b>	<b>58 (15.9%)</b>	<b>78 (21.4%)</b>	<b>136 (37.4%)</b>

Out of 364 pupils, there were 31.3% light and 1.9% moderate infections with *Trichuris trichiura*. There were 15.7 % males and 15.7 % females with light infections. There were 0.8% males and 1.1% females with moderate infections but no heavy infections were observed. There were more infection intensities in females (16.8%) than males (16.5%). There were more moderate infections (1.1%) in females than males (0.8%). There was no significant difference between the sexes (Table 5.9;  $p > 0.05$ ).

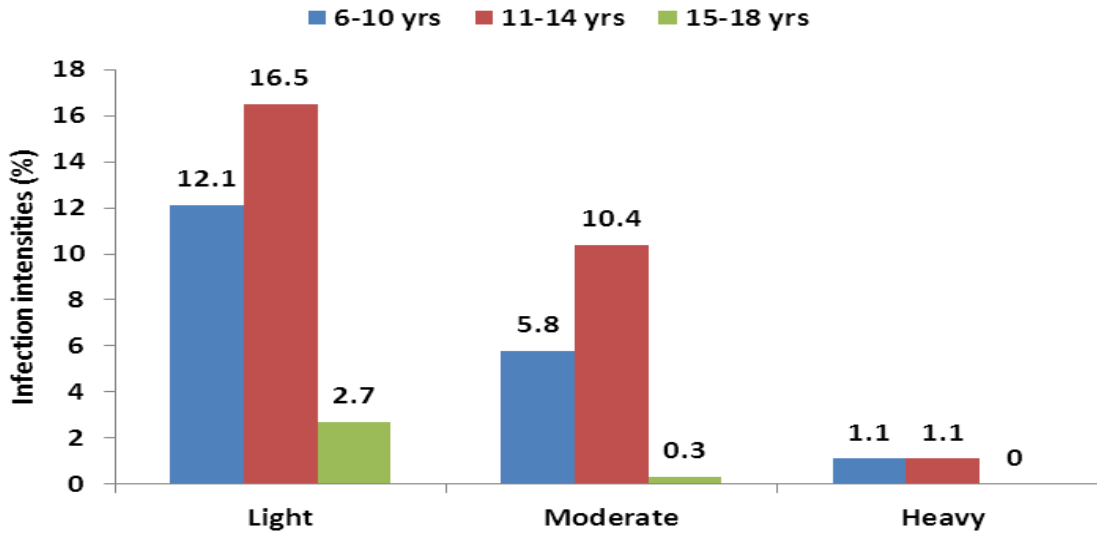
**Table 5.9: *T. trichiura* infection intensities by sex (n = 364)**

Intensity category	Sex (%)		Total
	Male	Female	
Light	57 (15.7%)	57 (15.7%)	114 (31.3%)
Moderate	<b>3 (0.8%)</b>	4 (1.1%)	7 (1.9%)
Heavy	-	-	-
<b>Total</b>	<b>60 (16.5%)</b>	<b>61 (16.8%)</b>	<b>121 (33.2%)</b>

**Legend: (-) Denotes no eggs detected**

#### 4.3.3 Geohelminthiases intensities in different Age-groups

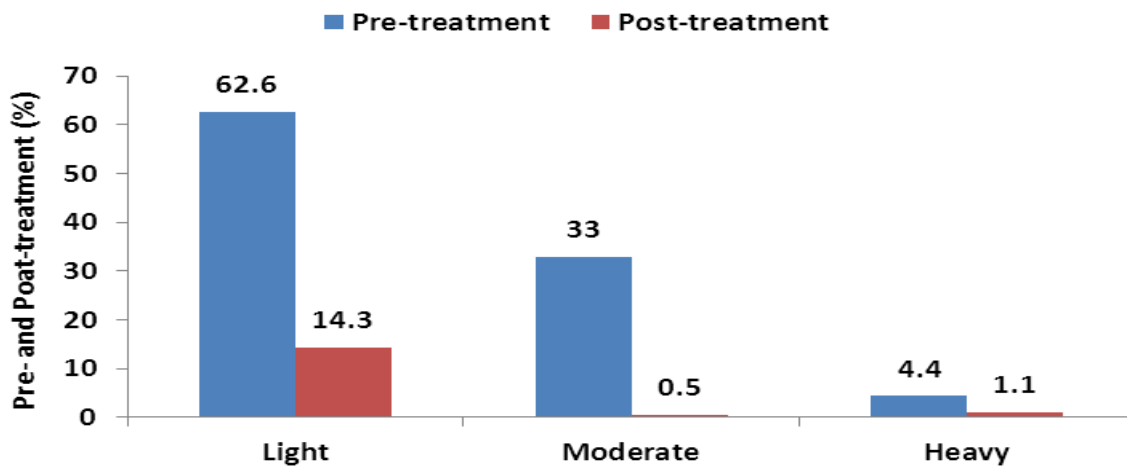
Out of 69 children within 6–10 year age-group, 12.1% had light infections, 5.8% had moderate and 1.1% heavy infections. Out of 102 children within 11–14 year age-group, 16.5% had light infections, 10.4% had moderate and 1.1% heavy infections pre-treatment. Out of 11 children within 15–18 year age-group, 2.7% had light infections and 0.3% had moderate infections pre-treatment (Fig. 4.3), with the 11–14 year age-group having the highest overall intensities (Light, Moderate and Heavy). The highest number of light infections (16.5%) occurred in the 11-14 year age-group and the lowest (2.7%) in the 15-18 age-group pre-treatment. Overall, the highest infection intensity (28%) occurred among children aged 11-14 years. There was significant difference between light infections in 6-10 year age-group compared to infections in 15-18 year age-group pre-treatment, with the 15-18 years having the least infection intensities ( $p < 0.05$ ). There was significant difference in light infections in 11-14 year age-group compared to infections in 15-18 year age-group pre-treatment ( $p < 0.05$ ). The highest number of heavy infections (1.1%) occurred in the 6-10 year- and 11-14 year age-group; there were no heavy infections within the 15-18 age-group (Fig. 4.3).



**Fig. 4.3: Distribution of infection intensities among pupils aged 6-18 years**

#### 4.3.4 Overall intensity of geohelminthiases pre- and post-treatment

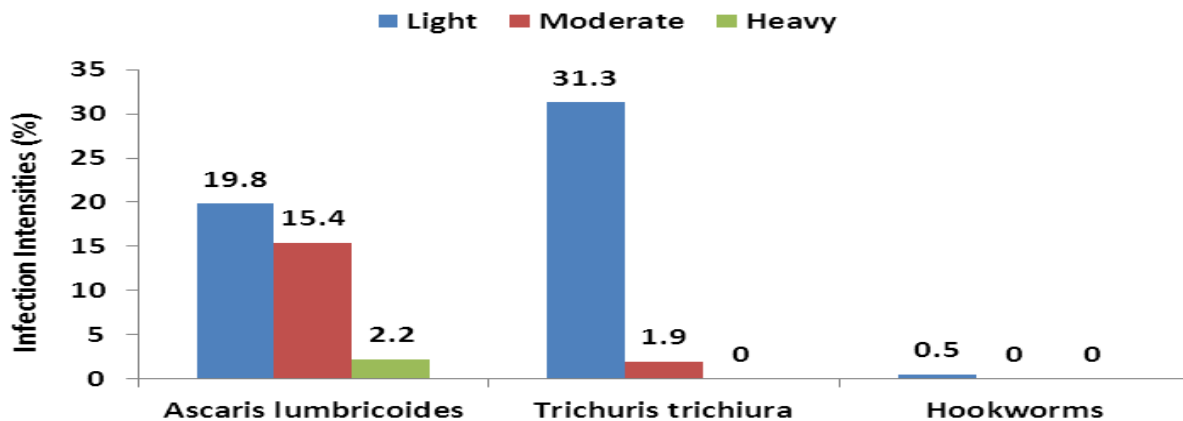
Overall, there were (62.6 %) light infections, (33.0%) moderate and (4.4%) heavy infections pre-treatment while (14.3%) light infections, (0.5%) moderate and (1.1%) heavy infections persistently occurred post-treatment. The results showed that there was significant reduction in parasite load intensity after treatment (Fig. 4.4;  $p < 0.05$ ).



**Fig. 4.4: Comparative infection intensities pre- and post-treatment (n = 182)**

#### 4.3.5 Infection intensities of *A. lumbricoides*, *T. trichiura* and Hookworms (n = 364)

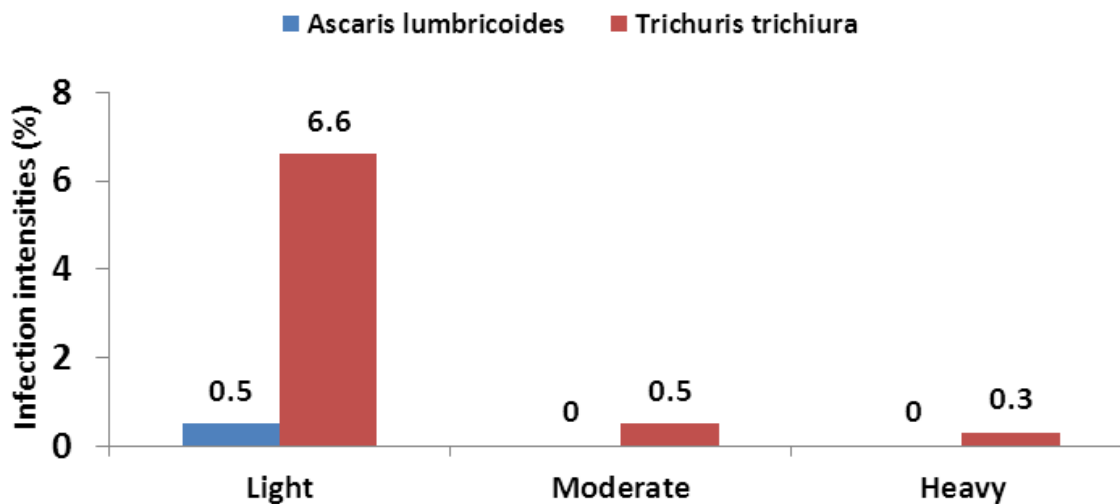
The results showed *A. lumbricoides* was responsible for (19.8%) light infections, (15.4%) moderate and (2.2%) heavy infections while *T. trichiura* was responsible for (31.3%) light and (1.9%) moderate infections. There were (0.5%) light infections with hookworms (*A. duodenale* or *N. americanus*) (Fig. 4.5). Results showed that there was significant difference in Light infection intensities with *A. lumbricoides* compared to *T. trichiura* ( $p < 0.05$ ). There was significant difference in light infections with *T. trichiura* compared with *A. lumbricoides* with *T. trichiura* having higher light infections ( $p < 0.05$ ). There was significant difference in moderate and heavy infections with *A. lumbricoides* compared with *T. trichiura*, with *A. lumbricoides* having higher infections ( $p < 0.05$ ).



**Fig. 4.5: Comparative infection intensities of specific geohelminths (n = 364)**

#### 4.3.6 Comparative infection intensities of *A. lumbricoides* and *T. trichiura* post-treatment

The study showed (6.6%) light, (0.5%) moderate and (0.3%) heavy infections with *T. trichiura* and (0.5%) light infections with *A. lumbricoides*, post-treatment (Fig. 4.6). Results showed significant difference in light infection intensities between *T. trichiura* and *A. lumbricoides*, post-treatment. *Trichuris trichiura* had significantly higher light infection intensity ( $p < 0.05$ ).



**Fig. 4.6: Infection intensity of specific geohelminths post-treatment (n = 364)**

#### **4.4 Prevalence of Haemo-protozoan parasites in blood in the study population**

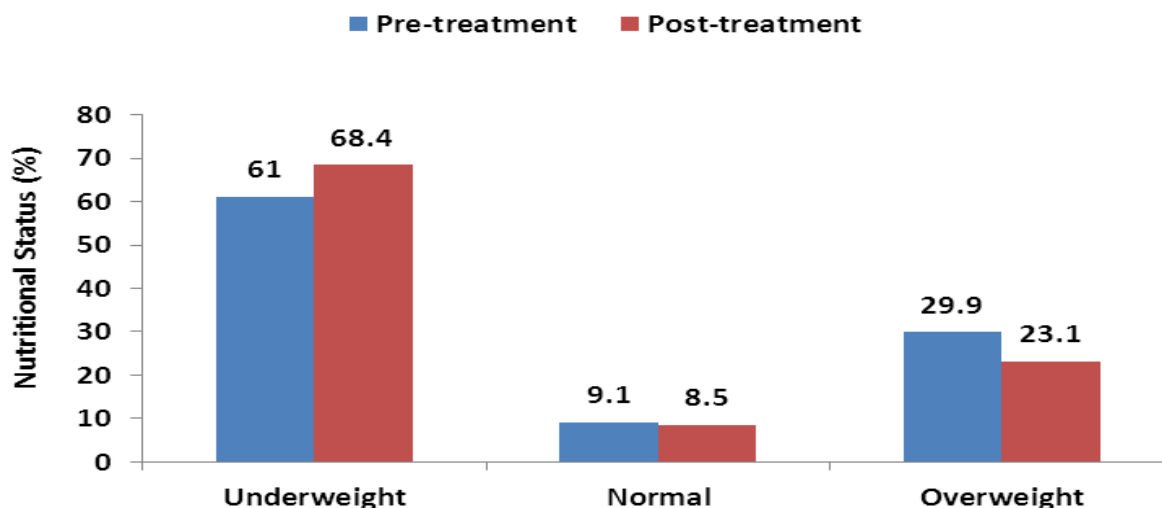
##### **4.4.1 Prevalence of *Plasmodium* species (malaria parasites) in blood of pupils**

The report of haematological screening of 364 finger-prick, blood-slide films was obtained from pupils, using Giemsa staining method (Baker *et al.*, 1998). However, results showed no presence *Plasmodium* species (malaria parasites) in the study population.

#### **4.5 Effects of geohelminthiases on Growth among school-age children**

##### **4.5.1 Body Mass Indices pre- and post-treatment**

Results of anthropometric measurements on 364 pupils showed (61.0 %) were underweight, (9.1%) had normal weight while (29.9%) were overweight, pre-treatment. Further, (68.4%) pupils were underweight, (8.5%) normal weight and (23.1%) overweight, post-treatment. There was no significant difference among underweight, normal and overweight children pre- and post-treatment (Fig. 4.7;  $p > 0.05$ ).



**Fig. 4.7: Body Mass Indices (BMI) categories pre-and post-treatment (n = 364)**

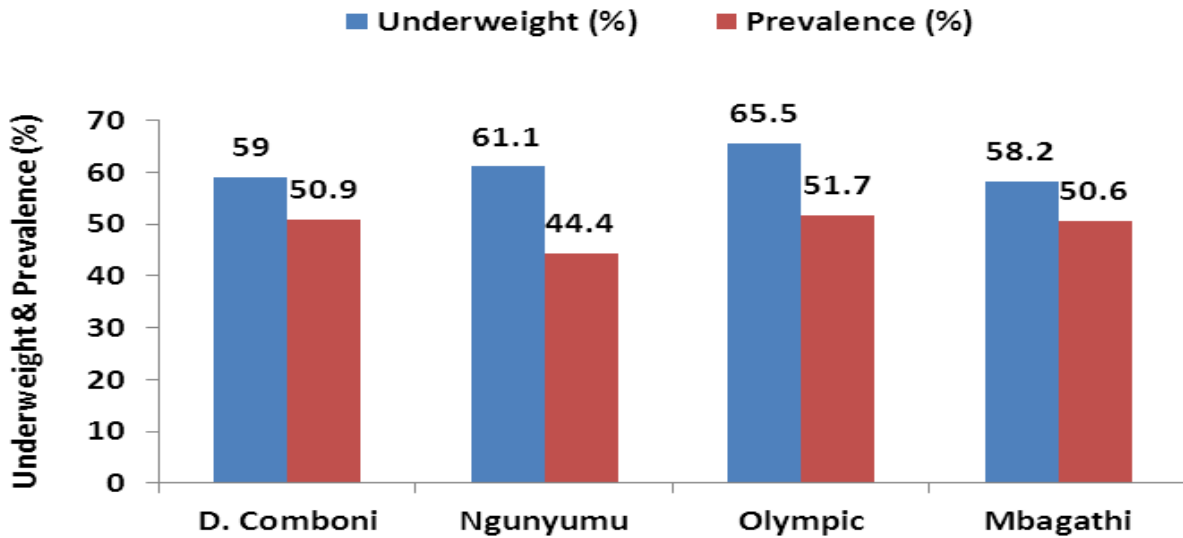
Results showed 102 (59.0%) pupils in D. Comboni school were underweight, 17 (9.8%) were Normal and 54 (31.2%) were Overweight, pre-treatment; 33 (61.1%) pupils in Ngunyumu were underweight, 6 (11.1%) were Normal and 15 (27.8%) were Overweight, pre-treatment. Also, 38 (65.5%) pupils in Olympic school were underweight, 6 (10.3%) were Normal and 14 (24.1%) were Overweight, pre-treatment. Further, 48 (58.2%) pupils in Mbagathi school were underweight, 6 (7.6%) were Normal and 25 (31.6%) were Overweight, pre-treatment (Table 6.0).

**Table 6.0: Pupils Nutritional Status by School pre-treatment (n = 364)**

School	No. of pupils	Underweight	Normal	Overweight
1	173	102 (59.0%)	17 (9.8%)	54 (31.2%)
2	54	33 (61.1%)	6 (11.1%)	15 (27.8%)
3	58	38 (65.5%)	6 (10.3%)	14 (24.1%)
4	79	48 (58.2%)	6 (7.6%)	25 (31.6%)
<b>Total</b>	<b>364</b>	<b>221 (60.7%)</b>	<b>35 (9.6%)</b>	<b>108 (29.7%)</b>

**Legend: 1 = D. Comboni; 2 = Ngunyumu; 3 = Olympic; 4 = Mbagathi**

Pearson Product Moment correlation coefficient showed there was significant correlation between prevalence and BMI (underweight) in the 4 Schools, pre-treatment ( $r = 0.895$ ;  $p < 0.05$ ; Fig. 4.8). There was significant difference between pre- and post-treatment BMI (underweight) (Fig. 4.9;  $p < 0.05$ ). This showed geohelminthiasis had significant adverse effect on growth of the children pre- and post-treatment.



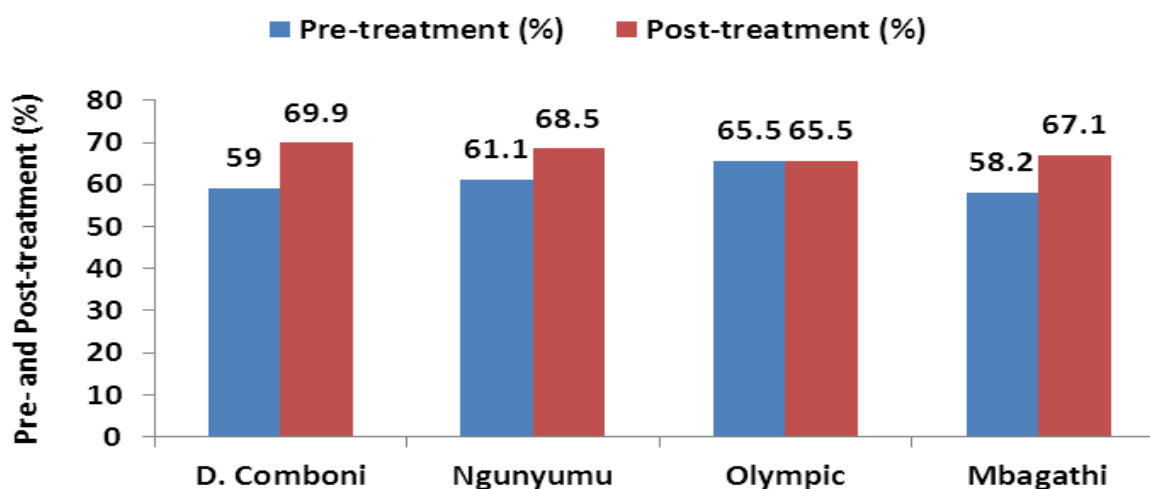
**Fig. 4.8: Comparison between Prevalence and Underweight pre-treatment (n = 364)**

Results showed 121 (69.9%) pupils in D. Comboni school were underweight, 10 (5.8%) were Normal and 42 (24.3%) were Overweight, post-treatment. Further, 37 (68.5%) pupils in Ngunyumu were underweight, 7 (13.0%) were Normal and 10 (18.5%) were Overweight, post-treatment. Also, 38 (65.5%) pupils in Olympic school were underweight, 8 (13.8%) were Normal and 13 (22.4%) were Overweight, pre-treatment. Further, 53 (67.1%) pupils in Mbagathi school were underweight, 6 (7.6%) were Normal and 19 (24.1%) were Overweight, pre-treatment (Table 6.1).

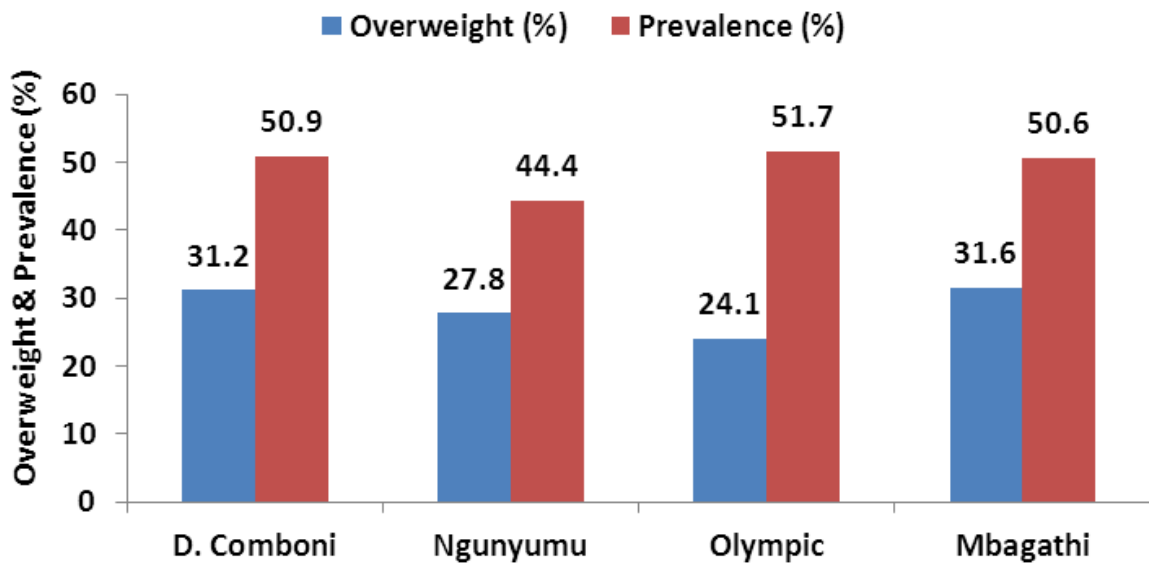
**Table 6.1: Pupils Nutritional Status by School post-treatment (n = 364)**

School	No. of pupils	Underweight	Normal	Overweight
1	173	121 (69.9%)	10 (5.8%)	42 (24.3%)
2	54	37 (68.5%)	7 (13.0%)	10 (18.5%)
3	58	38 (65.5%)	8 (13.8%)	13 (22.4%)
4	79	53 (67.1%)	6 (7.6%)	19 (24.1%)
<b>Total</b>	<b>364</b>	<b>221 (60.7%)</b>	<b>35 (9.6%)</b>	<b>108 (29.7.3%)</b>

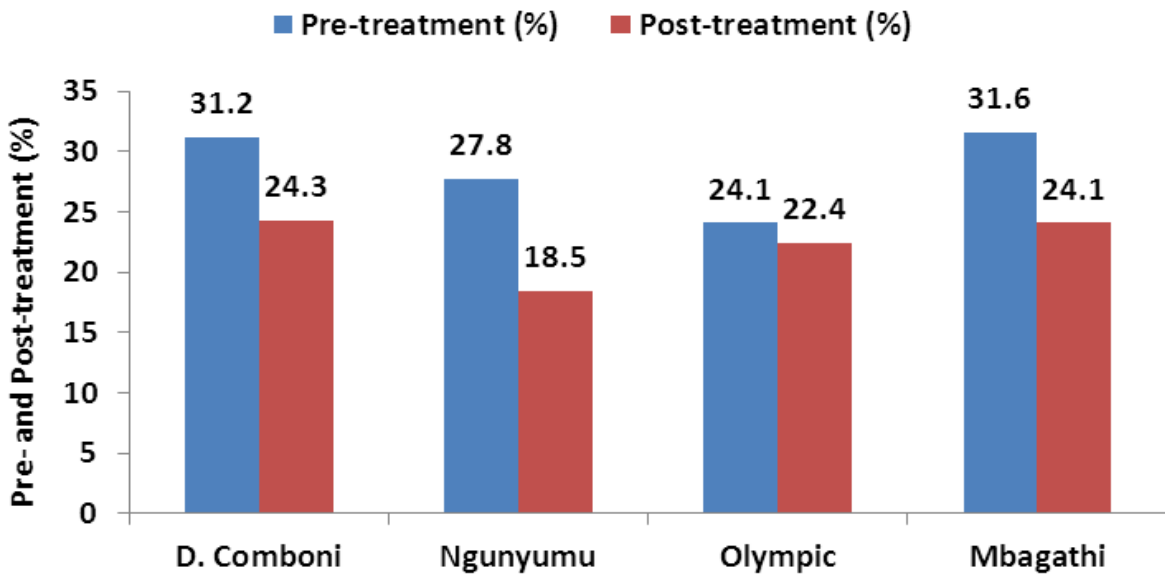
Legend: 1 = D. Comboni; 2 = Ngunyumu; 3 = Olympic; 4 = Mbagathi

**Fig. 4.9: Relationship between pre- and post-treatment Underweight (n = 364)**

Pearson Product Moment correlation coefficient showed there was significant correlation between Prevalence and BMI (Overweight) in 4 Schools, pre-treatment (Fig. 4.10;  $r = -0.809$ ;  $p < 0.05$ ). There was significant difference between pre- and post-treatment BMI (Overweight) (Fig. 4.11;  $p < 0.05$ ). This showed geohelminthiasis had significant adverse effect on growth of the children pre- and post-treatment.



**Fig. 4.10: Relationship between Prevalence and Overweight pre-treatment (n = 364)**



**Fig. 4.11: Comparison between pre- and post-treatment Overweight (n = 364)**

Results showed there was significant difference in Mean Head circumference measurements pre- and post-treatment (Table 6.2;  $p < 0.0001$ ).

**Table 6.2: Means of Head circumference of infected pupils pre- and post-treatment**

Head circumference (cms)		n = 182	
	Total head circumference	Mean head circumference	<i>p</i>
Pre-treatment	8,547	47.0	$p < 0.001$
Post-treatment	9,813	54.0	

There was no significant difference in BMI, between the infected and non-infected pupils in terms of head circumference (Table 6.3;  $p > 0.4652$ ).

\

**Table 6.3: Mean BMI of infected (n = 182) and non-infected (n = 182)**

Mean BMI			
	Total BMI	Mean BMI	<i>p</i>
Infected	3,184	18	$p > 0.4652$
Non-infected	3,024	17	

Intensity of infections with *T. trichiura* had significant adverse effect on the pupils' BMI between groups, pre-treatment (Table 6.4;  $p < 0.033$ ).

**Table 6.4: Relationship of *T. trichiura* infection Intensity with BMI (Underweight) between groups pre-treatment**

Infection status	(n)	*BMI Underweight cases (%)	F-value	p-Value
Negative controls	182	143 (78.6)	0.62666	$p < 0.033$
Light	110	91 (82.7)		
Moderate	6	5 (83.3)		

**\*Please note only BMI for Under-weight children are considered**

**\*Principal cut-off Points of BMI (Underweight) for Adolescents & Adults (10-18 years)  
= < 18.50**

**\*Normal Range of BMI = 18.50 – 24.99; Overweight  $\geq 25.00$   
(World Health Organization, 1995, 2000, 2004)**

There was no significant difference in BMI between infected pupils and non-infected ( $p > 0.3605$ ). Intensity of infections with *A. lumbricoides* did not significantly affect pupils' BMI between groups (Table 6.5;  $p > 0.3978$ ).

**Table 6.5: Relationship of *A. lumbricoides* infection Intensity with BMI (Underweight) between groups pre-treatment**

Infection status	n	*BMI Underweight cases (%)	F-value	p-Value
Negative controls	182	143 (78.6)	0.3978	$p > 0.3605$
Light	65	60 (92.3)		
Moderate	54	44 (81.5)		
Heavy	8	8 (100)		

**\*Please note only BMI for Under-weight children are considered**

**\*Principal cut-off Points of BMI (Underweight) for Adolescents & Adults (10-18 years)  
= < 18.50**

**\*Normal Range of BMI = 18.50-24.99 ; Overweight  $\geq 25.00$   
(World Health Organization, 1995, 2000, 2004)**

#### 4.6 Effects of geohelminthiases on Cognitive Functions in the study population

Results showed significant inverse correlation pre-treatment, between infections and Cognitive function performance; this suggested geohelminthiases depressed Cognitive performance,  $p < 0.05$ ), except with SS-B test results ( $p > 0.05$ ). Overall, Cognitive tests performance results were as follows: WGS ( $r = - 0.702$ ;  $p < 0.05$ ), WGI ( $r = - 0.794$ ;  $p < 0.05$ ), LM ( $r = - 0.533$ ;  $p < 0.05$ ), SPM ( $r = - 0.866$ ;  $p < 0.05$ ), Cod-B ( $r = - 0.623$ ;  $p < 0.05$ ) and DSP ( $r = - 0.666$ ;  $p < 0.05$ ), except SS-B with  $r = 0.017$ ;  $p > 0.05$ ) (Table 6.6).

**Key:** **WGS** (Word Generation Semantic), **WGI** (Word Generation Initial), **LM** (List Memory), **SPM** (Standard Progressive Matrices), **Cod-B** (Coding-B), **DSP** (Digit Span (Forward & Backward))

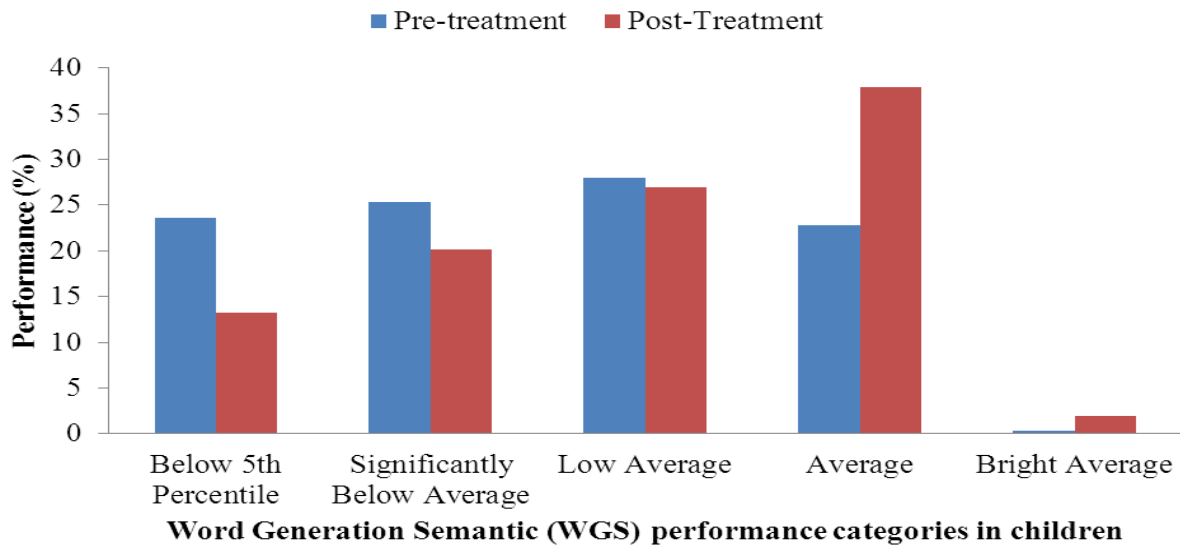
**Table 6.6: Effects of geohelminthiases on Cognitive Functions**

<b>Cognitive function tests</b>	<b>Correlation coefficient</b>	<b><i>p</i> - value</b>
Generation Semantic (WGS)	$r = - 0.702$	$< 0.05$
Word Generation Initial (WGI)	$r = - 0.794$	$< 0.05$
List Memory (LM)	$r = - 0.533$	$< 0.05$
Standard Progressive Matrices (SPM)	$r = - 0.866$	$< 0.05$
Coding-B (Cod-B)	$r = - 0.623$	$< 0.05$
<b>Symbol Search-B (SS-B)</b>	<b><math>r = 0.017</math></b>	<b><math>&gt; 0.05^*</math></b>
Digit Span (Backward & Forward) DSP	$r = - 0.666$	$< 0.05$

**\*Test result: Denotes not significant**

#### 4.6.1 Word Generation Semantic (WGS) Cognitive performance pre-and post-treatment

Out of 364 pupils, (23.6%) pupils scored below 5<sup>th</sup> percentile, (25.3%) were significantly below average, (28.0%) were low average, (22.8%) were average and (0.3%) had bright average performance, pre-treatment. 13.2% pupils scored below 5<sup>th</sup> percentile, (20.1%) significantly below average, (26.9%) low average (37.9%) average and (1.9%) had bright average performance, post-treatment. There was significant difference in WGS Cognitive performance, pre- and post-treatment, with post-treatment having better performance (Fig. 4.12;  $p < 0.0001$ ).



**Fig. 4.12: Word Generation Semantic (WGS) performance pre- and post-treatment (n = 364)**

There was no significant difference in WGS Cognitive performance between the non-infected and infected pupils ( $p > 0.05$ ). Pearson Product Moment correlation coefficient showed there was significant correlation between geohelminthic infections and WGS Cognitive performance results, pre-treatment ( $r = - 0.702$ ;  $p < 0.05$ ) and post-treatment ( $r = - 0.975$ ;  $p < 0.05$ ). This suggested that geohelminthiasis had significant adverse effect on WGS Cognitive performance in infected children before and after de-worming.

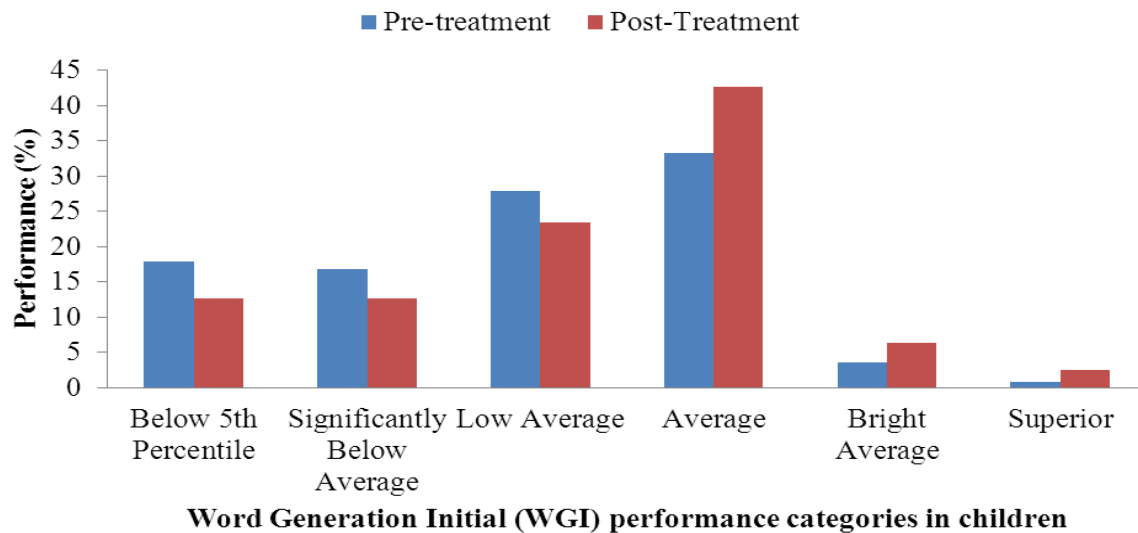
There was significant difference in WGS Cognitive performance between the infected compared to the non-infected children in 6-10, 11-14 and 15-18 year age-groups ( $p < 0.0001$ ). Linear Regression conducted on socio-economic factors or covariates (confounders) influencing the WGS Cognitive performance showed: age group ( $p < 0.0001$ ), *T. trichiura* infections ( $p < 0.014$ ), diarrhoea ( $p < 0.01$ ), eating raw foods ( $< 0.034$ ) and eating with unwashed hands ( $p < 0.029$ ) significantly adversely affected WGS Cognitive performance. Moreover, father's ability to grow food-crops ( $p < 0.045$ ), eating fruits ( $p < 0.027$ ), absence from school due to other reasons ( $p < 0.025$ ) and beating by sister ( $p < 0.013$ ) also significantly adversely affected WGS Cognitive performance. Furthermore, help with homework by friends ( $p > 0.049$ ), lack of table and chair for studies ( $p < 0.008$ ) also significantly adversely affected WGS Cognitive performance pre-treatment ( $p < 0.05$ ) (Table 6.7; Appendix 12 i).

**Table 6.7: Factors influencing WGS Cognitive performance**

<b>Factors</b>	<b><i>p</i>-Value</b>
Age group	< 0.0001
<i>T. trichiura</i> infections	< 0.014
Diarrhoea	< 0.01
Eating raw foods	< 0.034
Eating with unwashed hands	< 0.029
Father's ability to grow food-crops	< 0.045
Eating fruits	< 0.027
Absence from school due to other reasons	< 0.025
Beating by sister	< 0.013
help with homework by friends	> 0.049
Lack of table and chair for studies	< 0.008

#### 4.6.2 Word Generation Initial (WGI) Cognitive performance pre- and post-treatment

Out of 364 pupils, (17.9%) scored Below 5<sup>th</sup> percentile, (16.8%) significantly below average, (27.8%) low average, (33.2%) average, (3.6%) bright average and (0.8%) had Superior performance, pre-treatment. Further, 12.6% scored Below 5<sup>th</sup> percentile, (12.6%) significantly below average, (23.4%) low average, (42.6%) average, (6.3%) bright average and (2.5%) had Superior performance, post-treatment (Fig. 4.13). There was significant difference in WGI Cognitive performance in the study population, pre- and post-treatment ( $p < 0.0001$ ), with post-treatment group having better performance.



**Fig. 4.13: Word Generation Initial (WGI) performance pre- and post-treatment (n = 364)**

There was no significant difference in WGI Cognitive performance between the non-infected and infected pupils ( $p > 0.05$ ). Pearson Product Moment correlation coefficient showed there was no significant correlation between geohelminthic infections and WGI Cognitive performance, pre-treatment ( $r = - 0.794$ ;  $p > 0.05$ ). There was significant correlation post-treatment ( $r = - 0.537$ ;  $p < 0.05$ ). This showed that geohelminthic infections had significant adverse effect on WGI Cognitive performance in infected children after de-worming.

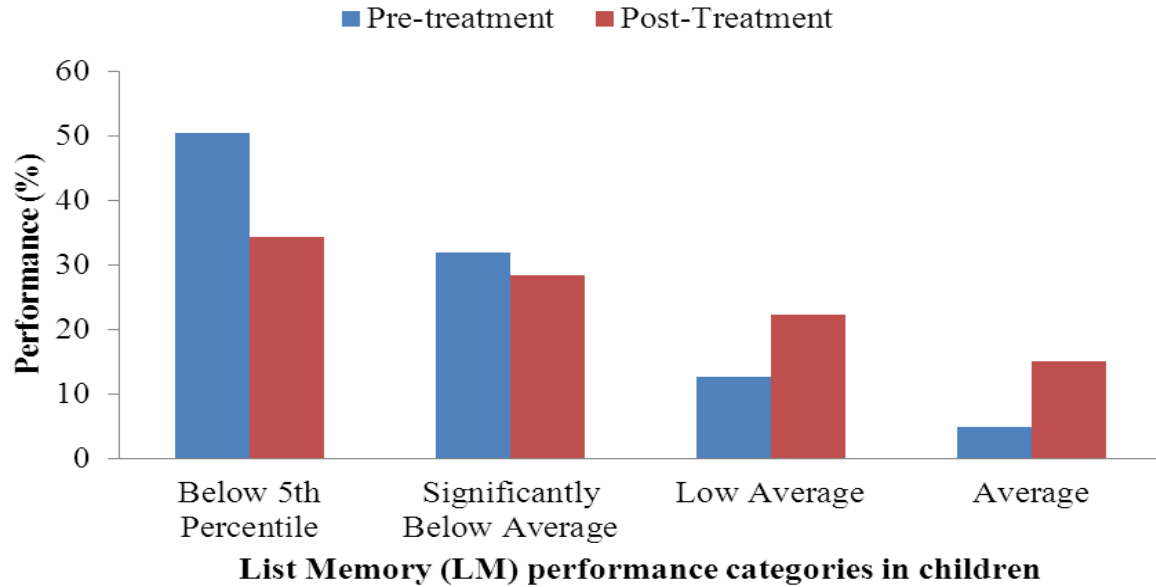
There was significant difference in WGI Cognitive performance between the infected compared to the non-infected children in 6-10, 11-14 and 15-18 year age-groups ( $p < 0.0001$ ). Results of Linear Regression conducted on socio-economic factors or covariates (confounders) influencing the WGI Cognitive performance performance, pre-treatment showed: age group ( $p < 0.0001$ ), forgetting ( $p < 0.044$ ), depressed alertness ( $p < 0.018$ ) and problems with remembering ( $p < 0.039$ ) significantly adversely affected WGI Cognitive performance pre-treatment (Table 6.8; Appendix 12 ii).

**Table 6.8: Factors influencing WGI Cognitive performance**

<b>Factors</b>	<b><i>p</i>-Value</b>
Age group	< 0.0001
Forgetting	< 0.044
Depressed alertness	< 0.018
Problems with remembering	< 0.039

#### **4.6.3 List Memory (LM) Cognitive Performance pre- and post-treatment**

Out of 364 pupils, (50.5%) were Below 5<sup>th</sup> percentile, (31.9%) significantly below average, (12.7%) low average and (4.9%) had average performance, pre-treatment (Fig.4.14). Further, (34.3%) scored Below 5<sup>th</sup> percentile, (28.4%) significantly below average, (22.3%) low average and (15.1%) had average performance, post-treatment. There was significant difference in LM Cognitive performance in the study population, pre- and post-treatment ( $p < 0.0001$ ).



**Fig. 4.14: List Memory (LM) Performance pre- and post-treatment (n = 364)**

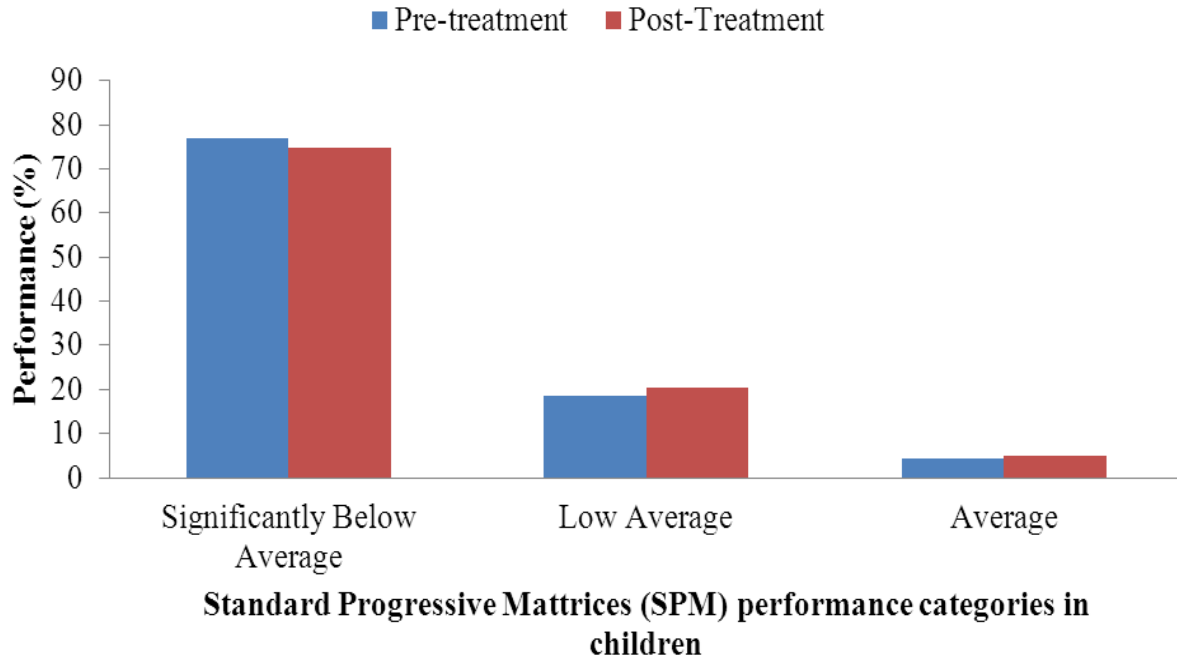
There was no significant difference in LM Cognitive performance between the non-infected and infected pupils ( $p > 0.05$ ). Pearson Product Moment correlation coefficient showed there was significant correlation between geohelminthic infections and LM Cognitive performance, pre-treatment ( $r = - 0.533$ ;  $p < 0.05$ ) and post-treatment ( $r = - 0.565$ ;  $< 0.05$ ). This showed that geohelminthic had significant inverse effect on LM Cognitive performance in infected children before and after de-worming. There was significant difference in LM Cognitive performance between infected children compared to non-infected in 6-10, 11-14 and 15-18 year age-groups ( $p < 0.0001$ ). Results of Linear Regression conducted on socio-economic factors (covariates) influencing LM Cognitive performance, pre-treatment showed: class ( $p < 0.007$ ), age-group ( $p < 0.0001$ ) and presence of fever ( $p < 0.024$ ) significantly adversely affected LM Cognitive performance. Further, seeing worms in stool ( $p < 0.05$ ) and pupils' depressed alertness ( $p < 0.005$ ) also significantly adversely affected LM Cognitive performance, pre-treatment (Table 6.9; Appendix 12 iii).

**Table 6.9: Factors influencing LM Cognitive performance**

<b>Factors</b>	<b><i>p</i>-Value</b>
Class	< 0.007
Age group	< 0.0001
Fever	< 0.024
Seeing worms in stool	< 0.05
Depressed alertness	< 0.005

#### **4.6.4 Standard Progressive Matrices (SPM) Cognitive performance pre-and post-treatment**

Out of 364 pupils, (76.9%) had significantly below average, (18.7%) low average and (4.4%) had average performance, pre-treatment (Fig. 4.15). Further, (74.7%) had significantly below average, (20.3%) low average and (5.0%) had average performance, post-treatment. There was no significant difference in SPM Cognitive performance between the non-infected and pupils infected with *T. trichiura* ( $p > 0.05$ ). There was no significant difference in SPM Cognitive performance between non-infected and infected pupils ( $p > 0.05$ ). Overall, there was no significant difference in SPM Cognitive performance in infected children compared to the non-infected ( $p > 0.05$ ); there was no significant difference in SPM Cognitive performance before and after treatment ( $p > 0.05$ ).



**Fig. 4.15: Standard Progressive Matrices (SPM) performance pre- and post-treatment (n = 364)**

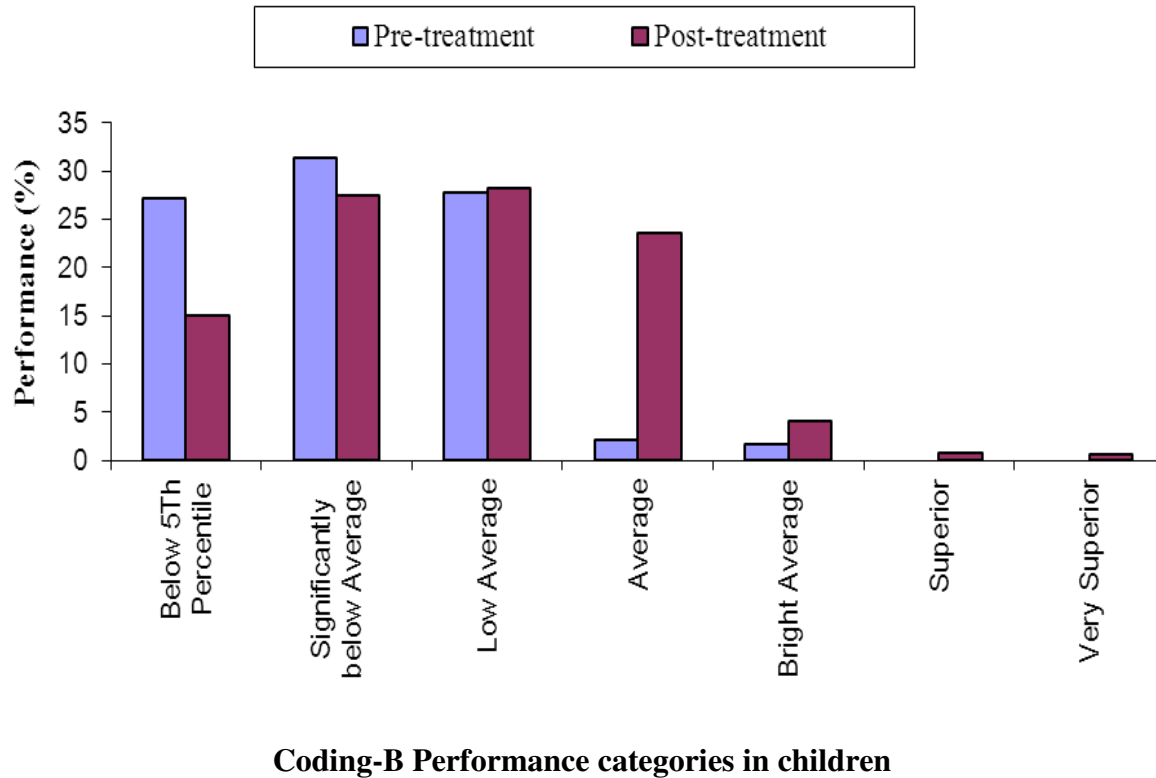
Pearson Product Moment correlation coefficient showed there was significant correlation between geohelminthic infections and SPM Cognitive performance, pre-treatment ( $r = - 0.866$ ;  $p < 0.05$ ) and post-treatment ( $r = - 0.855$ ;  $p < 0.05$ ). This suggested geohelminthiasis had significant adverse effect on SPM Cognitive performance in infected children before and after de-worming. There was no significant difference in SPM Cognitive performance between the non-infected compared to infected children in 6-10, 11-14 and 15-18 year age-groups ( $p > 0.05$ ). Results of Linear Regression conducted on socio-economic factors or covariates (confounders) influencing the SPM Cognitive performance pre-treatment showed the following results: class ( $p < 0.021$ ), age-group ( $p < 0.0001$ ), eating raw foods ( $p < 0.027$ ), help with homework by brother ( $p < 0.019$ ) and forgetting ( $p < 0.044$ ) significantly adversely affected SPM Cognitive performance (Table 7.0; Appendix 12 iv).

**Table 7.0: Factors influencing SPM Cognitive performance**

<b>Factors</b>	<b><i>p</i>-Value</b>
Class	< 0.021
Age group	< 0.0001
Eating raw foods	<i>p</i> < 0.027
Help with homework by brother	< 0.019
Forgetting	< 0.044

#### **4.6.5 Coding - B (Cod-B) Cognitive Performance pre- and post-treatment**

Out of 364 pupils, (27.2%) had Below 5<sup>th</sup> percentile, (31.3%) significantly below average, (27.8%) low average performance, (2.1%) average and (1.7%) had bright average performance, pre-treatment. Further, (15.1%) had Below 5<sup>th</sup> percentile, (27.5%) significantly below average, (28.3%) low average performance, (23.6%) average performance, (4.1%) bright average, (0.8%) Superior and (0.6%) had Very Superior performance, post-treatment (Fig. 4.16). There was a significant difference in Coding-B Cognitive performance in the study population, pre- and post-treatment ( $p < 0.0001$ ). There was no significant difference in Coding-B Cognitive performance between the non-infected and infected pupils ( $p > 0.05$ ).



**Fig. 4.16: Coding-B performance pre- and post-treatment (n = 364)**

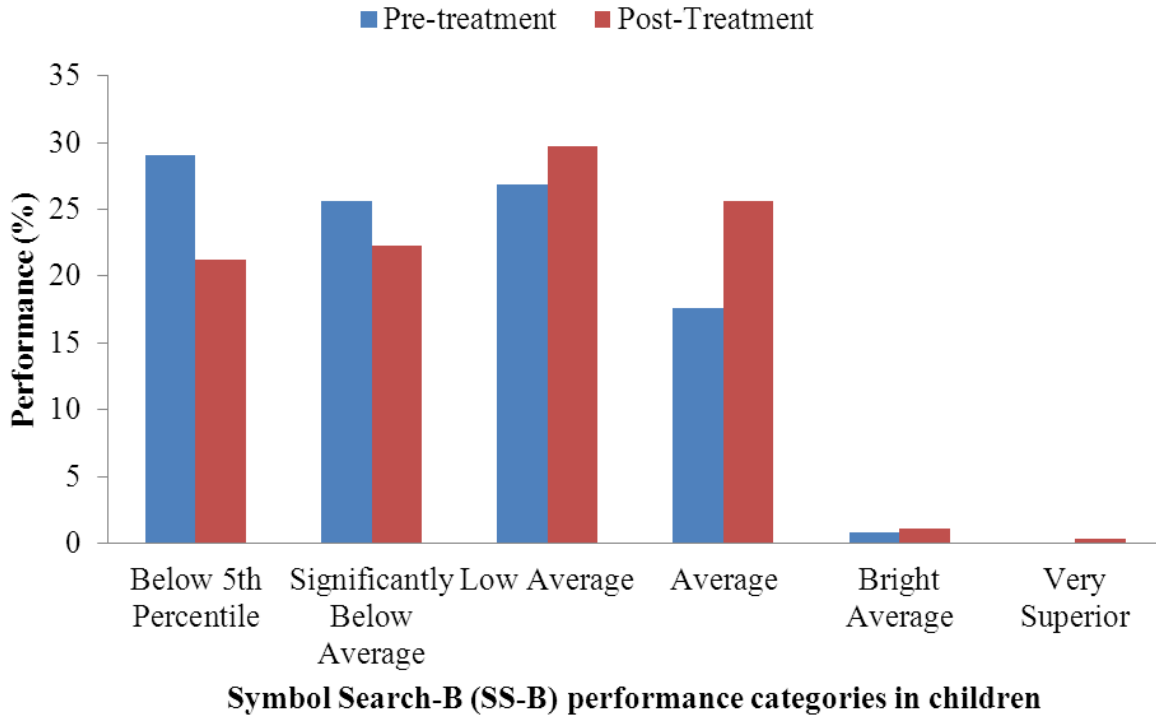
Pearson Product Moment correlation coefficient showed significant correlation occurred between geohelminthiasis and Coding-B Cognitive performance, pre-treatment ( $r = -0.623$ ;  $p < 0.05$ ) and post-treatment ( $r = -0.5$ ;  $p < 0.05$ ). This showed that Geohelminthic infections had significant adverse effect on Coding-B Cognitive performance in infected children. There was significant difference in Coding-B Cognitive performance between infected compared to non-infected children in 6-10, 11-14 and 15-18 year age-groups ( $p < 0.003$ ). Linear Regression conducted on socio-economic factors or covariates (confounders) influencing Coding-B Cognitive performance showed: class ( $p < 0.018$ ), village ( $p < 0.037$ ) and age-group ( $p < 0.0001$ ) significantly adversely affected Coding-B Cognitive performance (Table 7.1; Appendix 12 v).

**Table 7.1: Factors influencing Coding-B Cognitive performance**

<b>Factors</b>	<b><i>p</i>-Value</b>
Class	< 0.018
Village	< 0.037
Age group	< 0.0001

#### **4.6.6 Symbol Search - B (SS-B) Cognitive performance pre- and post-treatment**

Out of 364 pupils, (29.1%) had Below 5<sup>th</sup> percentile, (25.6%) significantly below average, (26.9%) low average, (17.6%) average and (0.8%) had bright average performance, pre-treatment. Further, (21.2%) had Below 5<sup>th</sup> percentile, (22.3%) significantly below average, (29.7%) low average, (25.6%) average, (1.1%) bright average and (0.3%) had Very Superior performance, post-treatment (Fig. 4.17). There was significant difference in Symbol Search-B Cognitive performance in the study population, pre- and post-treatment ( $p < 0.0003$ ). There was no significant difference in SS-B Cognitive performance between non-infected and infected children ( $p > 0.05$ ). Pearson Product Moment correlation coefficient showed there was no correlation between geohelminthiasis and SS-B Cognitive performance pre-treatment ( $r = 0.017$ ;  $p > 0.05$ ); however, significant correlation occurred post-treatment ( $r = 0.979$ ;  $p < 0.05$ ). This suggested that geohelminthiasis had significant adverse effect on Symbol Search-B Cognitive performance in infected children post-treatment.



**Fig. 4.17: Symbol Search-B (SS-B) performance pre- and post-treatment (n = 364)**

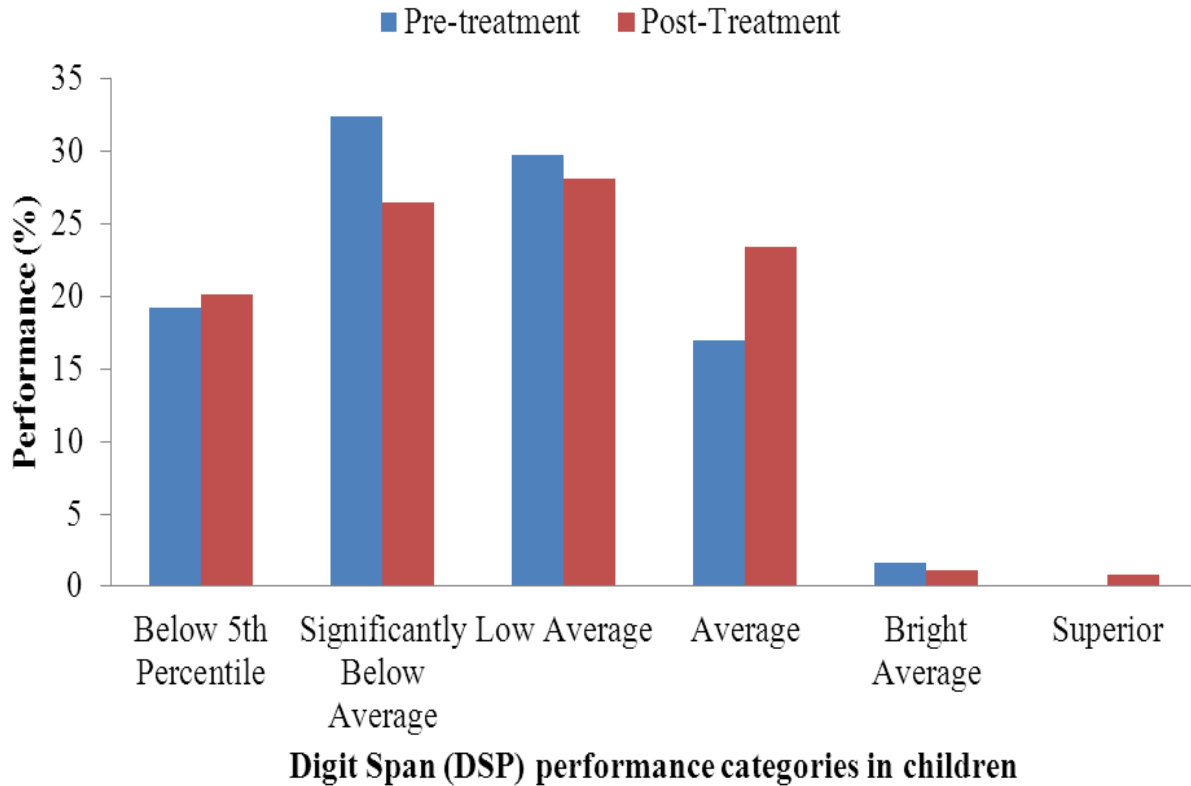
It was also observed that there was no significant difference in Symbol Search-B Cognitive performance between infected children compared to the non-infected in 6-10, 11-14 and 15-18 year age-groups ( $p > 0.097$ ). Linear Regression conducted on socio-economic factors or covariates (confounders) influencing the SS-B Cognitive performance showed: village of origin ( $p < 0.026$ ), age-group ( $p < 0.003$ ), infections with *A. lumbricoides* ( $p < 0.018$ ), vomiting episodes ( $p < 0.036$ ), absence in school by other reasons ( $p < 0.048$ ) and lack of school uniform ( $p < 0.037$ ), significantly adversely affected SS-B Cognitive performance (Table 7.2; Appendix 12 vi).

**Table 7.2: Factors influencing (SS-B) Cognitive performance**

<b>Factors</b>	<b><i>p</i>-Value</b>
Village	< 0.026
Age group	< 0.003
<i>A. lumbricoides</i> infections	< 0.018
Vomiting	< 0.036
Absence from school due to other reasons	< 0.048
Lack of school uniform	< 0.037

#### **4.6.7 Digit Span (DSP) Cognitive performance pre- and post-treatment**

Out of 364 pupils, (19.2%) had Below 5<sup>th</sup> percentile, (32.4%) significantly below average, (29.7%) low average, (17.0%) average and (1.6%) had bright average performance scores, pre-treatment. Further, (20.1%) had Below 5<sup>th</sup> percentile, (26.5%) significantly below average, (28.1%) low average performance, (23.4%) average, (1.1%) Bright average and (0.8%) had Superior performance, post-treatment (Fig. 4.18). There was significant difference in Digit Span Cognitive performance in the study population, pre- and post-treatment ( $p < 0.0001$ ). There was no significant difference in DSP Cognitive performance between non-infected and infected pupils ( $p > 0.05$ ).



**Fig. 4.18: Digit Span (DSP) performance pre- and post-treatment (n = 364)**

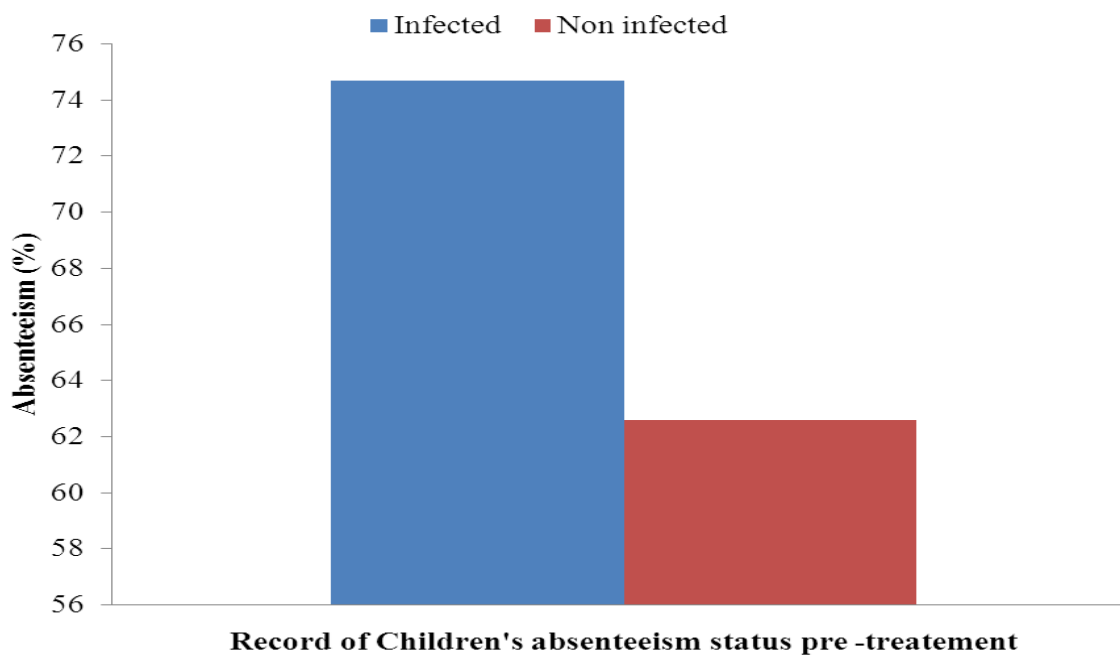
Pearson Product Moment correlation coefficient showed significant correlation between geohelminthiasis and DSP Cognitive performance, pre-treatment ( $r = -0.666$ ;  $p < 0.05$ ) and post-treatment ( $r = -0.765$ ;  $p < 0.05$ ). This suggested geohelminthic infections had significant adverse effect on DSP Cognitive performance, pre- and post-treatment. There was significant difference in DSP Cognitive performance between infected and non-infected children in 6-10, 11-14 and 15-18 year age-groups ( $p < 0.001$ ). Linear Regression conducted on socio-economic factors or covariates (confounders) influencing DSP Cognitive performance showed: class ( $p < 0.0001$ ), Sex ( $p < 0.044$ ), age-group ( $p < 0.0001$ ), infections with *T. trichiura* ( $p < 0.05$ ), pupils play with moist soil ( $p < 0.032$ ), lack of latrines ( $p < 0.009$ ) and missing supper occasionally ( $p < 0.05$ ) significantly adversely affected DSP Cognitive performance (Table 7.3; Appendix 12 vii).

**Table 7.3: Factors influencing DSP Cognitive performance**

<b>Factors</b>	<b><i>p</i>-Value</b>
Class	< 0.0001
Sex	< 0.044
Age group	< 0.0001
<i>T. trichiura</i> infections	< 0.045
Playing with moist soil	< 0.032
Lack of latrine	< 0.009
Missing supper occasionally	< 0.05

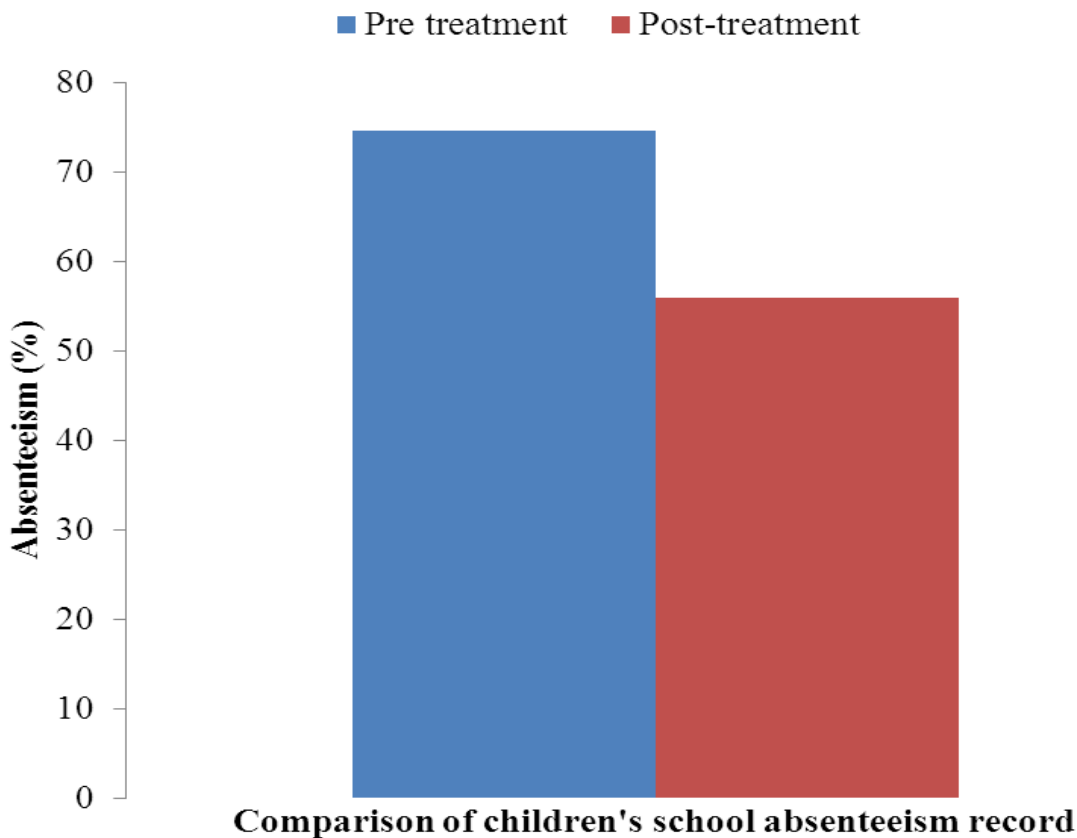
#### 4.7 Effects of geohelminthiasis on Absenteeism in school-age children

There was significant difference in absenteeism, between the infected and non-infected pupils pre-treatment (Fig. 4.19;  $p < 0.05$ ).



**Fig. 4.19: Infected and non-infected children's Absenteeism record pre-treatment (n = 182)**

Among 182 infected children, (74.7%) were absent from school pre-treatment, compared to (56.0%) post-treatment. Results showed there was significant reduction in absenteeism post-treatment ( $p < 0.05$ ; Fig. 4.20). Pearson product moment correlation showed there was significant correlation between geohelminthic infections and absenteeism ( $r = 0.7523$ ;  $p < 0.05$ ). This showed that geohelminthiases had significant adverse effect on school attendance in infected children. There was significant difference in absenteeism among the four schools, pre-treatment ( $p < 0.0001$ ) and post-treatment ( $p < 0.0016$ ). Mbagathi school had the highest pre-treatment absenteeism record (44.3%) and but highest prevalence rate occurred in Olympic school (51.7%) (Fig. 4.21). Intensity of infections with *A. lumbricoides* did not significantly affect absenteeism ( $p > 0.05$ ).



**Fig. 4.20: Infected children's Absenteeism record pre- and post-treatment (n = 182)**

Out of 364 pupils, (37.4%) were absent from school, pre-treatment. The highest absenteeism occurred in Mbagathi school (44.3%), followed by D. Comboni (39.3%), Ngunyumu (37.0%) and Olympic school (22.4%) (Table 7.4).

**Table 7.4: Absenteeism by School pre-treatment (n = 364)**

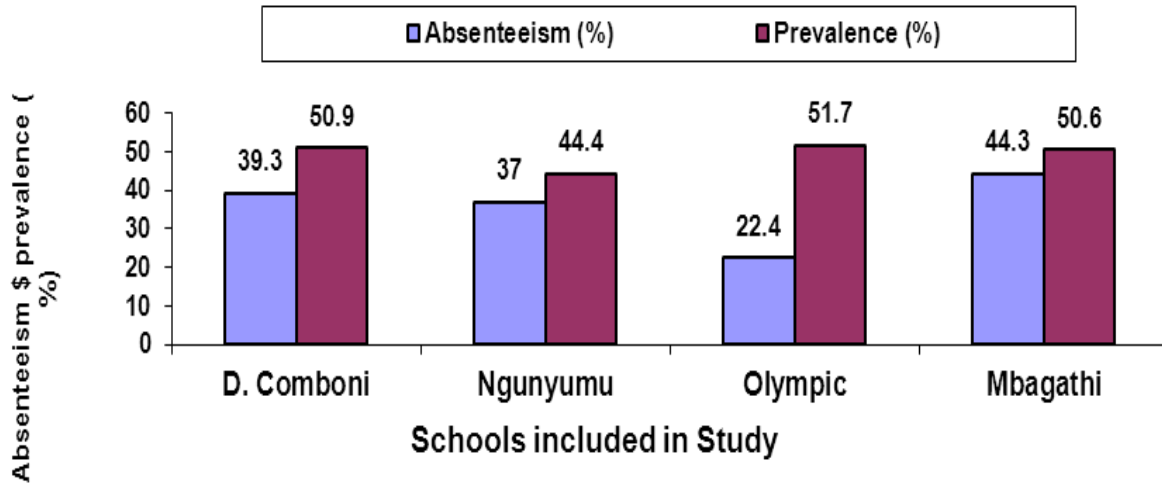
<b>School</b>	<b>No. of pupils sampled</b>	<b>No. Absent</b>	<b>Absenteeism (%)</b>
Daniel Comboni	173	68 (39.3%)	39.3
Ngunyumu	54	20 (37.0%)	37.0
Olympic	58	13 (22.4%)	22.4
Mbagathi	79	35 (44.3%)	44.3
<b>Total</b>	<b>364</b>	<b>136 (37.4%)</b>	

Out of 364 pupils, (28.0%) were absent from school, post-treatment. The highest absenteeism occurred in D. Comboni school (32.9%), followed by Ngunyumu (29.6%), Mbagathi (25.3%) and Olympic school (15.5%) (Table 7.5).

**Table 7.5: Absenteeism by School post-treatment (n = 364)**

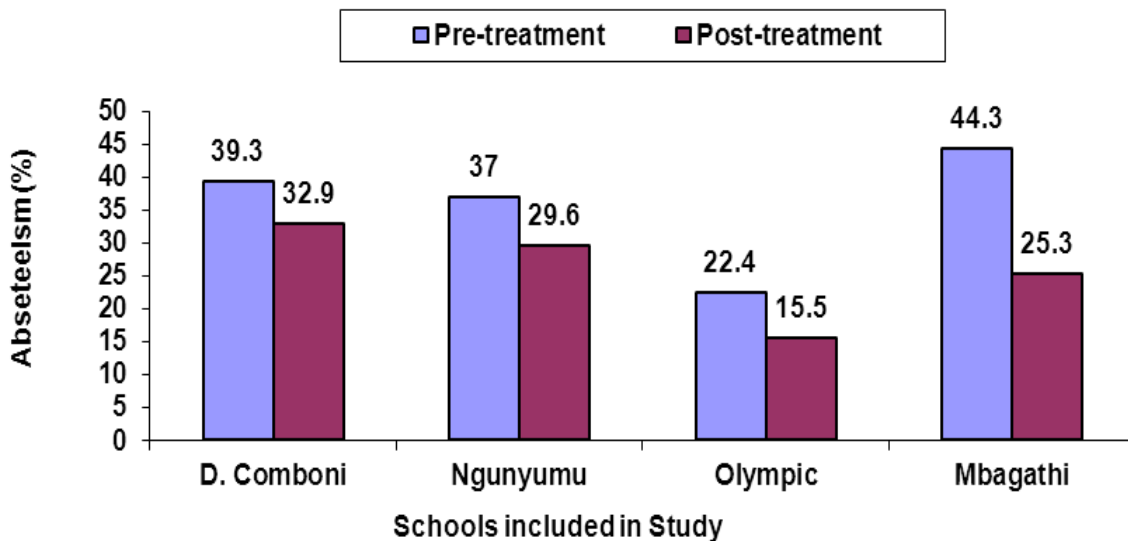
<b>School</b>	<b>No. of pupils sampled</b>	<b>No. Absent</b>	<b>Absenteeism (%)</b>
Daniel Comboni	173	57	32.9
Ngunyumu	54	16	29.6
Olympic	58	9	15.5
Mbagathi	79	20	25.3
<b>Total</b>	<b>364</b>	<b>102 (28.0%)</b>	

Results of Pearson's Product Moment correlation showed significant correlation between prevalence and absenteeism, pre-treatment (Fig. 4.21;  $r = 0.971$ ;  $p < 0.05$ ). This showed geohelminthiases significantly adversely affected school attendance among infected children.



**Fig. 4.21: Relationship of Absenteeism to Prevalence pre-treatment (n = 364)**

The t-test showed significant difference between pre-treatment and post-treatment absenteeism in schools (Fig. 4.22;  $p < 0.05$ ). This showed that geohelminthic infections had significant adverse effect on school attendance among infected children, pre- and post-treatment.



**Fig. 4.22: Comparison of Absenteeism records pre- and post-treatment (n = 364)**

However, the intensity of infections with *A. lumbricoides* did not significantly affect the pupils' absenteeism between groups, pre-treatment (Table 7.6;  $p > 0.6274$ ).

**Table 7.6: Relationship of *A. lumbricoides* infection Intensity with Absenteeism between groups pre-treatment**

Infection status	(n)	Absenteeism (%)	<i>p</i> -Value
Negative control	182	143 (78.6)	0.6274
Light	65	47 (72.3)	
Moderate	54	40 (74.1)	
Heavy*	8	4 (50)	

**\*Please note there were only 8 children with heavy infections**

In addition, the intensity of infections with *T. trichiura* did not significantly affect the pupils' absenteeism between groups, pre-treatment (Table 7.7;  $p > 0.8746$ ).

**Table 7.7: Relationship of *T. trichiura* infection Intensity with Absenteeism between groups pre-treatment**

Infection status	(n)	Absenteeism (%)	<i>p</i> -Value
Negative control	182	143 (78.6)	0.8746
Light	110	81 (73.6)	
Moderate*	6	5 (83.3)	

**\*Please note there were only 6 children with moderate infections**

The intensity of infections with *T. trichiura* did not significantly affect the pupils' absenteeism between groups, post-treatment (Table 7.8;  $p > 0.7986$ ).

**Table 7.8: Relationship of *T. trichiura* infection Intensity with Absenteeism between groups post-treatment**

Infection status	n	Absenteeism (%)	p-Value
Negative control	182	143 (78.6)	0.7986
Light	25	14 (56)	
Moderate	2	1 (50)	
Heavy*	1	1 (100)	

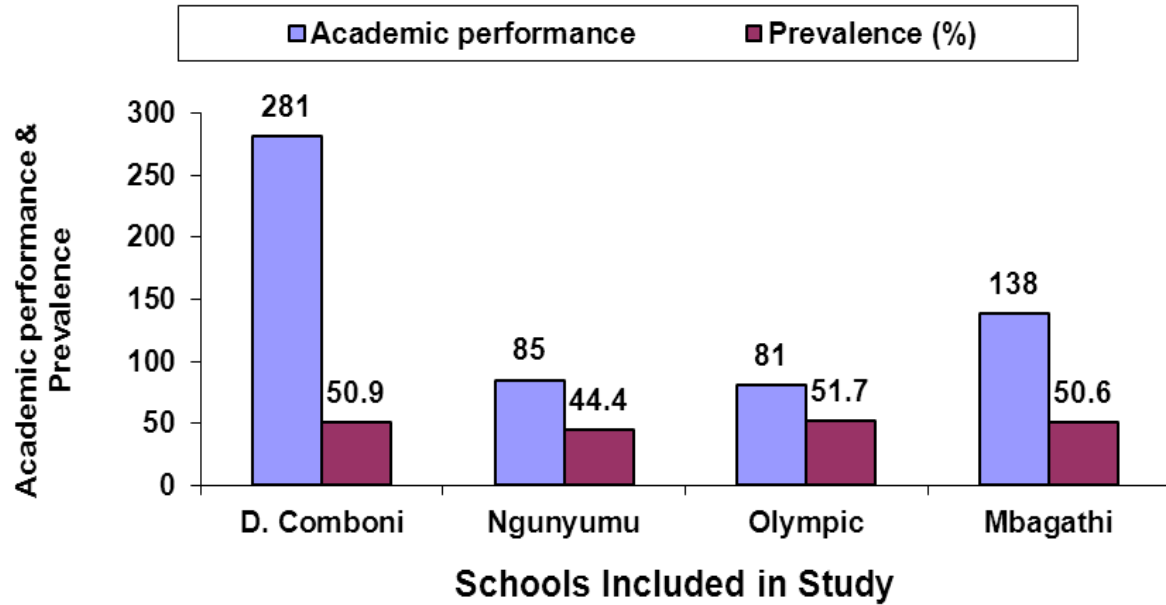
**\*Please note there was only 1 child with Heavy infection**

The intensity of infections with Hook worms (*A. duodenale* or *N. americanus*) did not significantly affect absenteeism, pre-treatment. There was no significant difference in absenteeism, between the non-infected and infected pupils ( $p > 0.05$ ).

#### **4.8 Determination of effects of geohelminthiasis on Academic performance**

##### **4.8.1 Infected children's Academic performance profile pre- and post-treatment**

The Pearson's Product Moment correlation showed significant inverse correlation between Prevalence and Academic performance, pre-treatment (Fig. 4.23;  $r = - 0.879$ ;  $p < 0.05$ ). This showed that geohelminthiasis 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 worms ( $p < 0.007$ ), failure to wear shoes ( $p < 0.049$ ) and lack of latrine ( $p < 0.048$ ) also significantly adversely affected Academic performance.



**Fig. 4.23: Infected children's Academic performance pre-treatment (n = 364)**

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 ( $p < 0.043$ ), lack of milk ( $p < 0.052$ ) and inability to concentrate on school work ( $p < 0.007$ ) also significantly adversely affected Academic performance [Table 7.9; Appendix 12 (viii)]. However, infections with *A. lumbricoides* did not significantly affect the pupils' academic performance ( $p > 0.05$ ).

**Table 7.9: Factors that affect Academic performance**

<b>Factor</b>	<b><i>p</i>-Value</b>
School	< 0.0001
Class	< 0.028
District	< 0.002
Village	< 0.049
<i>T. trichiura</i> infections	< 0.027
Hook worms ( <i>A. duodenale</i> or <i>N. americanus</i> )	< 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

## CHAPTER FIVE: DISCUSSION, CONCLUSION AND RECOMMENDATION

### 5.1 Discussion

#### 5.1.1 Introduction

This chapter discusses the prevalence and intensity of geohelminthiases and its effects on growth, cognitive functions and academic performance among pupils from Kibera and Korogocho slums of Nairobi County. The study involved screening stool samples, taking anthropometric measurements, analyzing cognitive functions and academic performance from pupils in classes 2-7 in 4 schools, covering 3 sub-Counties (Kasarani, Dagoretti and Lang'ata) in Nairobi County. This data is discussed in view of other past studies.

#### 5.1.2 Prevalence and Intensity of Geohelminthiases in pupils from selected schools in Kibera and Korogocho slums, Nairobi County

This study reported prevalence of *Ascaris lumbricoides* (37.9%), *Trichuris trichiura* (33.2%) and hookworms (0.6%) among school children in major slums (Kibera and Korogocho) in Nairobi County. There were no infections with *Strongyloides stercoralis* found in the study population. The prevalence rates for *A. lumbricoides* and *T. trichiura* were higher than those reported by Ngonjo *et al.* (2012) in a recent study in school-age children in slum schools located in Thika township, Central Kenya. The authors showed prevalence of *A. lumbricoides* was (27.2%) and *T. trichiura* (4.3%). The prevalence rate of hookworms (*Ancylostoma duodenale* or *Necator americanus*) (5.4%) was higher than that reported in our study (0.6%). The differences in findings between Nairobi and Thika slum schools can probably be explained. These variations may have been contributed by local geographical and socio-economic factors and socio-cultural practices of the indigenous populations involved.

Thika township slums have less crowded and less diverse communities; the population is exposed to better and more appropriate toilets and fewer industries compared to Korogocho and Kibera slums found in Nairobi City. Nairobi slums, contrary to Thika slums, have largely more diverse, multi-ethnic cultural groups, different living habits; there are also numerous industries and flying toilets are rampant and widespread in the slum population. The intensities of infections (epg) in this study showed: *A. lumbricoides* light (39.6%), moderate (31.3%) and heavy (4.4%) infections. *T. trichiura* showed light (63.7%) and moderate (3.3%) infections and hookworm light (1.1%). The intensities of infections reported in slum schools in Thika township by Ngonjo *et al.* (2012) were: *A. lumbricoides* light (72.6%), moderate (24.7%) and heavy (2.7%) infections. *T. trichiura* showed (100%) light infections and hookworms (70%) light and moderate (30%) infections. More light infections with *A. lumbricoides* were seen in Thika township compared with higher moderate and heavy infections seen in Nairobi County. More light infections with *T. trichiura* were seen in Thika township compared with Nairobi County. More moderate infections with *T. trichiura* were seen in Nairobi county but none in Thika township. More light and moderate infections with hookworms (*A. duodenale* or *N. americanus*) were seen in Thika township compared with Nairobi County.

Thus, these differences in infection intensities may have been attributed to variations in population density, cultural practices, overcrowding and lack of proper sanitation. Lack of clean water, health facilities, poor personal and communal hygiene practices may also significantly contribute to prevalence of infections (Ngonjo *et al.*, 2012). The high prevalence of geohelminths observed in schools may be associated with extreme overcrowding, unemployment, unhygienic environment, lack of public amenities and appropriate job skills.

Poor diet also predisposed school children to geohelminthiases. This situation agrees with observations of a recent study by Ngonjo *et al.* (2012) in Thika township, Central Kenya. These observations also agreed with findings of prevalence and intensity reported by WHO (2012) regarding elimination of geohelminthiases as a public health problem. The situation in Mbagathi, Olympic, Daniel Comboni and Ngunyumu schools is further supported by reports by Strunz *et al.* (2014). The author and associates reported that contaminated water, poor sanitation and hygiene often contribute to the transmission of geohelminthiases; this was a systematic review and metanalysis of several, previous studies by other investigators. Although females had higher infections than males, there was no statistically significant differences observed between the sexes. These findings agreed with reports from a study by Topcu and Ugurlu (2001). The authors had done a study on distribution of intestinal parasites in school-age children in Turkey. The distribution of parasites was done according to age, sex and socio-economic status which showed no positive relationship between infections and gender.

The issue of sex is controversial because different investigators have reported different results. Walker *et al.* (2011) carried out a similar independent study on individual predisposition, household clustering and risk factors for infection with *A. lumbricoides*; results showed that there was no difference in infection intensity between sexes. This observation was supported by work of Jardim-Botelho *et al.* (2008). The authors, working on hookworm, *A. lumbricoides* infection and polyparasitism, reported that helminthic infections affected boys and girls similarly. The high infection intensity observed among children aged 11-14 years in classes 2-4 agreed with similar reports by other investigators.

Mugono *et al.* (2014) reported similar results on prevalence and intensity of geohelminthiases and associated risk factors among school children in Ukara Island, North-Western Tanzania. The 11-14 year age-category was mostly associated with light to heavy infections among school-age children. These observations were also supported by Bundy *et al.* (2013) in a study on economic importance of worms, wisdom and wealth which concluded that children aged 11-14 years were most vulnerable to geohelminthiases. Mass treatment of geohelminthiases with broad-spectrum anthelmintics in endemic areas produced significant reduction in infection intensity and prevalence (Dickson *et al.*, 2007; Hawkes, 2013). Reduction in prevalence and intensities of geohelminthiases observed after treatment with albendazole indicated the efficacy of the drug. This agreed with similar observations by Parker and Allen (2011) in a study on deworming drugs for geohelminths in Uganda; the authors reported significant reduction in infection prevalence and intensity post-treatment.

Systematic review on several studies by other investigators was done by Taylor-Robinson *et al.* (2012) on effects of dewormers on nutritional indicators, haemoglobin and academic performance. The author and associates reported that significant reduction in worm-loads of geohelminths occurred post-treatment. Other pathogenic helminths found during examination of stool samples included *Hymenolepis nana*, *Tinea* species (*T. saginata* or *T. solium*) and *Schistosoma mansoni*. These helminths can cause diarrhoea, which leads to loss of fat-soluble vitamins, electrolytes, minerals and proteins necessary for maintenance of normal metabolic processes (WHO, 2012). Sustained and untreated diarrhoea may lead to development of metabolic acidosis which can adversely affect mental function of school children (WHO, 2006).

Matthys *et al.* (2011) studied prevalence and risk factors of associated with helminthic and intestinal protozoan infections in school-age children. Results showed diarrhoea was a common clinical manifestation which compromises children's learning abilities. Although no pupils were found infected with *Plasmodium* species in the study population, malaria commonly causes diarrhoeic episodes. Kinung'hi *et al.* (2014) studied malaria and helminthic co-infections in school and pre-school children. Results showed that untreated diarrhoeic episodes in clinically significant malaria may compromise mental function, often expressed as Cognitive dysfunction.

### **5.1.3 Effect s of Geohelminthiases on Growth in pupils from selected schools in Nairobi County**

This study reported significant number of infected children were underweight. Infections strongly correlated with Body Mass Indices (BMI) in four schools. Infections with *T. trichiura* adversely affected children's BMI. This malnutrition develops due to sustained loss of nutrients in the gastro-intestinal tract, especially in children and pregnant women. This observation agrees with findings by Silva and Assis (2008). The authors reported a positive association between geohelminth infections and physical growth in school-children. This study showed that geohelminthiases, even light infections, significantly adversely affect growth of school-age children. Duggan (2010) studied anthropometry as a tool for measuring malnutrition; reports showed that malnourished (underweight) children often correlated with low Body Mass Indices. Further, van Riet *et al.* (2007) studied induced immuno-modulation by chronic helminthic infections, consequences and mechanisms. The authors reported that geohelminthic infections adversely affect the immune system leading to weight loss. These findings support the view that geohelminthiases complex had a direct and sometimes, indirect adverse effects on children's physical fitness. This study reported that (29.9%) of infected children were overweight.

Infections strongly correlated with Body Mass Indices (BMI) of overweight children in all four schools. This may be caused by altered metabolism and impaired nutrient uptake in infected children. These findings agree with findings from other studies. Thus, for example, Kriemler *et al.* (2010) studied the effect of school-based physical activity programme on fitness and adiposity in primary school children; results showed that alteration of body metabolism can lead to increased adiposity and weight gain.

#### **5.1.4 Effects of Geohelminthiases on Cognitive Functions in pupils from selected schools in Nairobi County**

This study reported significant correlation between geohelminthic infections and Cognitive function performance in 6 cognitive function tests. These tests were namely: Word Generation Semantic (WGS), Word Generation Initial (WGI), List Memory (LM), Standard Progressive Matrices (SPM), Coding-B (Cod-B) and Digit Span (DSP) (Raven, 1958; Raven *et al.*, 1977; Korkman *et al.*, 2007; Harcourt Assessment, 2007). The Cognitive performance results obtained are unique to this study because the tests used had not been applied before on African children. Also, these tests had not been reported before by other investigators working on geohelminthiases on African children.

Significant differences were noted in WGS, WGI, LM, Coding-B, Symbol Search-B (SS-B) and DSP Cognitive performance, pre- and post-treatment. Also, post-treatment results showed better performance. Several investigators have shown geohelminthiases adversely affect cognitive abilities of children, regardless of their cultural background (Baddeley *et al.*, 1995; Wade and Tavis, 2011).

Dickson *et al.* (2007) studied the effects of anthelmintic drugs on Cognitive performance; results showed that geohelminthic infections retard mental development of school-age children. Treated children showed improved performance on tests of memory and other cognitive abilities. Jardim-Botelho *et al.* (2008) studied hookworms, *A. lumbricoides* infections and polyparasitism. The authors reported that geohelminths are associated with poor cognitive performance. Current results showed age-group (11-14 years) had significant inverse influence in WGS, WGI, LM, SPM, Cod-B, SS-B and DSP Cognitive performance in infected children. This may be because children aged 11-14 years are most vulnerable to geohelminthiases due to their habits of playing with soil. This agreed with findings by WHO (2012) in a report on geohelminthiases as a public health problem in children. Results showed that hookworms can adversely affect cognitive development of children through loss of iron, resulting in iron-deficiency anaemia. Iron is known to be important for the development of dopaminergic neuron receptors and for the bio-synthesis of iron-containing metallo-enzymes.

Further, these enzymes are essential for the turnover of endogenous neuro-transmitters, especially dopamine and serotonin. WGS and WGI sub-tests assess semantic memory function (general knowledge) involved in learning processes in pupils aged 3-16 Years. Results for WGS and WGI sub-tests closely agree with unrelated reports by Ezeamama *et al.* (2005). The authors had studied helminthic infections and cognitive impairment in Filipino children, showing that geohelminthic infections undermine cognitive function. The WGI result obtained in the current study is unique because the WGI Sub-test has not been applied before on African children; this is the first report showing association of geohelminthiases and general knowledge.

The LM Sub-test measures memory and learning skills in children aged 7-12 years; results obtained in the current study showed significant correlation between infections and LM Cognitive performance. This agrees with findings by Hürlimann *et al.* (2014) on a study on effect of deworming on school children's cognitive performance. Results showed that geohelminthiases depressed cognitive function performance. The Standard Progressive Matrices (SPM) measures non-verbal intelligence (IQ estimation) for children and adults (Raven, 1958; Raven *et al.*, 1977). Results showed significant inverse correlation of infections with SPM Cognitive performance. This suggested that geohelminthic infections depressed non-verbal cognitive skills of school children. This concurred with unrelated reports by Jardim-Botelho *et al.* (2008) in a study on hookworms, *A. lumbricoides* infections and polyparasitism. The authors reported that geohelminthic infections are associated with poorer cognitive performance and general intelligence. This study also presented evidence that polyparasitized children experience worse cognitive performance outcomes than children with only one helminthic infection.

The Coding-B and Symbol Search-B Sub-tests measure the speed of information processing for children aged 8-16 years (Korkman *et al.*, 2007; Harcourt Assessment, 2007). The results of the current study showed that geohelminthic infections significantly correlated with Coding-B Cognitive performance. Infections also significantly correlated with Symbol Search-B Cognitive performance, post-treatment. These observations suggest that geohelminthic infections depress the speed of information processing in the brain of infected children. These findings agree with reports of unrelated studies by Ezeamama *et al.* (2005) on helminthic infection and cognitive impairment.

Hürlimann *et al.* (2014) studied the effect of deworming on school children's cognitive performance. Results showed that geohelminthic infections depress the speed of information-processing in school-age children; the result of SS-B test is unique to this study. The reason is that the SS-B test has not been applied before on African children or reported by other investigators working on helminthiases in Africa. This is probably the first study in which SS-B Sub-test was applied in African primary school settings. The Digit Span (DSP) measures working memory and attention skills in children aged 6-16 years (Korkman *et al.*, 2007; Harcourt Assessment, 2007). Results showed that geohelminthiases significantly correlated with DSP Cognitive performance in school children. This study showed there was significant difference in DSP Cognitive performance ( $p < 0.0001$ ) suggesting that geohelminthiases can depress memory and attention skills. These cognitive functions are indispensable for learning processes and acquisition of new knowledge in school children. This observation agreed with reports by Jardim-Botelho *et al.* (2008) in a study on hookworms, *A. lumbricoides* infections and polyparasitism. Results showed that geohelminths are associated with poor Cognitive performance, even in light infections.

The study of Jardim-Botelho *et al.* (2008) presented evidence that poly-parasitized children experience worse cognitive outcomes than children with only one helminthic infection. Investigators showed that abdominal discomfort related to *A. lumbricoides* and *T. trichiura* infections can adversely affect Cognitive performance. This happened if infections were severe enough to distract children from cognitive tasks (Ezeamama *et al.*, 2005). Other helminthic parasites reported in this study include: *H. nana*, *Tinea* species (*T. saginata* or *T. solium*) and *S. mansoni*.

These helminths cause diarrhoea, which leads to loss of fat-soluble vitamins, electrolytes, minerals and proteins necessary for maintenance of normal metabolic processes. Sustained and untreated diarrhoeic episodes may lead to metabolic acidosis and cognitive dysfunction in school children. Matthys *et al.* (2011) studied the prevalence and risk factors of associated with helminthic and intestinal protozoan infections in school-age children. Results showed that untreated diarrhoea can compromise children's cognitive performance and functions. Although no pupils were infected with *Plasmodium* species in the current study population, diarrhoea is common in malaria. Kinung'hi *et al.* (2014) studied malaria and helminth co-infections in school and pre-school children; results showed that untreated malaria, especially with *P. falciparum*, may cause Cognitive dysfunction.

#### **5.1.5 Effects of Geohelminthiasis on School Attendance in pupils from selected schools in Nairobi County**

The results showed there was a significant reduction (18.7%) in school absenteeism after deworming. There was strong, positive correlation between geohelminthic infections and absenteeism, pre-treatment and negative correlation post-treatment period. The improvement in school attendance observed in this study may be evidence of the relief produced by de-worming. The children's immediate feeling of well-being after treatment may also have contributed to improved school attendance. This outcome agreed with findings from studies by Lustigman *et al.* (2012), Franziska *et al.* (2013) and Al-Delaimy *et al.* (2014). Results showed that geohelminthic infections are often associated with school absenteeism. However, school absenteeism may also be attributed to psychological, environmental and socio-economic factors (Addisu and Asmamaw, 2015).

This view was supported by reports of studies on control of helminthiases in schools (Prichard *et al.*, 2012; Taylor-Robinson *et al.*, 2012; Bundy *et al.*, 2013). The authors observed that school absenteeism was reduced by regular anthelmintic treatment. However, other miscellaneous factors may indirectly but significantly contribute to absenteeism (Taylor-Robinson *et al.*, 2012). Ezeamama *et al.* (2005) studied helminthic infections in children. Results showed that abdominal discomfort related to ascariasis and trichuriasis could significantly affect school attendance. Also, school children require remedial assistance in addition to anti-helminthic therapy to observe improvements in school attendance (Lustigman *et al.*, 2012; Al-Delaimy *et al.*, 2014; Addisu and Asmamaw, 2015).

#### **5.1.6 Effects of Geohelminthiases on Academic performance in pupils from selected schools in Nairobi County**

The results in this study showed there was strong, positive correlation between prevalence rates of geohelminthic infections and academic performance. Investigators have shown that school children with moderate and heavy geohelminthiases performed better than non-infected children (Nokes and Bundy, 1994; Nokes *et al.*, 1998; Jardim-Botelho *et al.*, 2008). This phenomenon was attributed to environmental factors, genetic endowment of individuals, quality of education, level of coaching and mentoring, among other factors. Anuar *et al.* (2014) studied geohelminthic infections in children and associated risk factors; the authors' results supported this phenomenon. Results showed that infected children performed better academically than normal children. This may be attributed to genetic endowment factors of individual children. This study reported that moderate and heavy intensity of infections with *A. lumbricoides* significantly adversely affected academic performance, Moderate and heavy ascariasis, is associated with malnutrition and poor mental development which impact negatively on children's learning abilities.

The results concurred with the findings in a study by Bundy *et al.* (2013). Results supported the economic sense of deworming school-age children which showed that *A. lumbricoides* produces adverse effects on children's learning abilities. The results showed significant difference in academic performance among the four schools, pre- and post-treatment ( $p < 0.0001$ ). This variation may be attributed to variation in geographical location of slum schools and socio-economic status of the parents/guardians. Daniel Comboni and Ngunyumu (Korogocho slum) were situated in the relatively economically poor Kasarani sub-County, while Mbagathi and Olympic schools (Kibera slum) were located on the edges of elite and cleaner surroundings in Dagoretti and Lang'ata sub-Counties, respectively. This observation agrees with findings of other investigators. Ojha *et al.* (2014) studied the public significance of geohelminths and results showed that *A. lumbricoides* and *T. trichiura* frequently co-exist in endemic areas.

These areas also lacked safe drinking water and inhabitants had poor personal and communal hygiene, sanitary habits, faecal disposal systems and socio-economic status. These conditions were more pronounced and severe in Kasarani sub-County compared with the elite areas of Dagoretti and Lang'ata sub-Counties. Bartram and Cairncross (2010) studied hygiene, sanitation and water forgotten foundations of health. Results showed that environmental factors exerted considerable influence in shaping mental function and academic performance in school-age children. Taylor-Robinson *et al.* (2012) studied the effects of deworming drugs for geohelminths in children; the authors reported that environmental factors are important confounding covariates which indirectly contribute to poor academic performance, pre- and post-treatment.

### 5.1.7 Limitations of the Study

Among the 7 cognitive function tests used in this study, WGS, WGI and LM are language-dependent. SPM, Cod-B, SS-B and DSP are non-language-dependent. Language-use in psychological tests has a significant bearing on final outcomes in evaluating psychological phenomena. Investigators have shown that psychological tests are not free of cultural influence (Wade and Tavis, 2011). This phenomenon is associated with reduction in sensitivity of test results. This observation was reported by Wade and Tavis (2011) in relation to studies on influences of cultural practices and norms on performance of psychological tests in school children. Wade and Tavis (2011) reported that results of cognitive function tests cannot be generalized in human communities because results may vary among myriad cultural groups.

Psychological tests used in this study were more culturally robust compared to mostly language-dependent tests used in other psychological studies (Harcourt Assessment, 2007). The simultaneous use of Kiswahili and English languages during administration of tests had an important cultural adaptation; this made the Cognitive performance results obtained in Kenyan slum schools unique to this study. The presence of myriad confounding covariates or factors in the environment which cannot be rigorously controlled, caused important limitations in this study. Confounding variables adversely influence Cognitive function; they are closely associated with distribution of helminths in slum-dwelling communities in endemic areas (Kvalsvig, 2003; de Souza *et al.*, 2007; Ellis *et al.*, 2007). Further, these confounders include: School, class, sex, age, socio-economic status (WHO, 2006), haemoglobin level (Gabielli *et al.*, 2005) and hunger. Other confounders included noise, parental education level, migration, child abusive behaviour (Franziska *et al.*, 2013), malnutrition and presence of other helminths (Al-Delaimy *et al.*, 2014).

Also included in this category are mood (emotional state) and teacher behaviour (Albright and Basaric-Keys, 2006). Other recognized confounders include school attendance (Gyorkos *et al.*, 2013), accessibility to health facilities and availability of clean water. Lack of latrines, school uniform, books, home-study desks/tables and socio-demographic factors are also important confounding factors affecting Cognitive functions (WHO, 2006).

## 5.2 Conclusion

- (i) The most prevalent geohelminths were *Ascaris lumbricoides* 37.4% and *Trichuris trichiura* 33.2%. Prevalence and intensity of infections with *A. lumbricoides* and *T. trichiura* were significantly reduced post-treatment. This indicated albendazole, 400 mg single oral dose was effective in expulsion of *A. lumbricoides*, *A. duodenale* or *N. americanus* but not *T. trichiura*. The highest prevalence and intensity of infections occurred in Class 2, 4 and 5. The most affected children were in the 6-10 year- and 11-14 year age-groups. Females had higher infections than males. The highest prevalence of infections occurred in Dagoretti and Lang'ata sub-Counties.
- (ii) Geohelminthiases adversely affected growth of school-age children as infected children showed stunted growth
- (iii) Geohelminthiases depressed Cognitive functions of school-age children.
- (iv) Geohelminthiases adversely affected school attendance
- (v) Geohelminthiases adversely affected academic performance of children

## 5.3 Recommendations

### 5.3.1 Recommendations from the study

The following recommendations apply to the Ministry of Health and Ministry of Education:

- (i) Regular population-based (mass-chemotherapy) with broad-spectrum and specific anthelmintics in schools can drastically reduce disease prevalence and intensity  
Health benefits and economic costs of treatment of various population groups that could result from chemotherapy programmes should be regularly assessed
- (ii) Sensitization campaigns on Health Education programmes on hygiene and effects of geohelminths on growth, child development, school absenteeism, cognitive function and academic performance should be encouraged and supported
- (iii) Regular counselling and motivation talks should be given to address environmental factors affecting academic performance. The County Government should address sanitation issues

### **5.3.2 Recommendations for further research**

Further research is needed to elucidate the indirect mechanisms through which geohelminths affect growth, cognitive functions, school attendance and Cognitive functions in children. Three, consecutive oral doses of 400 mgs albendazole should be tested for expulsion of *T. trichiura*.

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## APPENDICES

### Appendix 1: Cognitive Function Tests Battery

#### (i) Word Generation (WG) sub-test

##### Method

The child was given first the Semantic category and asked to produce as many words as possible in 60 seconds. Further, within the Semantic (WGS) category consisting of Item 1 (animals), the child was asked to produce as many names of animals as possible within 60 seconds. Timing began immediately after the administrator said the word “go” and at the end of 60 seconds, the sub-test administrator said “stop”. The same procedure was repeated for Item 2 (foods or drinks) in which the child was asked to name as many types of foods or drinks within 60 seconds; the administrator said “stop” at the end of 60 seconds. Within the Initial Letter (WGI) category, the child was asked to name as many different words as possible which start with the letter “S” within 60 seconds. Timing began immediately after the administrator said the word “go”; the sub-test administrator said “stop” at the end of 60 seconds. The child was asked to name as many words as possible that start with the letter “F”; the administrator said “stop” at the end of 60 seconds; each correct response was scored as 1 point. However, the correct responses excluded word repetitions, non-sense words, non-category words and proper nouns. The child’s responses were recorded word for word on a score sheet and the score was obtained by adding up the number of words the child gave correctly in each category. The Word Generation Semantic (WGS) Total score was considered to be the sum of the correct responses for Items 1 and 2 while the Word Generation Initial (WGI) Letter Total score was considered to be the sum of the correct responses for Items 3 and 4 on the child’s Record form.

**(ii) List Memory (LM) sub-test****Method**

The child was read a Word List by the sub-test administrator which consisted of the words store, puppy, finger, window, grass, letter, fish, pupil, winter, cat, pencil, fence, teacher, water, boat. The Word List was read at a rate of one word every second while ensuring that the child could not see the list on the record form. The child was asked to say all the words that can be remembered in any order of the child's choice and the responses were recorded verbatim in Trial 1. After the child finished, the same Word List was read again in Trial 2 and the child was asked to say all the words remembered, even the ones said before and the responses recorded verbatim. The same procedure was repeated for Trials 3, 4 and Trial 5, recording responses of each Trial verbatim. Repeated words and non-list words or wrong words were excluded from the Total correct score and 1 point was given for each correct word said. The sum of Total Correct scores for Trial 1, 2, 3, 4 and Trial 5 were obtained separately. The List Memory (LM) Total Correct was considered to be the sum of correct words for Trials 1-5 on the child's Record Form.

**(iii) Standard Progressive Matrices (SPM) test****Method**

The Standard progressive Matrices (SPM) consisted of Sets A, B, C, D and E. It was designed to test a person's IQ capacity (at time of the test), apprehend meaningless figures presented for the person's observation, see the relations between them and conceive the nature of the figure completing each system of relations presented. Thus, Standard progressive Matrices (SPM) was designed to cover the widest possible range of mental ability and to be equally useful with persons of all ages (6-65 yrs), whatever their education, nationality or physical condition.

The scale used is intended to cover the whole range of intellectual development. This includes the time when a child grasps the idea of finding a missing piece to complete a pattern and time taken to sufficiently assess a person's maximum capacity to form comparisons and reason by analogy, without being unduly exhausting or unwieldy. The test can be administered either to an individual or group. The administrator of the test opened the book containing the SPM Sets A, B, C, D and E at the first illustration A1, pointing to the upper figure. The administrator explained to the child that it was a pattern with a bit taken out and only one bit of the bits below A1 is the right shape to fit the space to complete the pattern. The child was asked to point at the correct number of the bit and this number was noted down by the administrator. Further, the administrator giving the test explained that on every page of the test booklet, there was a pattern with part or bit left out and which the child had to select and point the correct bit until the child completed pointing and selecting all the bits in the Set A, B, C, D and E; there was no time limit in the test.

The administrator recorded the number of the piece that the child pointed in each test in the appropriate place on the record form and simultaneously ensured the pages of the test booklet were turned over, one at a time. If necessary, the child's attention was guided to each problem in its standard order. Apart from this, the test administrator gave no assistance in the method of working; the standard order in which the problems were presented provided the necessary training. A person's score on the scale was the total number of problems solved correctly when the person was allowed to work quietly through the series from the beginning to the end.

The consistency of a person's work was assessed by subtracting from a person's score, on each of the five sets (Sets A, B, C, D & E) the score normally expected on each set, for the same total score, on a reference scale.

#### **(iv) Coding-B sub-test**

##### **Method**

Using a key the child drew each symbol in its corresponding shape or box within a specified time limit of 120 seconds; the sub-test administrator began timing after saying the last word of the instructions and timing was stopped when all the rows were completed or 120 seconds elapsed. The sub-test administrator placed the page with the sub-test in front of the child and pointed to the key at the boxes at the top of the page. Each box had a number in the top part and a special mark in the bottom part; each number had its own mark. The administrator pointed to the sample items in the left side of the page and explained that the boxes had numbers in the top parts but were empty in the bottom parts; the child was required to draw the marks that belonged to the empty boxes using a pencil without an eraser. The child was allowed to work alone on the remaining sample items and if the child made a mistake the error was corrected immediately. When the child had successfully completed the sample items, the administrator proceeded to the sub-test items and explained further. When the administrator said "go", the child began to work on the sub-test while the administrator simultaneously began timing; the administrator allowed 120 seconds for the sub-test. The total raw score was considered to be the number of correctly drawn symbols completed in 120 seconds.

**(v) Symbol Search-B sub-test****Method**

The child scanned a search group and indicated whether a target symbol (s) matched any of the symbols in the search group within a specified time limit of 120 seconds; the sub-test administrator began timing after saying the last word of the instructions. Timing was stopped when the child completed all the items or 120 seconds elapsed. The total raw score was the number of correct responses minus the number of incorrect responses. In addition, if the total raw score was equal to or less than 0, then the total raw score was entered as 0.

**(vi) Digit Span Backwards and Forwards (DSF)****(i) Digit Span Forwards (DSF)****Method**

The sub-test administrator told the child that some numbers would be said and when finished, the child repeated and said the numbers, after the administrator, in the same order as read aloud by the examiner. The child was told by the administrator to proceed to Trial 1 of Item 1 and then administered Trial 1 and Trial 2 of each item. The administrator proceeded to the next item if the discontinue criterion had not been met. However, the sub-test was discontinued after the child scored 0 on both trials of an item.

**(ii) Digit Span Backwards (DSB)****Method**

The child repeated numbers in the reverse order of that presented aloud by the administrator (examiner).

The sub-test administrator told the child that some more numbers would be said but this time round, when the administrator stopped, the child should say the numbers backwards, after the administrator. The administrator then proceeded to read the first practice trial indicated as 8-2, then 5-6. After the practice trial, the administrator proceeds to Trial 1 of Item 1 and then administered Trial 1 and Trial 2 of each item. However, assistance on the sample of Digit Span Backwards only, was to be provided. The administrator proceeded to the next item if the discontinue criterion had not been met. The sub-test was discontinued after the child scored 0 on both trials of an item. The Digit Span backwards was to be administered regardless of the child's performance on Digit Span Forwards. For each trial, 1 point was scored for a correct response or 0 points for an incorrect response or no response; the item score was the sum of the scores on the two trials for that item. The total raw score for Digit Span was the sum of the item scores for both Digit Span Forwards (DSF) and Digit Span Backwards (DSB)



**(ii) LIST MEMORY (LM) – (NEPSY-II) sub-Test (for ages 7-12 yrs)**  
**Present each list Trial Items at the rate of One Word every second**

Word List	Responses				
	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5
Store					
Puppy					
Finger					
Window					
Grass					
Letter					
Fish					
Pupil					
Winter					
Cat					
Pencil					
Fence					
Teacher					
Water					
Boat					
Total correct =					

**(iii) STANDARD PROGRESSIVE MATRICES (SPM) (IQ Estimate test) (All ages)**  
**No Time Limit for completion**

STANDARD PROGRESSIVE MATRICES (SPM) (IQ Test) SCORING KEY FORM					
	SET				
	A	B	C	D	E
<b>1</b>					
<b>2</b>					
<b>3</b>					
<b>4</b>					
<b>5</b>					
<b>6</b>					
<b>7</b>					
<b>8</b>					
<b>9</b>					
<b>10</b>					
<b>11</b>					
<b>12</b>					

**(iv) CODING (B) –(WISC-IV<sup>UK</sup>) sub-Test (for Ages 8-16 yrs)****Time Limit = 120 Seconds**

Age (yrs)	Coding	Time Limit (Seconds)	Completion Time (Seconds)	Total Raw Score (Max. Score = 119 Points)
8-16	B	120		

**(v) SYMBOL SEARCH (B)-(WISC-IV<sup>UK</sup>) sub-Test (for Ages 8-16 yrs)****Time Limit = 120 seconds**

Age (yrs)	Symbol Search	Time Limit (Seconds)	Completion Time (Seconds)	No. Correct	No. Wrong	Total Raw Score (Max. Score = 60 Points)
8-16	B	120				

**(vi) (a) Digit Span Forwards (DSF) sub-Test (for Ages 6-16 yrs)****No Time Limit: Discontinue after Scores of 0 on both Trials of an Item****(I) Digit Span Forwards (DSF) (Max. Score = 16 Points)**

	Item Trials	Response Scores	DSF Total Raw Score	Trial Score	Item Score
1.	2 - 9			0 1	0 1 2
	4 - 6			0 1	0 1 2
2.	3 - 8 - 6			0 1	0 1 2
	6 - 1 - 2			0 1	0 1 2
3.	3 - 4 - 1 - 7			0 1	0 1 2
	6 - 1 - 5 - 8			0 1	0 1 2
4.	8 - 4 - 2 - 3 - 9			0 1	0 1 2
	5 - 2 - 1 - 8 - 6			0 1	0 1 2
5.	3 - 8 - 9 - 1 - 7 - 4			0 1	0 1 2
	7 - 9 - 6 - 4 - 8 - 3			0 1	0 1 2
6.	5 - 1 - 7 - 4 - 2 - 3 - 8			0 1	0 1 2
	9 - 8 - 5 - 2 - 1 - 6 - 3			0 1	0 1 2
7.	1 - 8 - 4 - 5 - 9 - 7 - 6 - 3			0 1	0 1 2
	2 - 9 - 7 - 6 - 3 - 1 - 5 - 4			0 1	0 1 2
8.	5 - 3 - 8 - 7 - 1 - 2 - 4 - 6 - 9			0 1	0 1 2
	4 - 2 - 6 - 9 - 1 - 7 - 8 - 3 - 5		=	0 1	0 1 2

## (vi) (b) Digit Span Backwards (= DSB) sub-Test (for Ages 6-16 yrs)

**No Time Limit: Discontinue after Scores of 0 on both Trials of an Item****(II) Digit Span Backwards (DSB) (Max. Score = 16 Points)**

		Response Scores	DSB Total Raw Score	Trial Score	Item Score
<b>Sample Item</b>	<b>8 - 2</b>				
	<b>5 - 6</b>				
	<b>Item Trials</b>				
<b>1.</b>	2 - 1			<b>0 1</b>	<b>0 1 2</b>
	1 - 3			<b>0 1</b>	<b>0 1 2</b>
<b>2.</b>	3 - 5			<b>0 1</b>	<b>0 1 2</b>
	6 - 4			<b>0 1</b>	<b>0 1 2</b>
<b>3.</b>	5 - 7 - 4			<b>0 1</b>	<b>0 1 2</b>
	2 - 5 - 9			<b>0 1</b>	<b>0 1 2</b>
<b>4.</b>	7 - 2 - 9 - 6			<b>0 1</b>	<b>0 1 2</b>
	8 - 4 - 9 - 3			<b>0 1</b>	<b>0 1 2</b>
<b>5.</b>	4 - 1 - 3 - 5 - 7			<b>0 1</b>	<b>0 1 2</b>
	9 - 7 - 8 - 5 - 2			<b>0 1</b>	<b>0 1 2</b>
<b>6.</b>	1 - 6 - 5 - 2 - 9 - 8			<b>0 1</b>	<b>0 1 2</b>
	3 - 6 - 7 - 1 - 9 - 4			<b>0 1</b>	<b>0 1 2</b>
<b>7.</b>	8 - 5 - 9 - 2 - 3 - 4 - 6			<b>0 1</b>	<b>0 1 2</b>
	4 - 5 - 7 - 9 - 2 - 8 - 1			<b>0 1</b>	<b>0 1 2</b>
<b>8.</b>	6 - 9 - 1 - 7 - 3 - 2 - 5 - 8			<b>0 1</b>	<b>0 1 2</b>
	3 - 1 - 7 - 9 - 5 - 4 - 8 - 2		<b>=</b>	<b>0 1</b>	<b>0 1 2</b>

**Appendix 3:  
Cognitive Description sub-Test Scaled Scores, Percentile Rank and Overall IQ**

Overall IQ	SD's from mean	Description	Subtest Scaled Scores	Percentile Rank
145	+3		19	99.9
140	+2.7	Very Superior	18	99.6
135	+2.3	(≥ 130)	17	99
130	+2		16	98
125	+1.7	Superior	15	95
120	+1.3	(120-129)	14	91
115	+1	Bright Average	13	84
110	+0.7	(110-119)	12	75
105	+0.3		11	63
100	0	Average	10	50
95	-0.3	(90-109)	9	37
90	-0.7		8	25
85	-1	Low Average	7	16
80	-1.3	(80-89)	6	9
75	-1.7	Significantly below average	5	5
70	-2	(70-79)	4	2
65	-2.3	"Below 5th percentile"	3	1
60	-2.7	or give exact percentile	2	0.4
55	-3	(<69)	1	0.1

**Change**

Mild = 10 points (1 level)

Moderate = 2 or more levels

Severe = currently very badly off eg. was 120, is now VIQ = 100 and PIQ = 60

"Has suffered severe general deterioration with performance skills bearing the brunt or verbal skills relatively spared".

**Appendix 4: Structured School Questionnaire**

Date: Serial No.: School: Class:

Name: ID. No.: Gender: Sex:

Age (Yrs):

Village: Sub-Loc: Loc: Division:

District:

Height (cm.): Weight (Kg.): Head Circumference (cm.):

Upper Arm Circumference (cm.): Sub-Scapular skin thickness (mm.):

Unusual Physical features:

Q (1) Have you felt sick in the last three months? No  Yes 

Q (2) If yes to Q1 above, what were the symptoms?

Stomachache  Headache  Diarrhoea  Fever  Vomiting   
Coughing  Others 

Q (3) Where did you go for treatment?

Nowhere  Traditional healer  Dispensary Q (4) Have you ever seen worms in your stool? No  Yes 

Q (5) If yes to Q. 4 above, how big were the worms? (Ask the respondent to describe)

Small (< 2 cm.)  Medium ( $\leq$  5 cm.)  Large (> 5cm) Q (6) Did you inform your parent/ guardian or teacher about the worms? No  Yes Q (7) If yes to Q. 6 above, were you given any medicine? No  Yes Q (8) Do you eat raw fruits, vegetables, cassavas or sweet potatoes? No  Yes Q (9) If yes to Q9 above, do you wash them before eating? No  Yes Q (10) Do you wear shoes? No  Sometimes  Always

Q (11) Do you play or work in moist/ wet soil? No  0 Yes  1

Q (12) Do you use a latrine at home? No  0 Yes  1

Q (13) Do you wash your hands before eating? No  0 Yes  1 Sometimes  2

Q (14) What is economic activity of your father? None  0 Animal keeping  1

Crop farming  2 Formal employment  3 Casual employment  4 Business man  5

Q (15) What is economic activity (Occupation) of your mother? None  0 Animal keeping  1

Crop farming  2 Formal employment  3 Casual employment  4 Business woman  5

Q (16) What is education level of your father?

None  0 Primary  1 Secondary  2 College  3

Q (17) What is education level of your mother?

None  0 Primary  1 Secondary  2 College  3

Q (18) Do you eat the following meals? Breakfast? No  0 Yes  1 Sometimes  2

Lunch? No  0 Yes  1 Sometimes  2

Supper? No  0 Yes  1 Sometimes  2

Q (19) Do you usually eat the following foods?

A. Maize  1 Potatoes  2 Rice  3 Bread  4

B. Meat  1 Milk  2 Beans  3

C. Vegetables  1

D. Fruits  1

Q (20.) Have you been absent from school in the last one term? No  0 Yes  1

Q (21) If yes to Q. (20) above what was the reason? Sickness  1 Migrated  2 Others  3

Q (22) Are you beaten by your Father? No  0 Yes  1 Mother? No  0 Yes  1

Brother? No  0 Yes  1 Sister? No  0 Yes  1

Q (23) Who helps you with your homework? No one  0 Father  1 Mother  2

Brother  3 Sister  4 Friend  5 Neighbour  6

Q (24) Do your parents/ guardian buy you reading books? No  0 Yes  1

Q (25) Do you have a study table and chair at home? No  0 Yes  1

Q (26) Do your parents/ guardian buy you school uniform? No  0 Yes  1

Q (27) Among the following problems, which one(s) have you experienced recently?

Concentration  1 Forgetting  2 Paying attention  3 Remembering  4

.....END.....

**THANK YOU VERY MUCH FOR PARTICIPATING**

**NAME OF DATA COLLECTOR..... DATE.....**





**Appendix 6 (i): Ministry of Higher Education, Science and Technology License**



REPUBLIC OF KENYA

**MINISTRY OF HIGHER EDUCATION SCIENCE  
& TECHNOLOGY**

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JOGOO HOUSE "B"  
HARAMBEE AVENUE,  
P.O. Box 9583-00200  
NAIROBI

When Replying please quote

**Ref. MOHEST 13/001/ 38C 716/2**

**14<sup>th</sup> November 2008**

Benedict Mwenji  
Kenyatta University  
P.O. Box 3900  
**NAIROBI**

**RE: RESEARCH AUTHORIZATION**

Following your application for authority to carry out research on, *'Geohelmithiases and Cognitive Functions in Primary School Age Children in Class 3 and 4 of Kajiado District, Kenya,*

I am pleased to inform you that you have been authorized to carry out research in Kajiado District for a period ending 30<sup>th</sup> November 2010.

You are advised to report to the District Commissioner and the District Education Officer Kajiado District before embarking on your research.

On completion of your research, you are expected to submit two copies of your research report to this office.

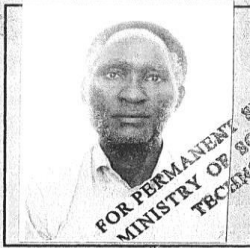
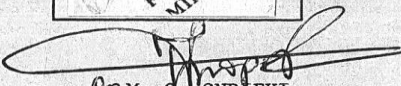
**M. O. ONDIEKI  
FOR: PERMANENT SECRETARY**

Copy to:

The District Commissioner  
**Kajiado District**

The District Education Officer  
**Kajiado District**

**Appendix 6 (ii): Ministry of Higher Education, Science & Technology ID. Card**

<p>PAGE 2</p> <p><b>THIS IS TO CERTIFY THAT:</b>                  Prof./Dr./Mr./Mrs./Miss..... <u>BENEDICT MWENJI</u></p> <p>.....                  of (Address)..... <u>KENYATTA UNIVERSITY</u>  <u>P.O. BOX 43844 NAIROBI</u></p> <p>.....                  has been permitted to conduct research in.....                  .....Location,  <u>KAJIADO</u>.....District,  <u>RIFT VALLEY</u>.....Province,                  on the topic..... <u>GEOHELMINTHIASES AND COGNITIVE</u>  <u>FUNCTION IN PRIMARY SCHOOL AGE CHILDREN</u>  <u>IN CLASS 3 AND 4 OF KAJIADO DISTRICT</u>  <u>KENYA.</u></p> <p>.....                  for a period ending <u>30TH NOVEMBER</u>, 20 <u>10</u></p>	<p>PAGE 3</p> <p>Research Permit No. <u>MOHEST 13/001/38C 715</u>                  Date of issue..... <u>12/11/2008</u>                  Fee received..... <u>KSHS.1,000/=</u></p> <div style="text-align: center;">  <p style="font-size: small; transform: rotate(-45deg); opacity: 0.5;">FOR PERMANENT SECRETARY MINISTRY OF SCIENCE AND TECHNOLOGY</p> </div> <p style="text-align: center;">   <u>M. C. ONDIEKI</u>                  Applicant's Signature FOR Permanent Secretary                  FOR PERMANENT SECRETARY                  MINISTRY OF SCIENCE AND TECHNOLOGY             </p>
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## Appendix 7: Directorate of City Education Approval Letter



TELEGRAM "SCHOOLING"  
TELEPHONE: 221166/224281  
EXT: 2426 /2590

CITY HALL ANNEXE  
P. O. BOX 30298 GPO  
NAIROBI

### CITY EDUCATION DEPARTMENT

GL/NC/141 VOL III/185

3<sup>rd</sup> June, 2010

The Headteachers  
Daniel Comboni primary school  
Mbagathi primary  
Ngunyumu primary  
Olympic primary  
Mukuru Kayaba primary

#### RE: RESEARCH AUTHORIZATION

Authority has been given to *Benedict M. Mwenji of Kenyatta University, Department of Zoological Sciences* to conduct a research on "*Intestinal Roundworms in school pupils in std. 2 to 6*". Parents should be informed early that the researcher will take stool and blood samples from the pupils for analysis.

To be on the safe side, you need to contact parents of the said pupils to give written consent by filling and signing a consent form which the researcher will provide you with. You will be the custodian of the signed forms. No parent should be forced to participate and no child should participate without the parents consent.

This activity should not interfere with teaching & learning in the school.

**JOSEPH M. MUSABA**  
**AG. DIRECTOR OF CITY EDUCATION**

c.c. Benedict M. Mwenji  
Kenyatta University  
P.O. Box 43844, **Nairobi**

“ Education Officers – Kasarani, Langata & Makadara districts

**Appendix 8 (i): Approval Letter of the Department of Health-Nairobi City Council**



**SHAUHI KWA UAMINIFI**

*MEDICAL OFFICER OF HEALTH*  
 TEL: 2224281/2219849/2218119/2219432/  
 2210382/2224292/91 Ext. 2390  
 D/L: 2248316  
 Website: Citycouncilofnairobi.go.ke

P.O BOX 30108-00100  
 CITY HALL  
 NAIROBI.

**PUBLIC HEALTH DEPARTMENT**

PHD/MOH/R.1 VOL.1 (74)/10

18<sup>TH</sup> MAY, 2010

BENEDICT M. MWENJI  
 KENYATTA UNIVERSITY  
 P O BOX 43844  
**NAIROBI**

**RE: REQUEST FOR AUTHORITY TO CARRY OUT RESEARCH ON  
 GEOHELMITHIASIS AND COGNITIVE FUNCTIONS IN PRIMARY SCHOOL  
 AGE CHILDREN IN CLASS 3 AND 4 IN NAIROBI DISTRICT SCHOOLS.**

Reference is made to the above subject matter.

I write to inform you that permission is granted but the following shall apply during your period of research.

- Payment of kshs.5,000 (Five thousand shillings only) Research fee.
- You will be expected to adhere to the rules and regulations pertaining to the City Council of Nairobi.
- That during your research there will be no cost devolving to the Council.
- That you undertake to indemnify the Council against any claim that may arise from the research.
- A copy of the research findings must be submitted to the office of the undersigned.

By a copy of this letter the in charge of the schools are requested to accord you the necessary assistance.

*Dr. R. K. Ayisi HSC*

**DR. ROBERT K. AYISI, HSC**  
**MEDICAL OFFICER OF HEALTH**

**Appendix 8 (ii): Authority License of Department of Health-Nairobi City Council**



**LOCAL AUTHORITY INTEGRATED FINANCIAL OPERATIONS MANAGEMENT SYSTEMS**

<b>BILL</b>	
Bill No.	ED1005-00110
Date Issued	31-May-2010

**LA Name: 001 CITY COUNCIL OF NAIROBI**

*(Customer Copy)*

**CUSTOMER SERVICES OFFICE**  
The Customer Services Office Notifies

**BENEDICT M MWENYI**

that the amount shown below is due to be paid at your earliest convenience.

Payment is due at the CASH OFFICE of the Council  
**KENYATTA UNIVERSITY**

DETAIL OF CHARGES			
No.	Account Code	Description	Amount (KSh)
1.	1-8243	ATTACHMENT AND RESEARCH FEES	5,000.00
<b>BILL TOTAL AMOUNT (KSH)</b>			<b>5,000.00</b>
0012492010052103 CSH5000 ED1005-00110-5000 [BENEDICT M MWENYI] 201005310820			

RECEIVED BY EWANJIKU	<b>Payment Information</b>
THANK YOU	

**Appendix 9: Modified Ridley's Formol-Ether Stool Concentration Method  
(Allen and Ridley, 1970)**

**Method**

- (1) 4 mls. of 10% Formol-saline solution were measured and poured into a mortar.
- (2) 2 gms. of stool were weighed, placed into the mortar bowl and using a pestle the stool was thoroughly emulsified.
- (3) The stool emulsion was sieved through four layers of wet surgical gauze into a centrifuge tube, using a thistle funnel.
- (4) 3-4 mls of diethyl-ether were added and a rubber cork placed onto the mouth of the tube.
- (5) The tube was then shaken thoroughly for twenty seconds, taking care to hold the cork firmly in place.
- (6) The tube contents were centrifuged at 2,000 revolutions per minute for 3 minutes and using an applicator stick, the plug of debris was removed.
- (7) The remaining fluid (supernatant) in the tube was decanted into the sink, leaving at the bottom a button of stool for microscopic examinations.
- (8) Using an applicator stick, the entire button was carefully dislodged from the tube bottom and poured directly onto a clean microscope slide.
- (9) The entire stool preparation was examined after mixing the film with a drop of 1% Lugol's iodine stain. Microscopy was done using x10 objective and x40 Objectives and all the eggs and/or larvae of parasites were counted. Results were divided by 2 to get the number of eggs or larvae per gram of stool and reported accordingly.

**Appendix 10: Kato-Katz Thick Stool Smear Method (WHO, 2012)****Method**

1. 1-2 gms of stool was placed on a sheet of disposable paper.
2. Stool was pressed through the gauze square to obtain an estimated 50 mgs of specimen.
3. 50 mgs of stool were transferred onto a glass slide.
4. A drop of 50% glycerol was added, mixed with the specimen and covered with a glass.
5. Using another slide, the preparation was carefully pressed on the laboratory bench.
6. The preparation is left at room temperature for 45-60 minutes to clear faecal debris.
7. Entire preparation was examined microscopically.
8. The number of eggs counted multiplied by a factor of 20 gave the number of eggs per gramme of stool.

**Appendix 11: Giemsa Staining Technique for *Plasmodium* species of man  
(Baker *et al.*, 1998)****Method**

- (1) Thin and thick blood films were prepared and fixed in absolute methanol for 3 minutes
- (2) Giemsa stain diluted (1 in 9) in buffered saline (pH 7-7.1) was flooded on slides and stained and allowed to stain for 1 hour
- (3) Blood films were washed and differentiated with buffered saline solution by controlling the degree of differentiation microscopically
- (4) Stained slides were drained and dried in the air at room temperature for 30 minutes
- (5) Stained slides were examined microscopically for *Plasmodia* species, using x 100 Oil immersion Objective

## Appendix 12 (i)

Table 4.19: Factors influencing WGS Cognitive Performance

	<i>p</i> -Value
Class	> 0.963*
School	> 0.908*
District	> 0.593*
Village	> 0.11*
Sex	> 0.056*
<i>A. lumbricoides</i> infections	> 0.675*
Hookworms	> 0.68*
Suffered sickness	> 0.72*
Stomachache	> 0.522*
Headache	> 0.351*
Fever	> 0.86*
Vomit	> 0.343*
Cough	> 0.269*
Treatment	> 0.994*
Seen worms in stool	> 0.681*
Worm-size	> 0.996*
Washing raw foods before eating	> 0.304*
Wearing shoes	> 0.091*
Playing with moist soil	> 0.061*
Lack of latrine	> 0.177*
Father's possession of farm animals	> 0.088*
Father's formal employment status	> 0.95*
Father's casual employment status	> 0.876*
Father's business status	> 0.674*
Father's education status	> 0.81*
Mother's education status	> 0.36*
Missing breakfast occasionally	> 0.34*
Missing lunch occasionally	> 0.396*
Missing supper occasionally	> 0.686*
Eating maize	> 0.789*
Eating meat	> 0.897*
Drinking milk	> 0.524*
Eating beans	> 0.956*
Absence from school	> 0.557*
Absence from school due to sickness	> 0.387*
Absence from school due to emigration	> 0.109*
Beating	> 0.062*
Beating by father	> 0.259*
Beating by mother	> 0.11*
Beating by brother	> 0.987*
Help with homework	> 0.209*
Help with homework by father	> 0.765*
Help with homework by mother	> 0.742*

Help with homework by brother	> 0.347*
Help with homework by sister	> 0.326*
Help with homework by neighbours	> 0.209*
Provision of school uniform	> 0.853*
Problems with concentrate on school work	> 0.131*
Forgetting	> 0.818*
Depressed alertness	> 0.253*
Problems with remembering	> 0.438*

\*Test result: Not significant

Appendix 12 (ii)  
Table 4.20: Factors influencing WGI Cognitive Performance *p*-Value

Class	
School	> 0.536*
District	> 0.945*
Village	> 0.123*
Sex	> 0.112*
<i>T. trichiura</i> infections	> 0.142*
<i>A. lumbricoides</i>	> 0.233*
Hook worms ( <i>A. duodenale</i> or <i>N. americanus</i> )	> 0.294*
Suffered sickness	> 0.519*
Stomachache	> 0.751*
Headache	> 0.799*
Diarrhoea	> 0.329*
Fever	> 0.915*
Vomit	> 0.592*
Cough	> 0.331*
Treatment	> 0.162*
Seeing worms in stool	> 0.616*
Worm-size	> 0.98*
Eating raw foods	< 0.406*
Washing raw foods before eating	> 0.061*
Lack of shoes	> 0.565*
Playing with moist soil	> 0.328*
Lack of latrine	> 0.908*
Eating with unwashed hands	< 0.566*
Father's possession of farm animals	> 0.69*
Father's ability to grow Food-crops	> 0.12*
Father's formal employment status	> 0.543*
Father's casual employment status	> 0.839*
Father's business status	> 0.658*
Father's education status	> 0.721*
Mother's education status	> 0.716*
Missing breakfast occasionally	> 0.078*

Missing lunch occasionally	> 0.61*
Missing supper occasionally	> 0.746*
Eating maize	> 0.642*
Eating meat	> 0.979*
Lack of milk	> 0.645*
Eating beans	> 0.607*
Eating fruits	> 0.756*
Absence from school	> 0.65*
Absence from school due to sickness	> 0.672*
Absence from school due to other reasons	> 0.472*
Absence from school due to emigration	> 0.369*
Beating	> 0.102*
Beating by father	> 0.363*
Beating by mother	> 0.685*
Beating by brother	> 0.522*
Beating by sister	> 0.493*
Help with homework	> 0.481*
Help with homework by father	> 0.937*
Help with homework by mother	> 0.443*
Help with homework by brother	> 0.325*
Help with homework by sister	> 0.1*
Help with homework by friends	> 0.965*
Help with homework by neighbours	> 0.285*
Lack of table and chair for studies	> 0.155*
Lack of school uniform	> 0.525*
Problems with concentration on school work	> 0.11*

\*Test result: Not significant

#### Appendix 12 (iii)

Table 4.21: Factors influencing LM Cognitive Performance *p*-Value

School	> 0.417*
District	> 0.817*
Village	> 0.442*
Sex	> 0.994*
<i>T. trichiura</i> infections	> 0.966*
<i>A. lumbricoides</i> infections	> 0.642*
Hook worms ( <i>A. duodenale</i> or <i>N. americanus</i> )	> 0.584*
Suffered sickness	> 0.422*
Stomachache	> 0.212*
Headache	> 0.891*
Diarrhoea	> 0.115*
Vomit	> 0.762*
Cough	> 0.566*
Treatment	> 0.719*
Worm-size	> 0.066*

<b>Eating raw foods</b>	<b>&gt; 0.521*</b>
<b>Washing raw foods before eating</b>	<b>&gt; 0.611*</b>
<b>Failure to wear shoes</b>	<b>&gt;0.171*</b>
<b>Playing with moist soil</b>	<b>&gt;0.427*</b>
<b>Lack of latrine</b>	<b>&gt; 0.479*</b>
<b>Washing hands before eating</b>	<b>&gt; 0.891*</b>
<b>Father's possession of farm animals</b>	<b>&gt; 0.213*</b>
<b>Father's ability to grow food-crops</b>	<b>&gt; 0.651*</b>
<b>Father's formal employment status</b>	<b>&gt; 0.833*</b>
<b>Father's casual employment status</b>	<b>&gt; 0.614*</b>
<b>Father's business status</b>	<b>&gt; 0.265*</b>
<b>Father's education status</b>	<b>&gt; 0.427*</b>
<b>Mother's education status</b>	<b>&gt; 0.09*</b>
<b>Missing breakfast occasionally</b>	<b>&gt; 0.817*</b>
<b>Missing lunch occasionally</b>	<b>&gt; 0.46*</b>
<b>Missing supper occasionally</b>	<b>&gt; 0.631*</b>
<b>Eating maize</b>	<b>&gt; 0.18*</b>
<b>Eating meat</b>	<b>&gt; 0.877*</b>
<b>Lack of milk</b>	<b>&gt; 0.606*</b>
<b>Eating beans</b>	<b>&gt; 0.274*</b>
<b>Eating fruits</b>	<b>&gt; 0.736*</b>
<b>Absence from school</b>	<b>&gt; 0.34*</b>
<b>Absence from school due to sickness</b>	<b>&gt; 0.573*</b>
<b>Absence from school due to other reasons</b>	<b>&gt; 0.777*</b>
<b>Absence from school due to emigration</b>	<b>&gt; 0.517*</b>
<b>Beating</b>	<b>&gt; 0.7*</b>
<b>Beating by father</b>	<b>&gt; 0.622*</b>
<b>Beating by mother</b>	<b>&gt; 0.676*</b>
<b>Beating by brother</b>	<b>&gt; 0.292*</b>
<b>Beating by sister</b>	<b>&gt; 0.067*</b>
<b>Help with homework</b>	<b>&gt; 0.061*</b>
<b>Help with homework by father</b>	<b>&gt; 0.805*</b>
<b>Help with homework by mother</b>	<b>&gt; 0.848*</b>
<b>Help with homework by brother</b>	<b>&gt; 0.238*</b>
<b>Help with homework by sister</b>	<b>&gt; 0.537*</b>
<b>Help with homework by friends</b>	<b>&gt; 0.795*</b>
<b>Help with homework by neighbours</b>	<b>&gt; 0.282*</b>
<b>Lack of table and chair for studies</b>	<b>&gt; 0.102*</b>
<b>Lack of school uniform</b>	<b>&gt; 0.407*</b>
<b>Problems with concentration on school work</b>	<b>&gt; 0.354*</b>
<b>Forgetting</b>	<b>&gt; 0.935*</b>
<b>Problems with remembering</b>	<b>&gt; 0.851*</b>

\*Test result: Not significant

**Appendix 12 (iv)**  
**Table 4.22: Factors influencing SPM Cognitive Performance** *p*-Value

School	> 0.717*
District	> 0.679*
Village	> 0.737*
Sex	> 0.252*
<i>T. trichiura</i> infections	> 0.393*
<i>A. lumbricoides</i> infections	> 0.249*
Hook worms ( <i>A. duodenale</i> or <i>N. americanus</i> )	> 0.51*
Suffered sickness	> 0.084*
Stomachache	> 0.794*
Headache	> 0.499*
Diarrhoea	> 0.701*
Fever	> 0.817*
Vomiting	> 0.94*
Cough	> 0.468*
Treatment	> 0.932*
Seeing worms in stool	> 0.231*
Worm-size	> 0.086*
Washing raw foods before eating	> 0.938*
Failure to wear shoes	> 0.339*
Playing with moist soil	> 0.933*
Lack of latrine	> 0.647*
Washing hands before eating	> 0.516*
Father's possession of farm animals	> 0.772*
Father's ability to grow food-crops	> 0.751*
Father's formal employment status	> 0.694*
Father's casual employment status	> 0.174*
Father's business status	> 0.779*
Father's education status	> 0.144*
Mother's education status	> 0.4*
Missing breakfast occasionally	> 0.949*
Missing lunch occasionally	> 0.441*
Missing supper occasionally	> 0.674*
Eating maize	> 0.284*
Eating meat	> 0.614*
Lack of milk	> 0.649*
Eating beans	> 0.64*
Eating fruits	> 0.188*
Absence from school	> 0.246*
Absence from school due to sickness	> 0.678*
Absence from school due to other reasons	> 0.358*
Absence from school due to emigration	> 0.312*
Beating	> 0.344*
Beating by father	> 0.439*

Beating by mother	> 0.065*
Being beaten by brother	> 0.135*
Beating by sister	> 0.262*
Help with homework	> 0.899*
Help with homework by father	> 0.968*
Help with homework by mother	> 0.229*
Help with homework by sister	> 0.237*
Help with homework by friends	> 0.175*
Help with homework by neighbours	> 0.803*
Lack of table and chair for studies	> 0.143*
Provision of school uniform	> 0.279*
Lack of concentration on school work	> 0.146*
Depressed alertness	> 0.796*
Problems with remembering	> 0.76*

\*Test result: Not significant

#### Appendix 12 (v)

**Table 4.23: Factors influencing Coding-B Cognitive Performance** *p*-Value

School	> 778*
District	> 0.379*
Sex	> 0.063*
<i>T. trichiura</i> infections	> 0.233*
<i>A. lumbricoides</i> infections	> 0.596*
Hook worms ( <i>A. duodenale</i> or <i>N. americanus</i> )	> 0.819*
Suffered sickness	> 0.565*
Stomachache	> 0.069*
Headache	> 0.45*
Diarrhoea	> 0.163*
Fever	> 0.214*
Vomiting	> 0.649*
Cough	> 0.062*
Treatment	> 0.467*
Seeing worms in stool	> 0.451*
Worm-size	> 0.965*
Eating raw foods	> 0.838*
Washing raw foods before eating	> 0.343*
Failure to wear shoes	> 0.879*
Playing with moist soil	> 0.342*
Lack of latrine	> 0.379*
Washing hands before eating	> 0.986*
Father's possession of farm animals	> 0.575*
Father's ability to grow food-crops	> 0.1*
Father's formal employment status	> 0.296*
Father's casual employment status	> 0.059*

Father's business status	> 0.097*
Father's education status	> 0.524*
Mother's education status	> 0.279*
Missing breakfast occasionally	> 0.83*
Missing lunch occasionally	> 0.605*
Missing supper occasionally	> 0.718*
Eating maize	> 0.554*
Eating meat	> 0.361*
Lack of milk	> 0.581*
Eating beans	> 0.167*
Eating fruits	> 0.366*
Absence from school	> 0.025*
Absence from school due to sickness	> 0.872*
Absence from school due to other reasons	> 0.078*
Absence from school due to emigration	> 0.055*
Beating	> 0.175*
Beating by father	> 0.25*
Beating by mother	> 0.877*
Beating by brother	> 0.219*
Beating by sister	> 0.777*
Help with homework	> 0.134*
Help with homework by father	> 0.764*
Help with homework by mother	> 0.339*
Help with homework by brother	> 0.168*
Help with homework by sister	> 0.741*
Help with homework by friends	> 0.635*
Help with homework by neighbours	> 0.065*
Lack of table and chair for studies	> 0.025*
Lack of school uniform	> 0.87*
Problems with concentrating on school work	> 0.395*
Forgetting	< 0.721*
Depressed alertness	> 0.218*
Problems with remembering	> 0.88*

\*Test result: Not significant

#### Appendix 12 (vi)

**Table 4.24: Factors influencing SS-B Cognitive Performance** *p*-Value

Class	> 0.225
School	> 772*
District	> 0.148*
Sex	> 0.931*
<i>T. trichiura</i> infections	> 0.47*
Hook worms ( <i>A. duodenale</i> or <i>N. americanus</i> )	> 0.149*

<b>Suffered sickness</b>	<b>&gt; 0.587*</b>
<b>Stomachache</b>	<b>&gt; 0.806*</b>
<b>Headache</b>	<b>&gt; 0.912*</b>
<b>Diarrhoea</b>	<b>&gt; 0.654*</b>
<b>Fever</b>	<b>&gt; 0.401*</b>
<b>Cough</b>	<b>&gt; 0.517*</b>
<b>Treatment</b>	<b>&gt; 0.82*</b>
<b>Seeing worms in stool</b>	<b>&gt; 0.217*</b>
<b>Worm-size</b>	<b>&gt; 0.172*</b>
<b>Eating raw foods</b>	<b>&gt; 0.082*</b>
<b>Washing raw foods before eating</b>	<b>&gt; 0.975*</b>
<b>Failure to wearing shoes</b>	<b>&gt;0.662*</b>
<b>Playing with moist soil</b>	<b>&gt;0.754*</b>
<b>Lack of latrine</b>	<b>&gt; 0.365*</b>
<b>Washing hands before eating</b>	<b>&gt; 0.29*</b>
<b>Father's possession of farm animals</b>	<b>&gt; 0.647*</b>
<b>Father's ability to grow food-crops</b>	<b>&gt; 0.064*</b>
<b>Father's formal employment status</b>	<b>&gt; 0.267*</b>
<b>Father's casual employment status</b>	<b>&gt; 0.175*</b>
<b>Father's business status</b>	<b>&gt; 0.701*</b>
<b>Father's education status</b>	<b>&gt; 0.492*</b>
<b>Mother's education status</b>	<b>&gt; 0.246*</b>
<b>Missing breakfast occasionally</b>	<b>&gt; 0.637*</b>
<b>Missing lunch occasionally</b>	<b>&gt; 0.495*</b>
<b>Missing supper occasionally</b>	<b>&gt; 0.502*</b>
<b>Eating maize</b>	<b>&gt; 0.339*</b>
<b>Eating meat</b>	<b>&gt; 0.842*</b>
<b>Lack of milk</b>	<b>&gt; 0.63*</b>
<b>Eating beans</b>	<b>&gt; 0.974*</b>
<b>Eating fruits</b>	<b>&gt; 0.973*</b>
<b>Absence from school</b>	<b>&gt; 0.42*</b>
<b>Absence from school due to emigration</b>	<b>&gt; 0.35*</b>
<b>Beating</b>	<b>&gt; 0.624*</b>
<b>Beating by father</b>	<b>&gt; 0.867*</b>
<b>Beating by mother</b>	<b>&gt; 0.831*</b>
<b>Beating by brother</b>	<b>&gt; 0.079*</b>
<b>Beating by sister</b>	<b>&gt; 0.432*</b>
<b>Help with homework</b>	<b>&gt; 0.28*</b>
<b>Help with homework by father</b>	<b>&gt; 0.552*</b>
<b>Help with homework by mother</b>	<b>&gt; 0.208*</b>
<b>Help with homework by brother</b>	<b>&gt; 0.275*</b>
<b>Help with homework by sister</b>	<b>&gt; 0.211*</b>
<b>Help with homework by friends</b>	<b>&gt; 0.153*</b>
<b>Help with homework by neighbours</b>	<b>&gt; 0.153*</b>
<b>Lack of table and chair for studies</b>	<b>&gt; 0.153*</b>

<b>Problems of concentration on school work</b>	<b>&gt; 0.928*</b>
<b>Forgetting</b>	<b>&lt; 0.996*</b>
<b>Depressed alertness</b>	<b>&gt; 0.171*</b>
<b>Problems with remembering</b>	<b>&gt; 0.507*</b>

\*Test result: Not significant

#### Appendix 12 (vii)

**Table 4.25: Factors influencing DSP Cognitive Performance** *p*-Value

<b>School</b>	<b>&gt; 431*</b>
<b>District</b>	<b>&gt; 0.931*</b>
<b>Village</b>	<b>&gt; 0.382*</b>
<b><i>A. lumbricoides</i> infections</b>	<b>&gt; 0.879*</b>
<b>Hook worms (<i>A. duodenale</i> or <i>N. americanus</i>)</b>	<b>&gt; 0.068*</b>
<b>Suffered sickness</b>	<b>&gt; 0.227*</b>
<b>Stomachache</b>	<b>&gt; 0.056*</b>
<b>Headache</b>	<b>&gt; 0.706*</b>
<b>Diarrhoea</b>	<b>&gt; 0.125*</b>
<b>Fever</b>	<b>&gt; 0.577*</b>
<b>Vomiting</b>	<b>&gt; 0.705*</b>
<b>Cough</b>	<b>&gt; 0.282*</b>
<b>Treatment</b>	<b>&gt; 0.987*</b>
<b>Seeing worms in stool</b>	<b>&gt; 0.163*</b>
<b>Worm-size</b>	<b>&gt; 0.081*</b>
<b>Eating raw foods</b>	<b>&gt; 0.22*</b>
<b>Washing raw foods before eating</b>	<b>&gt; 0.697*</b>
<b>Failure to wear shoes</b>	<b>&gt; 0.481*</b>
<b>Washing hands before eating</b>	<b>&gt; 0.946*</b>
<b>Father's possession of farm animals</b>	<b>&gt; 0.184*</b>
<b>Father's ability to grow food-crops</b>	<b>&gt; 0.647*</b>
<b>Father's formal employment status</b>	<b>&gt; 0.774*</b>
<b>Father's casual employment status</b>	<b>&gt; 0.869*</b>
<b>Father's business status</b>	<b>&gt; 0.126*</b>
<b>Father's education status</b>	<b>&gt; 0.818*</b>
<b>Mother's education status</b>	<b>&gt; 0.371*</b>
<b>Missing breakfast occasionally</b>	<b>&gt; 0.279*</b>
<b>Missing lunch occasionally</b>	<b>&gt; 0.244*</b>
<b>Eating maize</b>	<b>&gt; 0.108*</b>
<b>Eating meat</b>	<b>&gt; 0.834*</b>
<b>Lack of milk</b>	<b>&gt; 0.745*</b>
<b>Eating beans</b>	<b>&gt; 0.501*</b>
<b>Eating fruits</b>	<b>&gt; 0.055*</b>
<b>Absence from school</b>	<b>&gt; 0.496*</b>
<b>Absence from school due to sickness</b>	<b>&gt; 0.891*</b>

Absence from school due to other reasons	> 0.327*
Absence from school due to emigration	> 0.941*
Beating	> 0.076*
Beating by father	> 0.741*
Beating by mother	> 0.929*
Beating by brother	> 0.207*
Beating by sister	> 0.324*
Help with homework	> 0.739*
Help with homework by father	> 0.833*
Help with homework by mother	> 0.075*
Help with homework by brother	> 0.956*
Help with homework by sister	> 0.472*
Help with homework by friends	> 0.555*
Help with homework by neighbours	> 0.661*
Lack of table and chair for studies	> 0.467*
Lack of school uniform	> 0.127*
Problems with concentration on school work	> 0.173*
Forgetting	< 0.693*
Depressed alertness	> 0.105*
Problems with remembering	> 0.751*

\*Test result: Not significant

#### Appendix 12 (viii)

Table 4.29: Factors influencing Academic Performance *p*-Value

Sex	> 0.097*
Age-group	> 0.194*
<i>A. lumbricoides</i>	> 0.979*
Suffered sickness	> 0.389*
Stomachache	> 0.07*
Headache	> 0.235*
Diarrhoea	> 0.673*
Fever	> 0.592*
Vomiting	> 0.401*
Coughing	> 0.86*
Treatment	> 0.576*
Worms	> 0.506*
Worm-size	> 0.334*
Raw foods	> 0.923*
Wash food before eating	> 0.643*
Playing with moist soil	> 0.279*
Failure to wash hands before meals	> 0.687*
Keeping farm animals	> 0.76*
Growing food crops	> 0.703*
Father's formal employment	> 0.594*
Father owning business	> 0.434*

<b>Father's education status</b>	<b>&gt; 0.215*</b>
<b>Mother's education status</b>	<b>&gt; 0.982*</b>
<b>Missing breakfast occasionally</b>	<b>&gt; 0.428*</b>
<b>Missing lunch occasionally</b>	<b>&gt; 0.7*</b>
<b>Missing supper occasionally</b>	<b>&gt; 0.931*</b>
<b>Eating maize</b>	<b>&gt; 0.493*</b>
<b>Eating meat</b>	<b>&gt; 0.11*</b>
<b>Eating beans</b>	<b>&gt; 0.987*</b>
<b>Eating fruits</b>	<b>&gt; 0.966*</b>
<b>Absence from school</b>	<b>&gt; 0.91*</b>
<b>Absence from school due to sickness</b>	<b>&gt; 0.581*</b>
<b>Absence from school due to other reasons</b>	<b>&gt; 0.999*</b>
<b>Absence from school due to emigration</b>	<b>&gt; 0.446*</b>
<b>Absence from school due to beating</b>	<b>&gt; 0.972*</b>
<b>Beating by father</b>	<b>&gt; 0.095*</b>
<b>Beating by mother</b>	<b>&gt; 907*</b>
<b>Beating by brother</b>	<b>&gt; 0.075*</b>
<b>Beating by sister</b>	<b>&gt; 0.286*</b>
<b>Help with homework</b>	<b>&gt; 0.091*</b>
<b>Help with homework by father</b>	<b>&gt; 0.962*</b>
<b>Help with homework by mother</b>	<b>&gt; 0.56*</b>
<b>Help with homework by brother</b>	<b>&gt; 0.9*</b>
<b>Help with homework by sister</b>	<b>&gt; 0.669*</b>
<b>Help with homework by friend</b>	<b>&gt; 0.951*</b>
<b>Help with homework by neighbours</b>	<b>&gt; 0.367*</b>
<b>Lack of table for studies at home</b>	<b>&gt; 0.89*</b>
<b>Lack n of uniform by parents/guardians</b>	<b>&gt; 0.454*</b>
<b>Forgetting</b>	<b>&gt; 0.596*</b>
<b>Depressed alertness</b>	<b>&gt; 0.118*</b>
<b>Problems with remembering</b>	<b>&gt; 0.065*</b>
<b>Failure of parents to buy reading books</b>	<b>&gt; 0.632*</b>

**\*Test result: Not significant**

### Appendix 13: Classification Table for Nutritional States

**The International Classification of Adolescent & Adult Underweight, Overweight and Obesity, according to Body Mass Indices (BMI)**

*Source: Adapted from WHO, 1995, WHO, 2000 and WHO, 2004  
(Appropriate for Adolescents & Adults aged between 10 – 18 years)*

Classification	BMI (Kgs/M <sup>2</sup> )	
	Principal cut-off Points	Additional cut-off Points
<b>Underweight</b>	<b>&lt; 18.50</b>	<b>&lt; 18.50</b>
Severe thinness	< 16.00	< 16.00
Moderate thinness	16.00 – 16.99	16.00 – 16.99
Mild thinness	17.00 – 18.49	17.00 – 18.49
<b>Normal Range</b>	<b>18.50 – 24.99</b>	<b>18.50 – 22.99</b>
		<b>23.00 – 24.99</b>
<b>Overweight</b>	<b>≥ 25.00</b>	<b>≥ 25.00</b>
Pre-obese	25.00 – 29.99	25.00 – 27.49
		27.50 – 29.99
<b>Obese</b>	<b>≥ 30.00</b>	<b>≥ 30.00</b>
Obese Class I	30.00 – 34.99	30.00 – 32.49
		32.50 – 34.99
Obese Class II	35.00 – 39.99	35.00 – 37.49
		37.50 – 39.99
Obese Class III	≥ 40.00	≥ 40.00

*Source: Adapted from WHO, 1995, WHO, 2000 and WHO, 2004  
(For Adolescents & Adults Aged 10-18 yrs.)\**

### Appendix 14

Criteria used to identify Severe, Moderate and at Risk categories of Acute Malnutrition  
Source: Ministry of Medical Services & Ministry of Public Health and Sanitation

#### Integrated Management of Acute Malnutrition (March, 2010)

INDICATOR	SAM Severe Acute Malnutrition	MAM Moderate Acute Malnutrition	At Risk
<b>Infants: &lt; 6 Months</b>			
Weight for Length	< - 3 Z Score	Static weight or losing weight at home	Static weight or losing weight at home
Oedema	Oedema Present	Oedema Absent	Oedema Absent
Other signs	Too weak to suckle or feed	Poor feeding	Poor feeding
<b>Children: 6 Months - 10 years (Height: 65 - 130 cms)</b>			
W / H Z-Scores	< -3 Z - Score	> -3 to < -2 Z - Score	-2 to < -1 Z - Score
MUAC (cm)	< 11.5 cms ( < 5 years)	> 11.5 - 12.5 cms ( < 5 years)	12.5 – 13.5 cm
Oedema	Oedema Present	Oedema Absent	Oedema Absent
<b>Adolescents (10-18 years) Height (130 - 171.5 cms)</b>			
MUAC	< 16 cm	N/A	N/A
BMI for age			
Oedema	Oedema Present	Oedema Absent	Oedema Absent
<b>Adults (Older than 18 years)</b>			
MUAC (cm)	< 16 cm irrespective of clinical signs		N/A
MUAC (cm)	16 – 18.5 cm plus one of the following: (1) Oedema (2) Inability to stand (3) Apparent dehydration	16 – 18.5 cm with no relevant clinical signs	N/A
BMI (Kg/M <sup>2</sup> )	< 16	16 - 17	17 – 18.5
Oedema	Oedema Present	Oedema Absent	Oedema Absent
Pregnant & Lactating women			
MUAC (cm)	No available criteria	< 21 cm	

**Key: W/H Z-Scores = World Health Organization Z-Scores**

## Appendix 15: BMI-for-age BOYS – 5-19 years (z-scores)

## BMI-for-age BOYS

5 to 19 years (z-scores)



Year: Month	Month	L	M	S	Z scores (BMI in kg/m <sup>2</sup> )						
					-3SD	-2SD	-1SD	Median	1SD	2SD	3SD
5: 1	61	-0.7387	15.2641	0.08390	12.1	13.0	14.1	15.3	16.6	18.3	20.2
5: 2	62	-0.7621	15.2616	0.08414	12.1	13.0	14.1	15.3	16.6	18.3	20.2
5: 3	63	-0.7856	15.2604	0.08439	12.1	13.0	14.1	15.3	16.7	18.3	20.2
5: 4	64	-0.8089	15.2605	0.08464	12.1	13.0	14.1	15.3	16.7	18.3	20.3
5: 5	65	-0.8322	15.2619	0.08490	12.1	13.0	14.1	15.3	16.7	18.3	20.3
5: 6	66	-0.8554	15.2645	0.08516	12.1	13.0	14.1	15.3	16.7	18.4	20.4
5: 7	67	-0.8785	15.2684	0.08543	12.1	13.0	14.1	15.3	16.7	18.4	20.4
5: 8	68	-0.9015	15.2737	0.08570	12.1	13.0	14.1	15.3	16.7	18.4	20.5
5: 9	69	-0.9243	15.2801	0.08597	12.1	13.0	14.1	15.3	16.7	18.4	20.5
5:10	70	-0.9471	15.2877	0.08625	12.1	13.0	14.1	15.3	16.7	18.5	20.6
5:11	71	-0.9697	15.2965	0.08653	12.1	13.0	14.1	15.3	16.7	18.5	20.6
6: 0	72	-0.9921	15.3062	0.08682	12.1	13.0	14.1	15.3	16.8	18.5	20.7
6: 1	73	-1.0144	15.3169	0.08711	12.1	13.0	14.1	15.3	16.8	18.6	20.8
6: 2	74	-1.0365	15.3285	0.08741	12.2	13.1	14.1	15.3	16.8	18.6	20.8
6: 3	75	-1.0584	15.3408	0.08771	12.2	13.1	14.1	15.3	16.8	18.6	20.9
6: 4	76	-1.0801	15.3540	0.08802	12.2	13.1	14.1	15.4	16.8	18.7	21.0
6: 5	77	-1.1017	15.3679	0.08833	12.2	13.1	14.1	15.4	16.9	18.7	21.0
6: 6	78	-1.1230	15.3825	0.08865	12.2	13.1	14.1	15.4	16.9	18.7	21.1
6: 7	79	-1.1441	15.3978	0.08898	12.2	13.1	14.1	15.4	16.9	18.8	21.2
6: 8	80	-1.1649	15.4137	0.08931	12.2	13.1	14.2	15.4	16.9	18.8	21.3
6: 9	81	-1.1856	15.4302	0.08964	12.2	13.1	14.2	15.4	17.0	18.9	21.3
6:10	82	-1.2060	15.4473	0.08998	12.2	13.1	14.2	15.4	17.0	18.9	21.4
6:11	83	-1.2261	15.4650	0.09033	12.2	13.1	14.2	15.5	17.0	19.0	21.5
7: 0	84	-1.2460	15.4832	0.09068	12.3	13.1	14.2	15.5	17.0	19.0	21.6
7: 1	85	-1.2656	15.5019	0.09103	12.3	13.2	14.2	15.5	17.1	19.1	21.7
7: 2	86	-1.2849	15.5210	0.09139	12.3	13.2	14.2	15.5	17.1	19.1	21.8

2007 WHO Reference

**BMI-for-age BOYS**

5 to 19 years (z-scores)



Year: Month	Month	L	M	S	Z-scores (BMI in kg/m <sup>2</sup> )						
					-3 SD	-2 SD	-1 SD	Median	1 SD	2 SD	3 SD
7: 3	87	-1.3040	15.5407	0.09176	12.3	13.2	14.3	15.5	17.1	19.2	21.9
7: 4	88	-1.3228	15.5608	0.09213	12.3	13.2	14.3	15.6	17.2	19.2	22.0
7: 5	89	-1.3414	15.5814	0.09251	12.3	13.2	14.3	15.6	17.2	19.3	22.0
7: 6	90	-1.3596	15.6023	0.09289	12.3	13.2	14.3	15.6	17.2	19.3	22.1
7: 7	91	-1.3776	15.6237	0.09327	12.3	13.2	14.3	15.6	17.3	19.4	22.2
7: 8	92	-1.3953	15.6455	0.09366	12.3	13.2	14.3	15.6	17.3	19.4	22.4
7: 9	93	-1.4126	15.6677	0.09406	12.4	13.3	14.3	15.7	17.3	19.5	22.5
7:10	94	-1.4297	15.6903	0.09445	12.4	13.3	14.4	15.7	17.4	19.6	22.6
7:11	95	-1.4464	15.7133	0.09486	12.4	13.3	14.4	15.7	17.4	19.6	22.7
8: 0	96	-1.4629	15.7368	0.09526	12.4	13.3	14.4	15.7	17.4	19.7	22.8
8: 1	97	-1.4790	15.7606	0.09567	12.4	13.3	14.4	15.8	17.5	19.7	22.9
8: 2	98	-1.4947	15.7848	0.09609	12.4	13.3	14.4	15.8	17.5	19.8	23.0
8: 3	99	-1.5101	15.8094	0.09651	12.4	13.3	14.4	15.8	17.5	19.9	23.1
8: 4	100	-1.5252	15.8344	0.09693	12.4	13.4	14.5	15.8	17.6	19.9	23.3
8: 5	101	-1.5399	15.8597	0.09735	12.5	13.4	14.5	15.9	17.6	20.0	23.4
8: 6	102	-1.5542	15.8855	0.09778	12.5	13.4	14.5	15.9	17.7	20.1	23.5
8: 7	103	-1.5681	15.9116	0.09821	12.5	13.4	14.5	15.9	17.7	20.1	23.6
8: 8	104	-1.5817	15.9381	0.09864	12.5	13.4	14.5	15.9	17.7	20.2	23.8
8: 9	105	-1.5948	15.9651	0.09907	12.5	13.4	14.6	16.0	17.8	20.3	23.9
8:10	106	-1.6076	15.9925	0.09951	12.5	13.5	14.6	16.0	17.8	20.3	24.0
8:11	107	-1.6199	16.0205	0.09994	12.5	13.5	14.6	16.0	17.9	20.4	24.2
9: 0	108	-1.6318	16.0490	0.10038	12.6	13.5	14.6	16.0	17.9	20.5	24.3
9: 1	109	-1.6433	16.0781	0.10082	12.6	13.5	14.6	16.1	18.0	20.5	24.4
9: 2	110	-1.6544	16.1078	0.10126	12.6	13.5	14.7	16.1	18.0	20.6	24.6
9: 3	111	-1.6651	16.1381	0.10170	12.6	13.5	14.7	16.1	18.0	20.7	24.7

2007 WHO Reference

**BMI-for-age BOYS**

5 to 19 years (z-scores)

Year: Month	Month	L	M	S	Z-scores (BMI in kg/m <sup>2</sup> )						
					-3 SD	-2 SD	-1 SD	Median	1 SD	2 SD	3 SD
9: 4	112	-1.6753	16.1692	0.10214	12.6	13.6	14.7	16.2	18.1	20.8	24.9
9: 5	113	-1.6851	16.2009	0.10259	12.6	13.6	14.7	16.2	18.1	20.8	25.0
9: 6	114	-1.6944	16.2333	0.10303	12.7	13.6	14.8	16.2	18.2	20.9	25.1
9: 7	115	-1.7032	16.2665	0.10347	12.7	13.6	14.8	16.3	18.2	21.0	25.3
9: 8	116	-1.7116	16.3004	0.10391	12.7	13.6	14.8	16.3	18.3	21.1	25.5
9: 9	117	-1.7196	16.3351	0.10435	12.7	13.7	14.8	16.3	18.3	21.2	25.6
9:10	118	-1.7271	16.3704	0.10478	12.7	13.7	14.9	16.4	18.4	21.2	25.8
9:11	119	-1.7341	16.4065	0.10522	12.8	13.7	14.9	16.4	18.4	21.3	25.9
10: 0	120	-1.7407	16.4433	0.10566	12.8	13.7	14.9	16.4	18.5	21.4	26.1
10: 1	121	-1.7468	16.4807	0.10609	12.8	13.8	15.0	16.5	18.5	21.5	26.2
10: 2	122	-1.7525	16.5189	0.10652	12.8	13.8	15.0	16.5	18.6	21.6	26.4
10: 3	123	-1.7578	16.5578	0.10695	12.8	13.8	15.0	16.6	18.6	21.7	26.6
10: 4	124	-1.7626	16.5974	0.10738	12.9	13.8	15.0	16.6	18.7	21.7	26.7
10: 5	125	-1.7670	16.6376	0.10780	12.9	13.9	15.1	16.6	18.8	21.8	26.9
10: 6	126	-1.7710	16.6786	0.10823	12.9	13.9	15.1	16.7	18.8	21.9	27.0
10: 7	127	-1.7745	16.7203	0.10865	12.9	13.9	15.1	16.7	18.9	22.0	27.2
10: 8	128	-1.7777	16.7628	0.10906	13.0	13.9	15.2	16.8	18.9	22.1	27.4
10: 9	129	-1.7804	16.8059	0.10948	13.0	14.0	15.2	16.8	19.0	22.2	27.5
10:10	130	-1.7828	16.8497	0.10989	13.0	14.0	15.2	16.9	19.0	22.3	27.7
10:11	131	-1.7847	16.8941	0.11030	13.0	14.0	15.3	16.9	19.1	22.4	27.9
11: 0	132	-1.7862	16.9392	0.11070	13.1	14.1	15.3	16.9	19.2	22.5	28.0
11: 1	133	-1.7873	16.9850	0.11110	13.1	14.1	15.3	17.0	19.2	22.5	28.2
11: 2	134	-1.7881	17.0314	0.11150	13.1	14.1	15.4	17.0	19.3	22.6	28.4
11: 3	135	-1.7884	17.0784	0.11189	13.1	14.1	15.4	17.1	19.3	22.7	28.5

2007 WHO Reference

**BMI-for-age BOYS**

5 to 19 years (z-scores)

Year: Month	Month	L	M	S	Z-scores (BMI in kg/m <sup>2</sup> )						
					-3 SD	-2 SD	-1 SD	Median	1 SD	2 SD	3 SD
11: 4	136	-1.7884	17.1262	0.11228	13.2	14.2	15.5	17.1	19.4	22.8	28.7
11: 5	137	-1.7880	17.1746	0.11266	13.2	14.2	15.5	17.2	19.5	22.9	28.8
11: 6	138	-1.7873	17.2236	0.11304	13.2	14.2	15.5	17.2	19.5	23.0	29.0
11: 7	139	-1.7861	17.2734	0.11342	13.2	14.3	15.6	17.3	19.6	23.1	29.2
11: 8	140	-1.7846	17.3240	0.11379	13.3	14.3	15.6	17.3	19.7	23.2	29.3
11: 9	141	-1.7828	17.3752	0.11415	13.3	14.3	15.7	17.4	19.7	23.3	29.5
11:10	142	-1.7806	17.4272	0.11451	13.3	14.4	15.7	17.4	19.8	23.4	29.6
11:11	143	-1.7780	17.4799	0.11487	13.4	14.4	15.7	17.5	19.9	23.5	29.8
12: 0	144	-1.7751	17.5334	0.11522	13.4	14.5	15.8	17.5	19.9	23.6	30.0
12: 1	145	-1.7719	17.5877	0.11556	13.4	14.5	15.8	17.6	20.0	23.7	30.1
12: 2	146	-1.7684	17.6427	0.11590	13.5	14.5	15.9	17.6	20.1	23.8	30.3
12: 3	147	-1.7645	17.6985	0.11623	13.5	14.6	15.9	17.7	20.2	23.9	30.4
12: 4	148	-1.7604	17.7551	0.11656	13.5	14.6	16.0	17.8	20.2	24.0	30.6
12: 5	149	-1.7559	17.8124	0.11688	13.6	14.6	16.0	17.8	20.3	24.1	30.7
12: 6	150	-1.7511	17.8704	0.11720	13.6	14.7	16.1	17.9	20.4	24.2	30.9
12: 7	151	-1.7461	17.9292	0.11751	13.6	14.7	16.1	17.9	20.4	24.3	31.0
12: 8	152	-1.7408	17.9887	0.11781	13.7	14.8	16.2	18.0	20.5	24.4	31.1
12: 9	153	-1.7352	18.0488	0.11811	13.7	14.8	16.2	18.0	20.6	24.5	31.3
12:10	154	-1.7293	18.1096	0.11841	13.7	14.8	16.3	18.1	20.7	24.6	31.4
12:11	155	-1.7232	18.1710	0.11869	13.8	14.9	16.3	18.2	20.8	24.7	31.6
13: 0	156	-1.7168	18.2330	0.11898	13.8	14.9	16.4	18.2	20.8	24.8	31.7
13: 1	157	-1.7102	18.2955	0.11925	13.8	15.0	16.4	18.3	20.9	24.9	31.8
13: 2	158	-1.7033	18.3586	0.11952	13.9	15.0	16.5	18.4	21.0	25.0	31.9
13: 3	159	-1.6962	18.4221	0.11979	13.9	15.1	16.5	18.4	21.1	25.1	32.1

2007 WHO Reference

**BMI-for-age BOYS**

5 to 19 years (z-scores)

Year: Month	Month	L	M	S	Z-scores (BMI in kg/m <sup>2</sup> )						
					-3 SD	-2 SD	-1 SD	Median	1 SD	2 SD	3 SD
13: 4	160	-1.6888	18.4860	0.12005	14.0	15.1	16.6	18.5	21.1	25.2	32.2
13: 5	161	-1.6811	18.5502	0.12030	14.0	15.2	16.6	18.6	21.2	25.2	32.3
13: 6	162	-1.6732	18.6148	0.12055	14.0	15.2	16.7	18.6	21.3	25.3	32.4
13: 7	163	-1.6651	18.6795	0.12079	14.1	15.2	16.7	18.7	21.4	25.4	32.6
13: 8	164	-1.6568	18.7445	0.12102	14.1	15.3	16.8	18.7	21.5	25.5	32.7
13: 9	165	-1.6482	18.8095	0.12125	14.1	15.3	16.8	18.8	21.5	25.6	32.8
13:10	166	-1.6394	18.8746	0.12148	14.2	15.4	16.9	18.9	21.6	25.7	32.9
13:11	167	-1.6304	18.9398	0.12170	14.2	15.4	17.0	18.9	21.7	25.8	33.0
14: 0	168	-1.6211	19.0050	0.12191	14.3	15.5	17.0	19.0	21.8	25.9	33.1
14: 1	169	-1.6116	19.0701	0.12212	14.3	15.5	17.1	19.1	21.8	26.0	33.2
14: 2	170	-1.6020	19.1351	0.12233	14.3	15.6	17.1	19.1	21.9	26.1	33.3
14: 3	171	-1.5921	19.2000	0.12253	14.4	15.6	17.2	19.2	22.0	26.2	33.4
14: 4	172	-1.5821	19.2648	0.12272	14.4	15.7	17.2	19.3	22.1	26.3	33.5
14: 5	173	-1.5719	19.3294	0.12291	14.5	15.7	17.3	19.3	22.2	26.4	33.5
14: 6	174	-1.5615	19.3937	0.12310	14.5	15.7	17.3	19.4	22.2	26.5	33.6
14: 7	175	-1.5510	19.4578	0.12328	14.5	15.8	17.4	19.5	22.3	26.5	33.7
14: 8	176	-1.5403	19.5217	0.12346	14.6	15.8	17.4	19.5	22.4	26.6	33.8
14: 9	177	-1.5294	19.5853	0.12363	14.6	15.9	17.5	19.6	22.5	26.7	33.9
14:10	178	-1.5185	19.6486	0.12380	14.6	15.9	17.5	19.6	22.5	26.8	33.9
14:11	179	-1.5074	19.7117	0.12396	14.7	16.0	17.6	19.7	22.6	26.9	34.0
15: 0	180	-1.4961	19.7744	0.12412	14.7	16.0	17.6	19.8	22.7	27.0	34.1
15: 1	181	-1.4848	19.8367	0.12428	14.7	16.1	17.7	19.8	22.8	27.1	34.1
15: 2	182	-1.4733	19.8987	0.12443	14.8	16.1	17.8	19.9	22.8	27.1	34.2
15: 3	183	-1.4617	19.9603	0.12458	14.8	16.1	17.8	20.0	22.9	27.2	34.3

2007 WHO Reference

**BMI-for-age BOYS**

5 to 19 years (z-scores)

Year: Month	Month	L	M	S	Z-scores (BMI in kg/m <sup>2</sup> )						
					-3 SD	-2 SD	-1 SD	Median	1 SD	2 SD	3 SD
15: 4	184	-1.4500	20.0215	0.12473	14.8	16.2	17.9	20.0	23.0	27.3	34.3
15: 5	185	-1.4382	20.0823	0.12487	14.9	16.2	17.9	20.1	23.0	27.4	34.4
15: 6	186	-1.4263	20.1427	0.12501	14.9	16.3	18.0	20.1	23.1	27.4	34.5
15: 7	187	-1.4143	20.2026	0.12514	15.0	16.3	18.0	20.2	23.2	27.5	34.5
15: 8	188	-1.4022	20.2621	0.12528	15.0	16.3	18.1	20.3	23.3	27.6	34.6
15: 9	189	-1.3900	20.3211	0.12541	15.0	16.4	18.1	20.3	23.3	27.7	34.6
15:10	190	-1.3777	20.3796	0.12554	15.0	16.4	18.2	20.4	23.4	27.7	34.7
15:11	191	-1.3653	20.4376	0.12567	15.1	16.5	18.2	20.4	23.5	27.8	34.7
16: 0	192	-1.3529	20.4951	0.12579	15.1	16.5	18.2	20.5	23.5	27.9	34.8
16: 1	193	-1.3403	20.5521	0.12591	15.1	16.5	18.3	20.6	23.6	27.9	34.8
16: 2	194	-1.3277	20.6085	0.12603	15.2	16.6	18.3	20.6	23.7	28.0	34.8
16: 3	195	-1.3149	20.6644	0.12615	15.2	16.6	18.4	20.7	23.7	28.1	34.9
16: 4	196	-1.3021	20.7197	0.12627	15.2	16.7	18.4	20.7	23.8	28.1	34.9
16: 5	197	-1.2892	20.7745	0.12638	15.3	16.7	18.5	20.8	23.8	28.2	35.0
16: 6	198	-1.2762	20.8287	0.12650	15.3	16.7	18.5	20.8	23.9	28.3	35.0
16: 7	199	-1.2631	20.8824	0.12661	15.3	16.8	18.6	20.9	24.0	28.3	35.0
16: 8	200	-1.2499	20.9355	0.12672	15.3	16.8	18.6	20.9	24.0	28.4	35.1
16: 9	201	-1.2366	20.9881	0.12683	15.4	16.8	18.7	21.0	24.1	28.5	35.1
16:10	202	-1.2233	21.0400	0.12694	15.4	16.9	18.7	21.0	24.2	28.5	35.1
16:11	203	-1.2098	21.0914	0.12704	15.4	16.9	18.7	21.1	24.2	28.6	35.2
17: 0	204	-1.1962	21.1423	0.12715	15.4	16.9	18.8	21.1	24.3	28.6	35.2
17: 1	205	-1.1826	21.1925	0.12726	15.5	17.0	18.8	21.2	24.3	28.7	35.2
17: 2	206	-1.1688	21.2423	0.12736	15.5	17.0	18.9	21.2	24.4	28.7	35.2
17: 3	207	-1.1550	21.2914	0.12746	15.5	17.0	18.9	21.3	24.4	28.8	35.3

2007 WHO Reference

**BMI-for-age BOYS**

5 to 19 years (z-scores)

Year: Month	Month	L	M	S	Z-scores (BMI in kg/m <sup>2</sup> )						
					-3 SD	-2 SD	-1 SD	Median	1 SD	2 SD	3 SD
17: 4	208	-1.1410	21.3400	0.12756	15.5	17.1	18.9	21.3	24.5	28.9	35.3
17: 5	209	-1.1270	21.3880	0.12767	15.6	17.1	19.0	21.4	24.5	28.9	35.3
17: 6	210	-1.1129	21.4354	0.12777	15.6	17.1	19.0	21.4	24.6	29.0	35.3
17: 7	211	-1.0986	21.4822	0.12787	15.6	17.1	19.1	21.5	24.7	29.0	35.4
17: 8	212	-1.0843	21.5285	0.12797	15.6	17.2	19.1	21.5	24.7	29.1	35.4
17: 9	213	-1.0699	21.5742	0.12807	15.6	17.2	19.1	21.6	24.8	29.1	35.4
17:10	214	-1.0553	21.6193	0.12816	15.7	17.2	19.2	21.6	24.8	29.2	35.4
17:11	215	-1.0407	21.6638	0.12826	15.7	17.3	19.2	21.7	24.9	29.2	35.4
18: 0	216	-1.0260	21.7077	0.12836	15.7	17.3	19.2	21.7	24.9	29.2	35.4
18: 1	217	-1.0112	21.7510	0.12845	15.7	17.3	19.3	21.8	25.0	29.3	35.4
18: 2	218	-0.9962	21.7937	0.12855	15.7	17.3	19.3	21.8	25.0	29.3	35.5
18: 3	219	-0.9812	21.8358	0.12864	15.7	17.4	19.3	21.8	25.1	29.4	35.5
18: 4	220	-0.9661	21.8773	0.12874	15.8	17.4	19.4	21.9	25.1	29.4	35.5
18: 5	221	-0.9509	21.9182	0.12883	15.8	17.4	19.4	21.9	25.1	29.5	35.5
18: 6	222	-0.9356	21.9585	0.12893	15.8	17.4	19.4	22.0	25.2	29.5	35.5
18: 7	223	-0.9202	21.9982	0.12902	15.8	17.5	19.5	22.0	25.2	29.5	35.5
18: 8	224	-0.9048	22.0374	0.12911	15.8	17.5	19.5	22.0	25.3	29.6	35.5
18: 9	225	-0.8892	22.0760	0.12920	15.8	17.5	19.5	22.1	25.3	29.6	35.5
18:10	226	-0.8735	22.1140	0.12930	15.8	17.5	19.6	22.1	25.4	29.6	35.5
18:11	227	-0.8578	22.1514	0.12939	15.8	17.5	19.6	22.2	25.4	29.7	35.5
19: 0	228	-0.8419	22.1883	0.12948	15.9	17.6	19.6	22.2	25.4	29.7	35.5

2007 WHO Reference

## Appendix 16: BMI-for-age GIRLS – 5-19 years (z-scores)

## BMI-for-age GIRLS

5 to 19 years (z-scores)



Year: Month	Month	L	M	S	Z-scores (BMI in kg/m <sup>2</sup> )						
					-3 SD	-2 SD	-1 SD	Median	1 SD	2 SD	3 SD
5: 1	61	-0.8886	15.2441	0.09692	11.8	12.7	13.9	15.2	16.9	18.9	21.3
5: 2	62	-0.9068	15.2434	0.09738	11.8	12.7	13.9	15.2	16.9	18.9	21.4
5: 3	63	-0.9248	15.2433	0.09783	11.8	12.7	13.9	15.2	16.9	18.9	21.5
5: 4	64	-0.9427	15.2438	0.09829	11.8	12.7	13.9	15.2	16.9	18.9	21.5
5: 5	65	-0.9605	15.2448	0.09875	11.7	12.7	13.9	15.2	16.9	19.0	21.6
5: 6	66	-0.9780	15.2464	0.09920	11.7	12.7	13.9	15.2	16.9	19.0	21.7
5: 7	67	-0.9954	15.2487	0.09966	11.7	12.7	13.9	15.2	16.9	19.0	21.7
5: 8	68	-1.0126	15.2516	0.10012	11.7	12.7	13.9	15.3	17.0	19.1	21.8
5: 9	69	-1.0296	15.2551	0.10058	11.7	12.7	13.9	15.3	17.0	19.1	21.9
5:10	70	-1.0464	15.2592	0.10104	11.7	12.7	13.9	15.3	17.0	19.1	22.0
5:11	71	-1.0630	15.2641	0.10149	11.7	12.7	13.9	15.3	17.0	19.2	22.1
6: 0	72	-1.0794	15.2697	0.10195	11.7	12.7	13.9	15.3	17.0	19.2	22.1
6: 1	73	-1.0956	15.2760	0.10241	11.7	12.7	13.9	15.3	17.0	19.3	22.2
6: 2	74	-1.1115	15.2831	0.10287	11.7	12.7	13.9	15.3	17.0	19.3	22.3
6: 3	75	-1.1272	15.2911	0.10333	11.7	12.7	13.9	15.3	17.1	19.3	22.4
6: 4	76	-1.1427	15.2998	0.10379	11.7	12.7	13.9	15.3	17.1	19.4	22.5
6: 5	77	-1.1579	15.3095	0.10425	11.7	12.7	13.9	15.3	17.1	19.4	22.6
6: 6	78	-1.1728	15.3200	0.10471	11.7	12.7	13.9	15.3	17.1	19.5	22.7
6: 7	79	-1.1875	15.3314	0.10517	11.7	12.7	13.9	15.3	17.2	19.5	22.8
6: 8	80	-1.2019	15.3439	0.10562	11.7	12.7	13.9	15.3	17.2	19.6	22.9
6: 9	81	-1.2160	15.3572	0.10608	11.7	12.7	13.9	15.4	17.2	19.6	23.0
6:10	82	-1.2298	15.3717	0.10654	11.7	12.7	13.9	15.4	17.2	19.7	23.1
6:11	83	-1.2433	15.3871	0.10700	11.7	12.7	13.9	15.4	17.3	19.7	23.2
7: 0	84	-1.2565	15.4036	0.10746	11.8	12.7	13.9	15.4	17.3	19.8	23.3
7: 1	85	-1.2693	15.4211	0.10792	11.8	12.7	13.9	15.4	17.3	19.8	23.4
7: 2	86	-1.2819	15.4397	0.10837	11.8	12.8	14.0	15.4	17.4	19.9	23.5

2007 WHO Reference

**BMI-for-age GIRLS**

5 to 19 years (z-scores)



Year: Month	Month	L	M	S	Z-scores (BMI in kg/m <sup>2</sup> )						
					-3 SD	-2 SD	-1 SD	Median	1 SD	2 SD	3 SD
7: 3	87	-1.2941	15.4593	0.10883	11.8	12.8	14.0	15.5	17.4	20.0	23.6
7: 4	88	-1.3060	15.4798	0.10929	11.8	12.8	14.0	15.5	17.4	20.0	23.7
7: 5	89	-1.3175	15.5014	0.10974	11.8	12.8	14.0	15.5	17.5	20.1	23.9
7: 6	90	-1.3287	15.5240	0.11020	11.8	12.8	14.0	15.5	17.5	20.1	24.0
7: 7	91	-1.3395	15.5476	0.11065	11.8	12.8	14.0	15.5	17.5	20.2	24.1
7: 8	92	-1.3499	15.5723	0.11110	11.8	12.8	14.0	15.6	17.6	20.3	24.2
7: 9	93	-1.3600	15.5979	0.11156	11.8	12.8	14.1	15.6	17.6	20.3	24.4
7:10	94	-1.3697	15.6246	0.11201	11.9	12.9	14.1	15.6	17.6	20.4	24.5
7:11	95	-1.3790	15.6523	0.11246	11.9	12.9	14.1	15.7	17.7	20.5	24.6
8: 0	96	-1.3880	15.6810	0.11291	11.9	12.9	14.1	15.7	17.7	20.6	24.8
8: 1	97	-1.3966	15.7107	0.11335	11.9	12.9	14.1	15.7	17.8	20.6	24.9
8: 2	98	-1.4047	15.7415	0.11380	11.9	12.9	14.2	15.7	17.8	20.7	25.1
8: 3	99	-1.4125	15.7732	0.11424	11.9	12.9	14.2	15.8	17.9	20.8	25.2
8: 4	100	-1.4199	15.8058	0.11469	11.9	13.0	14.2	15.8	17.9	20.9	25.3
8: 5	101	-1.4270	15.8394	0.11513	12.0	13.0	14.2	15.8	18.0	20.9	25.5
8: 6	102	-1.4336	15.8738	0.11557	12.0	13.0	14.3	15.9	18.0	21.0	25.6
8: 7	103	-1.4398	15.9090	0.11601	12.0	13.0	14.3	15.9	18.1	21.1	25.8
8: 8	104	-1.4456	15.9451	0.11644	12.0	13.0	14.3	15.9	18.1	21.2	25.9
8: 9	105	-1.4511	15.9818	0.11688	12.0	13.1	14.3	16.0	18.2	21.3	26.1
8:10	106	-1.4561	16.0194	0.11731	12.1	13.1	14.4	16.0	18.2	21.3	26.2
8:11	107	-1.4607	16.0575	0.11774	12.1	13.1	14.4	16.1	18.3	21.4	26.4
9: 0	108	-1.4650	16.0964	0.11816	12.1	13.1	14.4	16.1	18.3	21.5	26.5
9: 1	109	-1.4688	16.1358	0.11859	12.1	13.2	14.5	16.1	18.4	21.6	26.7
9: 2	110	-1.4723	16.1759	0.11901	12.1	13.2	14.5	16.2	18.4	21.7	26.8
9: 3	111	-1.4753	16.2166	0.11943	12.2	13.2	14.5	16.2	18.5	21.8	27.0

2007 WHO Reference

**BMI-for-age GIRLS**

5 to 19 years (z-scores)

Year: Month	Month	L	M	S	Z-scores (BMI in kg/m <sup>3</sup> )						
					-3 SD	-2 SD	-1 SD	Median	1 SD	2 SD	3 SD
9: 4	112	-1.4780	16.2580	0.11985	12.2	13.2	14.6	16.3	18.6	21.9	27.2
9: 5	113	-1.4803	16.2999	0.12026	12.2	13.3	14.6	16.3	18.6	21.9	27.3
9: 6	114	-1.4823	16.3425	0.12067	12.2	13.3	14.6	16.3	18.7	22.0	27.5
9: 7	115	-1.4838	16.3858	0.12108	12.3	13.3	14.7	16.4	18.7	22.1	27.6
9: 8	116	-1.4850	16.4298	0.12148	12.3	13.4	14.7	16.4	18.8	22.2	27.8
9: 9	117	-1.4859	16.4746	0.12188	12.3	13.4	14.7	16.5	18.8	22.3	27.9
9:10	118	-1.4864	16.5200	0.12228	12.3	13.4	14.8	16.5	18.9	22.4	28.1
9:11	119	-1.4866	16.5663	0.12268	12.4	13.4	14.8	16.6	19.0	22.5	28.2
10: 0	120	-1.4864	16.6133	0.12307	12.4	13.5	14.8	16.6	19.0	22.6	28.4
10: 1	121	-1.4859	16.6612	0.12346	12.4	13.5	14.9	16.7	19.1	22.7	28.5
10: 2	122	-1.4851	16.7100	0.12384	12.4	13.5	14.9	16.7	19.2	22.8	28.7
10: 3	123	-1.4839	16.7595	0.12422	12.5	13.6	15.0	16.8	19.2	22.8	28.8
10: 4	124	-1.4825	16.8100	0.12460	12.5	13.6	15.0	16.8	19.3	22.9	29.0
10: 5	125	-1.4807	16.8614	0.12497	12.5	13.6	15.0	16.9	19.4	23.0	29.1
10: 6	126	-1.4787	16.9136	0.12534	12.5	13.7	15.1	16.9	19.4	23.1	29.3
10: 7	127	-1.4763	16.9667	0.12571	12.6	13.7	15.1	17.0	19.5	23.2	29.4
10: 8	128	-1.4737	17.0208	0.12607	12.6	13.7	15.2	17.0	19.6	23.3	29.6
10: 9	129	-1.4708	17.0757	0.12643	12.6	13.8	15.2	17.1	19.6	23.4	29.7
10:10	130	-1.4677	17.1316	0.12678	12.7	13.8	15.3	17.1	19.7	23.5	29.9
10:11	131	-1.4642	17.1883	0.12713	12.7	13.8	15.3	17.2	19.8	23.6	30.0
11: 0	132	-1.4606	17.2459	0.12748	12.7	13.9	15.3	17.2	19.9	23.7	30.2
11: 1	133	-1.4567	17.3044	0.12782	12.8	13.9	15.4	17.3	19.9	23.8	30.3
11: 2	134	-1.4526	17.3637	0.12816	12.8	14.0	15.4	17.4	20.0	23.9	30.5
11: 3	135	-1.4482	17.4238	0.12849	12.8	14.0	15.5	17.4	20.1	24.0	30.6

2007 WHO Reference

**BMI-for-age GIRLS**

5 to 19 years (z-scores)

Year: Month	Month	L	M	S	Z-scores (BMI in kg/m <sup>2</sup> )						
					-3 SD	-2 SD	-1 SD	Median	1 SD	2 SD	3 SD
11: 4	136	-1.4436	17.4847	0.12882	12.9	14.0	15.5	17.5	20.2	24.1	30.8
11: 5	137	-1.4389	17.5464	0.12914	12.9	14.1	15.6	17.5	20.2	24.2	30.9
11: 6	138	-1.4339	17.6088	0.12946	12.9	14.1	15.6	17.6	20.3	24.3	31.1
11: 7	139	-1.4288	17.6719	0.12978	13.0	14.2	15.7	17.7	20.4	24.4	31.2
11: 8	140	-1.4235	17.7357	0.13009	13.0	14.2	15.7	17.7	20.5	24.5	31.4
11: 9	141	-1.4180	17.8001	0.13040	13.0	14.3	15.8	17.8	20.6	24.7	31.5
11:10	142	-1.4123	17.8651	0.13070	13.1	14.3	15.8	17.9	20.6	24.8	31.6
11:11	143	-1.4065	17.9306	0.13099	13.1	14.3	15.9	17.9	20.7	24.9	31.8
12: 0	144	-1.4006	17.9966	0.13129	13.2	14.4	16.0	18.0	20.8	25.0	31.9
12: 1	145	-1.3945	18.0630	0.13158	13.2	14.4	16.0	18.1	20.9	25.1	32.0
12: 2	146	-1.3883	18.1297	0.13186	13.2	14.5	16.1	18.1	21.0	25.2	32.2
12: 3	147	-1.3819	18.1967	0.13214	13.3	14.5	16.1	18.2	21.1	25.3	32.3
12: 4	148	-1.3755	18.2639	0.13241	13.3	14.6	16.2	18.3	21.1	25.4	32.4
12: 5	149	-1.3689	18.3312	0.13268	13.3	14.6	16.2	18.3	21.2	25.5	32.6
12: 6	150	-1.3621	18.3986	0.13295	13.4	14.7	16.3	18.4	21.3	25.6	32.7
12: 7	151	-1.3553	18.4660	0.13321	13.4	14.7	16.3	18.5	21.4	25.7	32.8
12: 8	152	-1.3483	18.5333	0.13347	13.5	14.8	16.4	18.5	21.5	25.8	33.0
12: 9	153	-1.3413	18.6006	0.13372	13.5	14.8	16.4	18.6	21.6	25.9	33.1
12:10	154	-1.3341	18.6677	0.13397	13.5	14.8	16.5	18.7	21.6	26.0	33.2
12:11	155	-1.3269	18.7346	0.13421	13.6	14.9	16.6	18.7	21.7	26.1	33.3
13: 0	156	-1.3195	18.8012	0.13445	13.6	14.9	16.6	18.8	21.8	26.2	33.4
13: 1	157	-1.3121	18.8675	0.13469	13.6	15.0	16.7	18.9	21.9	26.3	33.6
13: 2	158	-1.3046	18.9335	0.13492	13.7	15.0	16.7	18.9	22.0	26.4	33.7
13: 3	159	-1.2970	18.9991	0.13514	13.7	15.1	16.8	19.0	22.0	26.5	33.8

2007 WHO Reference

**BMI-for-age GIRLS**

5 to 19 years (z-scores)

Year: Month	Month	L	M	S	Z-scores (BMI in kg/m <sup>2</sup> )						
					-3 SD	-2 SD	-1 SD	Median	1 SD	2 SD	3 SD
13: 4	160	-1.2894	19.0642	0.13537	13.8	15.1	16.8	19.1	22.1	26.6	33.9
13: 5	161	-1.2816	19.1289	0.13559	13.8	15.2	16.9	19.1	22.2	26.7	34.0
13: 6	162	-1.2739	19.1931	0.13580	13.8	15.2	16.9	19.2	22.3	26.8	34.1
13: 7	163	-1.2661	19.2567	0.13601	13.9	15.2	17.0	19.3	22.4	26.9	34.2
13: 8	164	-1.2583	19.3197	0.13622	13.9	15.3	17.0	19.3	22.4	27.0	34.3
13: 9	165	-1.2504	19.3820	0.13642	13.9	15.3	17.1	19.4	22.5	27.1	34.4
13:10	166	-1.2425	19.4437	0.13662	14.0	15.4	17.1	19.4	22.6	27.1	34.5
13:11	167	-1.2345	19.5045	0.13681	14.0	15.4	17.2	19.5	22.7	27.2	34.6
14: 0	168	-1.2266	19.5647	0.13700	14.0	15.4	17.2	19.6	22.7	27.3	34.7
14: 1	169	-1.2186	19.6240	0.13719	14.1	15.5	17.3	19.6	22.8	27.4	34.7
14: 2	170	-1.2107	19.6824	0.13738	14.1	15.5	17.3	19.7	22.9	27.5	34.8
14: 3	171	-1.2027	19.7400	0.13756	14.1	15.6	17.4	19.7	22.9	27.6	34.9
14: 4	172	-1.1947	19.7966	0.13774	14.1	15.6	17.4	19.8	23.0	27.7	35.0
14: 5	173	-1.1867	19.8523	0.13791	14.2	15.6	17.5	19.9	23.1	27.7	35.1
14: 6	174	-1.1788	19.9070	0.13808	14.2	15.7	17.5	19.9	23.1	27.8	35.1
14: 7	175	-1.1708	19.9607	0.13825	14.2	15.7	17.6	20.0	23.2	27.9	35.2
14: 8	176	-1.1629	20.0133	0.13841	14.3	15.7	17.6	20.0	23.3	28.0	35.3
14: 9	177	-1.1549	20.0648	0.13858	14.3	15.8	17.6	20.1	23.3	28.0	35.4
14:10	178	-1.1470	20.1152	0.13873	14.3	15.8	17.7	20.1	23.4	28.1	35.4
14:11	179	-1.1390	20.1644	0.13889	14.3	15.8	17.7	20.2	23.5	28.2	35.5
15: 0	180	-1.1311	20.2125	0.13904	14.4	15.9	17.8	20.2	23.5	28.2	35.5
15: 1	181	-1.1232	20.2595	0.13920	14.4	15.9	17.8	20.3	23.6	28.3	35.6
15: 2	182	-1.1153	20.3053	0.13934	14.4	15.9	17.8	20.3	23.6	28.4	35.7
15: 3	183	-1.1074	20.3499	0.13949	14.4	16.0	17.9	20.4	23.7	28.4	35.7

2007 WHO Reference

**BMI-for-age GIRLS**

5 to 19 years (z-scores)

Year: Month	Month	L	M	S	Z-scores (BMI in kg/m <sup>2</sup> )						
					-3 SD	-2 SD	-1 SD	Median	1 SD	2 SD	3 SD
15: 4	184	-1.0996	20.3934	0.13963	14.5	16.0	17.9	20.4	23.7	28.5	35.8
15: 5	185	-1.0917	20.4357	0.13977	14.5	16.0	17.9	20.4	23.8	28.5	35.8
15: 6	186	-1.0838	20.4769	0.13991	14.5	16.0	18.0	20.5	23.8	28.6	35.8
15: 7	187	-1.0760	20.5170	0.14005	14.5	16.1	18.0	20.5	23.9	28.6	35.9
15: 8	188	-1.0681	20.5560	0.14018	14.5	16.1	18.0	20.6	23.9	28.7	35.9
15: 9	189	-1.0603	20.5938	0.14031	14.5	16.1	18.1	20.6	24.0	28.7	36.0
15:10	190	-1.0525	20.6306	0.14044	14.6	16.1	18.1	20.6	24.0	28.8	36.0
15:11	191	-1.0447	20.6663	0.14057	14.6	16.2	18.1	20.7	24.1	28.8	36.0
16: 0	192	-1.0368	20.7008	0.14070	14.6	16.2	18.2	20.7	24.1	28.9	36.1
16: 1	193	-1.0290	20.7344	0.14082	14.6	16.2	18.2	20.7	24.1	28.9	36.1
16: 2	194	-1.0212	20.7668	0.14094	14.6	16.2	18.2	20.8	24.2	29.0	36.1
16: 3	195	-1.0134	20.7982	0.14106	14.6	16.2	18.2	20.8	24.2	29.0	36.1
16: 4	196	-1.0055	20.8286	0.14118	14.6	16.2	18.3	20.8	24.3	29.0	36.2
16: 5	197	-0.9977	20.8580	0.14130	14.6	16.3	18.3	20.9	24.3	29.1	36.2
16: 6	198	-0.9898	20.8863	0.14142	14.7	16.3	18.3	20.9	24.3	29.1	36.2
16: 7	199	-0.9819	20.9137	0.14153	14.7	16.3	18.3	20.9	24.4	29.1	36.2
16: 8	200	-0.9740	20.9401	0.14164	14.7	16.3	18.3	20.9	24.4	29.2	36.2
16: 9	201	-0.9661	20.9656	0.14176	14.7	16.3	18.4	21.0	24.4	29.2	36.3
16:10	202	-0.9582	20.9901	0.14187	14.7	16.3	18.4	21.0	24.4	29.2	36.3
16:11	203	-0.9503	21.0138	0.14198	14.7	16.3	18.4	21.0	24.5	29.3	36.3
17: 0	204	-0.9423	21.0367	0.14208	14.7	16.4	18.4	21.0	24.5	29.3	36.3
17: 1	205	-0.9344	21.0587	0.14219	14.7	16.4	18.4	21.1	24.5	29.3	36.3
17: 2	206	-0.9264	21.0801	0.14230	14.7	16.4	18.4	21.1	24.6	29.3	36.3
17: 3	207	-0.9184	21.1007	0.14240	14.7	16.4	18.5	21.1	24.6	29.4	36.3

2007 WHO Reference

**BMI-for-age GIRLS**

5 to 19 years (z-scores)

Year: Month	Month	L	M	S	Z-scores (BMI in kg/m <sup>2</sup> )						
					-3 SD	-2 SD	-1 SD	Median	1 SD	2 SD	3 SD
17: 4	208	-0.9104	21.1206	0.14250	14.7	16.4	18.5	21.1	24.6	29.4	36.3
17: 5	209	-0.9024	21.1399	0.14261	14.7	16.4	18.5	21.1	24.6	29.4	36.3
17: 6	210	-0.8944	21.1586	0.14271	14.7	16.4	18.5	21.2	24.6	29.4	36.3
17: 7	211	-0.8863	21.1768	0.14281	14.7	16.4	18.5	21.2	24.7	29.4	36.3
17: 8	212	-0.8783	21.1944	0.14291	14.7	16.4	18.5	21.2	24.7	29.5	36.3
17: 9	213	-0.8703	21.2116	0.14301	14.7	16.4	18.5	21.2	24.7	29.5	36.3
17:10	214	-0.8623	21.2282	0.14311	14.7	16.4	18.5	21.2	24.7	29.5	36.3
17:11	215	-0.8542	21.2444	0.14320	14.7	16.4	18.6	21.2	24.8	29.5	36.3
18: 0	216	-0.8462	21.2603	0.14330	14.7	16.4	18.6	21.3	24.8	29.5	36.3
18: 1	217	-0.8382	21.2757	0.14340	14.7	16.5	18.6	21.3	24.8	29.5	36.3
18: 2	218	-0.8301	21.2908	0.14349	14.7	16.5	18.6	21.3	24.8	29.6	36.3
18: 3	219	-0.8221	21.3055	0.14359	14.7	16.5	18.6	21.3	24.8	29.6	36.3
18: 4	220	-0.8140	21.3200	0.14368	14.7	16.5	18.6	21.3	24.8	29.6	36.3
18: 5	221	-0.8060	21.3341	0.14377	14.7	16.5	18.6	21.3	24.9	29.6	36.2
18: 6	222	-0.7980	21.3480	0.14386	14.7	16.5	18.6	21.3	24.9	29.6	36.2
18: 7	223	-0.7899	21.3617	0.14396	14.7	16.5	18.6	21.4	24.9	29.6	36.2
18: 8	224	-0.7819	21.3752	0.14405	14.7	16.5	18.6	21.4	24.9	29.6	36.2
18: 9	225	-0.7738	21.3884	0.14414	14.7	16.5	18.7	21.4	24.9	29.6	36.2
18:10	226	-0.7658	21.4014	0.14423	14.7	16.5	18.7	21.4	24.9	29.6	36.2
18:11	227	-0.7577	21.4143	0.14432	14.7	16.5	18.7	21.4	25.0	29.7	36.2
19: 0	228	-0.7496	21.4269	0.14441	14.7	16.5	18.7	21.4	25.0	29.7	36.2

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