

**THE INFLUENCE OF INTESTINAL PARASITES ON ACADEMIC
PERFORMANCE AMONG PRIMARY SCHOOL CHILDREN IN
NAIROBI PROVINCE, KENYA.**

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DECLARATION

This thesis is my original work and has not been presented for a degree in any other university or any other award.

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I confirm that this work was carried out under my supervision as the University Supervisor.

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DEDICATION

I dedicate my work to my father Lazarus Mugo Mwenji and late mother, Priscilla Wangeci who impressed on me early in my youth of the great power inherent in acquiring good education. I also dedicate this thesis to my wife, Mrs. Elizabeth N. Mwenji and my children, Victor Mwenji Mugo and Robert Mwenji Mwaura, for their patience and tolerance throughout this study.

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ABBREVIATIONS AND ACRONYMS

| | |
|--------|---|
| CDC | Centre for Disease Control and Prevention. |
| DALY's | Disability adjusted years. |
| DEC | Diethyl Carbamazine. |
| DVBD | Division of Vector Borne Diseases. |
| FRESH | Focussing resources on effective school health. |
| MOE | Ministry of Education. |
| MOH | Ministry of Health |
| PEM | Protein – energy malnutrition |
| ROK | Republic of Kenya. |
| SPSS | Statistical Package for Social Sciences. |
| STH | Soil Transmitted Helminths. |
| UNESCO | United Nations Educational, Scientific and Cultural Organization. |
| UNICEF | United Nations Children's Education Fund. |
| WHO | World Health Organization. |

DEFINITION OF OPERATIONAL TERMS

| | |
|-------------------|---|
| Anthelmintic | Drugs used to treat helminthic infections. |
| Antibiotic | Drugs used to treat bacterial and some protozoan infections. |
| Arthropods | Living organisms classified in the animal kingdom with jointed appendages for walking. |
| Cyst | A developmental or immature stage of some unicellular and Multi-cellular parasites designed to resist adverse environmental conditions. |
| Geohelminths | Soil-transmitted helminthes. |
| Helminths | Any of the various parasitic worms, including the flukes, tapeworms and nematodes. |
| Intermediate host | The organism that harbours the immature stage of the parasite or in which the asexual multiplication occurs. |
| Metacercariae | -The infective developmental stage of some flukes(Trematodes) |
| Mls | Millilitres. |
| Parasite | An organism that lives on or in another organism (host) for the purpose of obtaining food and shelter and occasionally does harm to the host. |
| Pathogen | A term describing the ability of an organism to cause disease. |
| Plerocercoid | The infective stage of <i>Diphyllbothrium latum</i> . |
| Protozoa | A term denoting single-celled organisms, excluding bacteria, viruses and fungi. |
| Trophozoite | The vegetative or invasive stage of some protozoans |

ABSTRACT

The purpose of this study was to assess the influence of intestinal parasites on academic performance among primary school children in Nairobi Province, Kenya. Intestinal parasites belong to two main taxonomic groups: protozoa and helminths. Pathogenic protozoa are *Entamoeba histolytica*, *Giardia lamblia* and *Balantidium coli* while intestinal helminths comprise of nematodes hookworms (*Ancylostoma duodenale* and *Necator americanus*), *Ascaris lumbricoides*, *Strongyloides stercoralis*, *Trichuris trichiura* and *Enterobius vermicularis*, cestodes (tapeworms) and trematodes (flukes). Infected persons, especially children, suffer sub-optimal arousal levels that undermine intellectual and academic development and impaired general health. The objectives of this study were to determine the prevalence and types of intestinal parasites affecting school-age children, factors contributing to prevalence and to establish effects of intestinal parasites on academic performance. A cross-sectional design was used to investigate children in classes three to seven drawn from five primary schools. Hospital Hill school was high-cost, Parkroad and St. Teresa Girls' were medium cost and Kiboro and Daniel Comboni were low-cost schools. Data was collected using Ridley's method of stool concentration and end-of-term scores for three preceding terms and one immediate term. Data was analyzed using the SPSS software, the correlation coefficient, the Chi square, the Odds Ratio, Analysis of variance and the t-test. The highest number of infections was from Daniel Comboni (99) and lowest from Hospital Hill school (5). The highest infection rate was from Daniel Comboni (9.0%) and lowest from Hospital Hill (0.5%). The highest number of infections were caused by *Entamoeba histolytica* (7.4%) and lowest by hookworms (0.1%). The Odds Ratio showed pupils had 87.4 times higher risk of infection with *E. histolytica* than with hookworms. The factors predisposing children to infections included children's status on knowledge of intestinal parasites, attitudes towards infections, prevailing practices and unhygienic environmental factors. The highest mean performance score was from Hospital Hill (83.0) and the lowest from Kiboro (44.4). Positive association between academic performance and intestinal infections was noted in Kiboro but not in other schools. The type of school attended significantly affected performance ($F=246.9$, $\alpha < 0.0001$) than infection by *E. histolytica*. Mean performances were significantly different between boys and girls ($F = 14.17$; $df = 1$; $\alpha < 0.001$). Mean score for boys (60.6) was significantly lower than for girls (62.8). Females performed better than males at an average score of 4.849 ($t = 3.8$, $\alpha < 0.0001$). Generally, uninfected children performed significantly better than the infected by an average of 9.109 ($t = 6.2$, $\alpha = 0.0001$). Overall prevalence was 16.4%. The most prevalent parasites were *E. histolytica* (7.4%) and *T. trichiura* (7.3%). The highest number of infections was by *E. histolytica* (7.4%) across all age groups. The most prominent factors predisposing to infections were failure to wash hands before meals and infrequent cleaning of toilets which attracted *Fannia scalaris* (latrine flies). Mean performance scores decreased from high-cost schools to low-cost schools. Infected children were two times at higher risk of performing poorer than uninfected children. The Ministry of Public Health and Sanitation and Ministry of Education should mount regular treatment programmes in schools. Public Health Education programmes should be emphasized in all schools high level of sanitation maintained. The impact of Public Health Education in primary schools should be further investigated.

CHAPTER 1: INTRODUCTION

1.1 Background Information

Parasites are organisms belonging to one or two major taxonomic groups called Protozoa and Helminths (worms) (Smyth, 1972; Plorde, 1994). Plorde (1994) showed that parasitic diseases remain among the major causes of human misery and death in the world today. Thus, parasitic diseases are important obstacles to development (World Bank, 1999; WHO, 2000), especially in the economically less favoured nations of the third world. Parasitic diseases result from infection by Protozoa, Helminths (WHO, 1981; WHO, 1987) and some arthropods (Service, 1980; Kitron, 1998). They have an immense influence on the lives of man and all lower vertebrates, producing a great variety of illnesses. The effects of these illnesses could be either rapidly fatal, severe, chronic, incidental or even asymptomatic (Smyth, 1972; Lucas, 1995; Rao, 2002).

Protozoan and Helminthic parasites (WHO, 1981; WHO, 1987) produce a variety of acute, chronic and debilitating intestinal infections, some of which culminate in death of the host (Monto *et al.*, 1991). Intestinal infections continue to challenge clinicians and public health services on a global scale (Farthing *et al.*, 1992). Several investigators have reported that growth deficits in children can be attributed to *Ascaris lumbricoides* (Willett, Kilama and Kihamia, 1979), *Trichuris trichiura* (Cooper and Bundy, 1988) and *Giardia lamblia* (Gupta and Urrutia, 1982). Sternberg *et al.* (1997; 1997b) and Waite and Neilson (1991) showed that intestinal infection with worms may have a detrimental effect on cognition and educational achievement in children. However, the mechanism by which mental processes are affected is uncertain, but evidence suggests that the mechanism is indirect (Pollitt, 1997).

Bundy and Drake (2004) showed that helminthiases have potential consequences on the physical, psychological and intellectual development of children and contribute (WHO, 1995) to health cost burdens of health care systems in many countries. Studies carried out among school-going children in Kenya showed that prevalence of intestinal helminthiases was high, ranging from 10% to 90% (Rijpstra, 1975; Brooker *et al.*, 2000; Muchiri *et al.*, 2001). This high level of infection constitutes significant loss to the benefit expected from schooling and impairs physical development (Kightlinger *et al.*, 1998).

1.2 Statement of the problem

There is a general lack of interest in the control of important intestinal protozoan diseases such as amoebiasis and giardiasis. However, intestinal helminthiases are an equally important public health concern in the tropics and sub-tropics (Kaethe, 1992). Although these helminthiases affect people of all age categories, studies have shown that the burden of disease is usually higher among the school-going children. There is a correlation between soil-transmitted helminths infections and detrimental effects on cognitive functions (Nokes *et al.*, 1991; Nokes and Bundy, 1993; Nokes and Bundy, 1994) but the mechanism by which worms affect cognitive function remains to be clarified (Kvalsvig *et al.*, 1991). It has been observed that children suffering from helminthic infections may experience some sub-optimal arousal levels and impaired performance tests (Nokes *et al.*, 1991; Nokes and Bundy, 1993). The purpose of this study is to determine the influence of intestinal parasites on academic performance of children attending primary schools situated within Nairobi Province, a study whose type and content has not been carried out before.

1.2.1 Justification of the study

No firm and consistent policy exists on the control of intestinal infections compared to policies already in place on diseases such as malaria and filariasis. Intestinal parasites have been shown to produce a detrimental effect on cognition and educational achievement in children (Pollitt, 1997), although the mechanism by which mental processes are affected is uncertain, but indirect. (Kitron, 1998). The purpose of this study was to provide evidence-based information for the Ministry of Education which can be used in the enhancement and improvement of Academic Performance in primary school-age children in the Republic of Kenya.

1.3 Research Questions

- (a) What types of intestinal parasites are common among primary school children in Nairobi Province?
- (b) What is the influence of intestinal parasites on academic performance of the children?

1.4 Research Hypothesis

Intestinal parasites do not influence the academic performance of children attending primary schools.

1.5 Objectives

1.5.1 Main Objective

To establish the influence of intestinal parasites on the academic performance of children attending some selected primary schools in Nairobi Province.

1.5.2 Specific Objectives

- (a) To determine prevalence of intestinal parasites among the school children in the study areas.
- (b) To identify the types of parasites prevalent among the school children in the study areas.
- (c) To determine the factors that contribute to the prevalence of intestinal infections among school children in the study areas.
- (d) To establish the effects of intestinal infections on academic performance in primary school children in the study areas.

1.6 Significance and Anticipated Output

The significance of this study was that, currently, there is a huge increase of school-age children in all primary schools in Kenya making use of the free primary education programme initiated by the government in 2003. All these children are exposed to the deleterious effects of intestinal parasites. These children will, therefore, benefit from the data and information emanating from this study, which will result in reduction of the prevalence and spread of intestinal infections which could be contributing to overall academic performance and wasted, unrealized full human potential.

1.7 Delimitations and Limitations of the study

This study shall involve only primary school children. Some of the limitations included the lack of baseline data indicating when the school-age children found to be infected acquired the intestinal infections.

The nutritional status, socio-economic, personal hygiene, immune status, genetic predisposition of each child, exercise and games programmes and teacher behaviour could also contribute to lowered academic performance each term. All these are extraneous (independent) variables which could affect the academic performance (the dependent variable) and introduce errors in the final results.

CHAPTER 2: LITERATURE REVIEW

2.1 Global distribution of intestinal parasites

It has been estimated that among the important protozoa causing diseases in man, currently *Entamoeba histolytica* that causes amoebiasis affects 10% of the world's population. The proportion is highest in the cities of the tropics and sub-tropics, but no country is free of amoebiasis. In addition, giardiasis caused by *Giardia lamblia* occurs worldwide (Lucas, 1995). Other important intestinal protozoa causing infections in man in various parts of the world sporadically, especially in immuno-compromised AIDS patients include: *Isospora belli* causing coccidiosis and *Cryptosporidium parvum* causing cryptosporidiosis. Still, other important intestinal protozoans occasionally producing infections in man include: *Sarcocystis hominis* causing diarrhoea, *Trichomonas hominis* causing diarrhoea, and *Balantidium coli* causing balantidiasis or balantidial dysentery in certain parts of the world (Plorde, 1994; Chiodini *et al.*, 2001).

The most common parasitic intestinal nematodes (roundworms) in humans are *Ascaris lumbricoides*, the large intestinal roundworm that causes ascariasis, *Necator americanus* and *Ancylostoma duodenale*, two species of hookworms that cause necatoriasis and ancylostomiasis, respectively (Chamlong, 1983; Brooker and Michael, 2000; Muchiri *et al.*, 2001) and *Trichuris trichiura*, the whipworm that causes trichuriasis. Other nematodes include *Strongyloides stercoralis* that causes strongyloidiasis and *Enterobius vermicularis* which causes enterobiasis (WHO, 1987). Among the important intestinal trematode diseases include fasciolopsiasis caused by *Fasciolopsis buski* which affects 10 million people and heterophiasis caused by *Heterophyes heterophyes* (WHO, 1994; Chiodini *et al.*, 2001).

Ascariasis caused by *Ascaris lumbricoides* affects 1.5 billion people, hookworms (*Ancylostoma duodenale* and *Necator americanus*) 1 billion, trichuriasis due to *Trichuris trichiura* 800 million, enterobiasis caused by *Enterobius vermicularis* 350 million, strongyloidiasis caused by *Strongyloides stercoralis* 90 million (Toll, 1947; Plorde, 1994; Chiodini *et al.*, 2001).

Cestodiasis is a common name for intestinal infections caused by cestodes; such cestodes include *Taenia saginata*, *Taenia solium* and *Diphyllobothrium latum* which affects 16 million people world wide *Taenia solium* which affects 5 million people and *Taenia saginata*, affecting people in beef-eating countries, specifically cause a disease called taeniasis, while infection with *Diphyllobothrium latum* is known as diphyllobothriasis. *Hymenolepis nana* currently affects 36 million people world wide (Jeffrey and Leach, 1975; Plorde, 1994; Chiodini *et al.*, 2001). *Schistosoma mansoni* affects 57 million people world wide (Chiodini *et al.*, 2001) and is also the trematode that causes the most significant intestinal infection in man (Bundy *et al.*, 1998).

2.2 Transmission of intestinal parasites

According to WHO (1964), WHO (1981), WHO (1987) and Chiodini *et al.* (2001), the main routes of entry of intestinal parasites into the human body are ingestion, skin penetration, inhalation and auto-infection.

2.2.1 Ingestion

Ingestion of viable infective protozoan cysts occurs in amoebiasis caused by *Entamoeba histolytica* (Fig. 2.1). Giardiasis which is caused by *Giardia lamblia* (Fig. 2.2) and also in infections caused by *Isospora belli*, *Cryptosporidium parvum*, *Sarcosystis hominis* and the ciliate called *Balantidium coli* are acquired by ingestion of infective cysts. Furthermore, intestinal infection caused by *Trichomonas hominis* involves the ingestion of live trophozoites, which serve as the infective stage. Ingestion of viable, infective embryonated eggs eaten with contaminated food or drink occurs in ascariasis caused by *Ascaris lumbricoides* (Crompton and Tulley, 1987), trichuriasis caused by *Trichuris trichiura* and occasionally, enterobiasis caused by *Enterobius vermicularis*, hymenolepiasis caused by *Hymenolepis nana*, and cysticercosis caused by *Taenia solium* tapeworms (Cheesbrough, 1981; Lucas, 1995; Chiodini *et al.*, 2001).

In addition, eating undercooked or raw beef or pork could lead to beef tapeworm infection caused by *Taenia saginata* and pork tapeworm infection caused by *Taenia solium*, respectively. Moreover, ingestion of fish infected with the plerocercoid larvae leads to diphyllbothriasis caused by *Diphyllbothrium latum* and ingestion of infective cysts of *Sarcocystis hominis* in undercooked beef or pork could also lead to diarrhea and abdominal pains. Eating water plants containing encysted metacercariae results in fasciolopsiasis caused by *Fasciolopsis buski* (Plorde, 1994; WHO, 1994); ingestion of infected fish containing encysted metacercariae of *Heterophyes heterophyes* could lead to heterophyiasis (WHO, 1964; WHO, 1994; Chiodini *et al.*, 2001).

2.2.2 Skin penetration

Skin penetration by the infective filariform larvae of hookworms (*Ancylostoma duodenale* and *Necator americanus*) and those of *Strongyloides stercoralis* lead to hookworm infection (ancylostomiasis and necatoriasis) and strongyloidiasis (Heyneman, 1998), respectively (Plorde, 1994). Penetration of the infective cercariae of schistosome species leads to a disease called schistosomiasis (Bilharziasis) (WHO, 1964; Nash *et al.*, 1982; Chiodini *et al.*, 2001).

2.2.3 Inhalation

Inhalation of viable embryonated eggs of *Ascaris lumbricoides* (Crompton and Tulley, 1987), and *Enterobius vermicularis* results in ascariasis and enterobiasis, respectively (WHO, 1964).

2.2.4 Auto-infection

Auto-infection is a common mode of infection with strongyloidiasis (Heyneman, 1998) and with *Enterobius vermicularis* causing enterobiasis and cysticercosis caused by *Taenia solium* and with hymenolepiasis caused by *Hymenolepis nana* and in cryptosporidiosis caused by *cryptosporidium parvum* and in the diarrhoea caused by *Sarcocystis hominis* (WHO, 1964; Lucas, 1995; Chiodini *et al.*, 2001). In addition, transmission of intestinal helminthic infections in endemic areas is dependent on many factors, including the species of helminths in the area, seasonality of transmission and infection rate (Muchiri *et al.*, 2001).

Different modes of transmission exist, for example: *Ascaris lumbricoides*, *Trichuris trichiura* and hookworms are soil-transmitted (Crompton, 1999). The process of transmission involves three major life cycles for intestinal nematodes: the direct, direct modified and percutaneous (Freedman, 1992). Direct life cycle involves transmission from the soil into the digestive system where maturation of the worm occurs with *Trichuris trichiura*. Indirect life cycle is similar to the direct life cycle, but involves migration of the larvae through the circulatory and respiratory systems, before final migration into the digestive system, where maturation occurs, for example, with *Ascaris lumbricoides*.

The percutaneous life cycle involves penetration through the skin and migration through the circulatory system, respiratory system and finally into the digestive system where maturation occurs as shown for hookworms. Excessive clustering of eggs of *Ascaris lumbricoides* and *Trichuris trichiura* suggests that concurrent infection with these species occurs at a greater frequency than would be expected by chance (Brooker *et al.*, 2000). This is further proof that *Ascaris lumbricoides* and *Trichuris trichiura* have a common transmission route (WHO, 1964). Evidence from Panama (Andrade *et al.*, 2001), Malaysia (Kan *et al.*, 1989) and Madagascar (Kightlinger *et al.*, 1998) also indicates that even within a given locality, the prevalence of intestinal helminthiases varies from one household to another, as a result of differences in socio-cultural, behavioural and economic backgrounds. Majority of intestinal infections with pathogenic parasites occur among people living in overcrowded areas, especially city slums (WHO, 1964; Florde, 1994; Rao, 2002).

Children growing in such endemic communities are prone to infections soon after being weaned and are thereafter constantly re-infected and multi-parasite infections are also common. Children harbouring such intestinal infections suffer from exacerbated morbidity; this makes them even more vulnerable to other infections (Chan *et al.*, 1994). Bundy and Drake showed that parasitic worms may be the commonest agents of chronic intestinal infection in humans (Bundy and Drake, 2004). The factors which contribute to the persistence of intestinal infections include poverty, illiteracy, social inequality and the low status of women. Other identified factors include inadequate nutrition, poor sanitation, inadequate housing, rapid urbanization and failure to implement known preventive strategies.

Indeed, also included are changing life-styles, limited access to health care and inadequate surveillance systems (Detels and Brestow, 2002). Infections with helminths significantly contribute to anaemia, protein-energy malnutrition, stunting, restlessness and abdominal pain. (Adams *et al.*, 1994). As a result of this, a direct association has been established between school performance and intestinal helminthic infections (Levav *et al.*, 1995; Sternberg *et al.*, 1997). School-going children with multiple helminthic infections have been indicated to have poorer school performances than uninfected children or those infected with a single species of intestinal helminths (Kvalsvig *et al.*, 1991). About 20% of disability adjusted life years (DALY's) lost due to communicable diseases among school children is a direct result of intestinal nematode infections (World Bank, 1993).

Stephenson (1987) demonstrated that the prevalence of soil-transmitted helminthic infections (*Ascaris lumbricoides*, *Trichuris trichiura* and hookworms- (*Ancylostoma duodenale* and *Necator americanus*) may result in morbidity, malnutrition and iron-deficiency anaemia. In addition, Soemantri (1989) showed that the possible contribution of *Ascaris lumbricoides*, Fig. 2.3, *Trichuris trichiura* (Fig. 2.4) and hookworms (Fig. 2.5) to impaired cognitive function and educational achievements has been demonstrated by the association between iron-deficiency anaemia and malnutrition in Indonesian children. According to the Special Committee of Experts (WHO, 1964) and Watkins and Pollitt (1997) it was demonstrated that infection of children with intestinal worms may impair educational performance. A causal link existed between parasitic infection and impaired cognitive function or delayed cognitive development; treatment of infected children had a therapeutic and beneficial effect.

Consensus has emerged that iron-deficiency impairs the cognitive development of children and since the learning abilities of children provide the skills for development, will contribute to loss of productivity (ACC / SCN / 2000). Pollitt (1990) who studied cognitive development in relation to iron-deficiency caused by hookworms concluded that ample evidence exists to link iron-deficiency with impaired educational performance. Sternberg *et al.* (1997, 1997b) and Waite and Neilson (1991) showed that intestinal infection with worms may have a detrimental effect on cognitive function and educational achievement in children. However, the mechanism by which mental processes are affected is uncertain, although available evidence suggests that the mechanism is indirect.

Moreover, Cooper and Bundy (1988) showed that iron-deficiency anaemia in infants and young children is associated with significantly lower scores on psychological tests. These effects of iron-deficiency during infancy were associated with lower developmental test scores at 5 years of age. Recent studies in Tanzania have shown that school children infected with worms achieved significantly lower scores in some tests of cognitive ability. The degree of deficit was related to the intensity of infection (Sternberg *et al.*, 1997). In Kenya, intestinal helminthic infections are ranked as the fifth major cause of out-patient attendance after malaria, pneumonia, dysentery and skin disease (DVBD-MOH-Kenya, 2000; ROK, 2001a). Sternberg *et al.* (1997) showed that intestinal infection with worms may have a detrimental effect on cognition and educational achievement in children. However, the mechanism by which mental processes are affected is uncertain, but evidence suggests that the mechanism is indirect. The most plausible mediators are the common sequelae of infection: iron-deficiency anemia (IDA), under-nutrition (Pollitt, 1997). Cooper and Bundy (1988) showed that IDA in infants and young children is associated with significantly lower scores on psychological tests. Moreover, the effects of IDA during infancy are associated with lower developmental test scores at 5 years of age.

Entamoeba histolytica (causing amoebiasis)

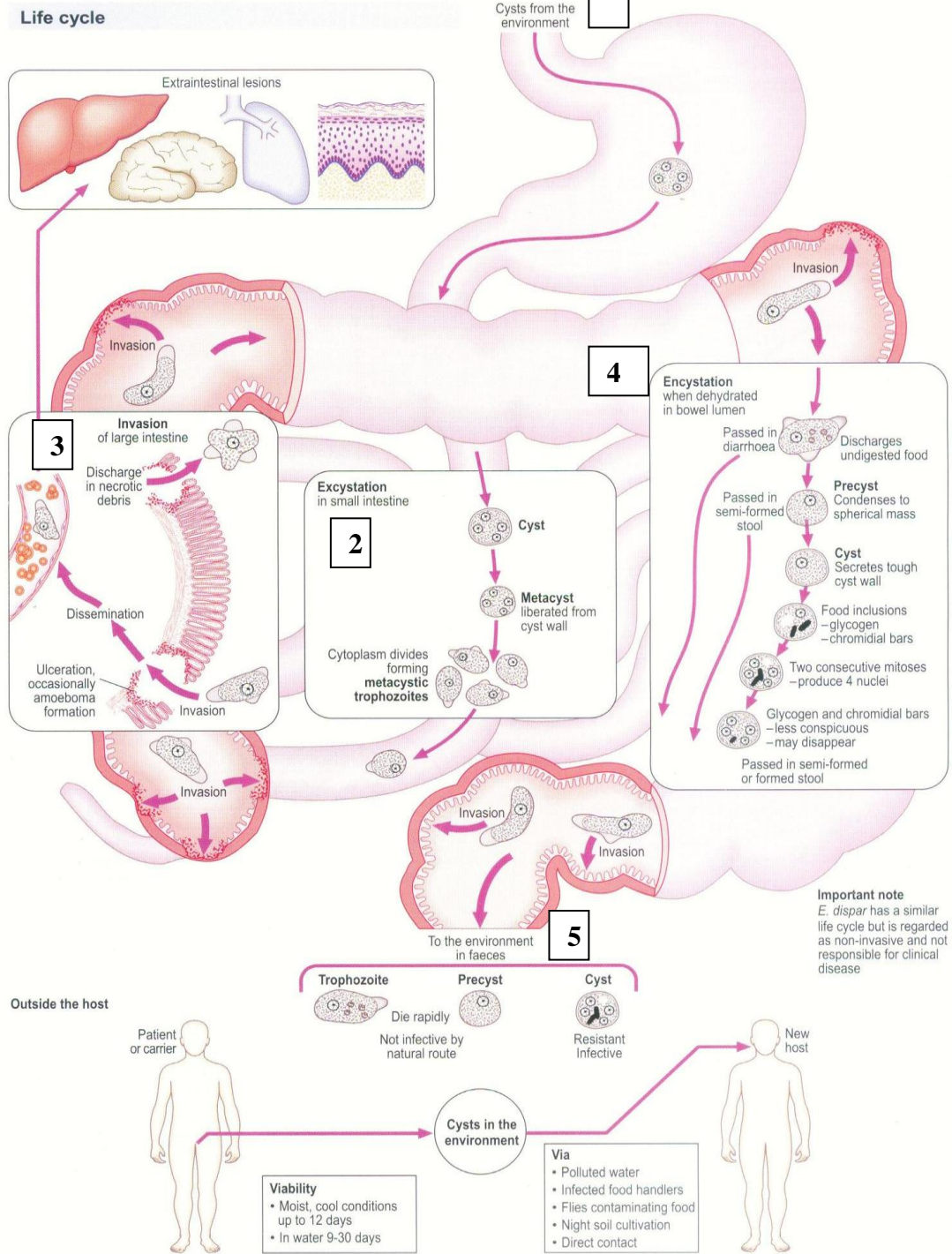


Fig. 2.1 Life cycle of *Entamoeba histolytica* in man (Adopted from Chiodini *et al.*, 2001)

2.2.1 Legend of the life cycle of *Entamoeba histolytica* in man

- (1) Viable cysts of *Entamoeba histolytica* are ingested with contaminated food or drink or by person-to-person contact through contaminated fingers..
- (2) The cysts excyst in the duodenum, jejunum and the ileum, producing immature trophozoites (vegetative or invasive stages or forms).
- (3) The amoebic trophozoites invade intestinal mucosa and some of the surrounding tissues and organs, such as the liver and the lungs producing extra-intestinal abscesses.
- (4) Encystation of some amoebic trophozoites occurs in the colon and rectal region.
- (5) The cysts transform into pre-cysts and later to infective cysts which are voided in stools. Trophic forms continue to invade the tissues of the rectal region as shown in Figure 2.1.

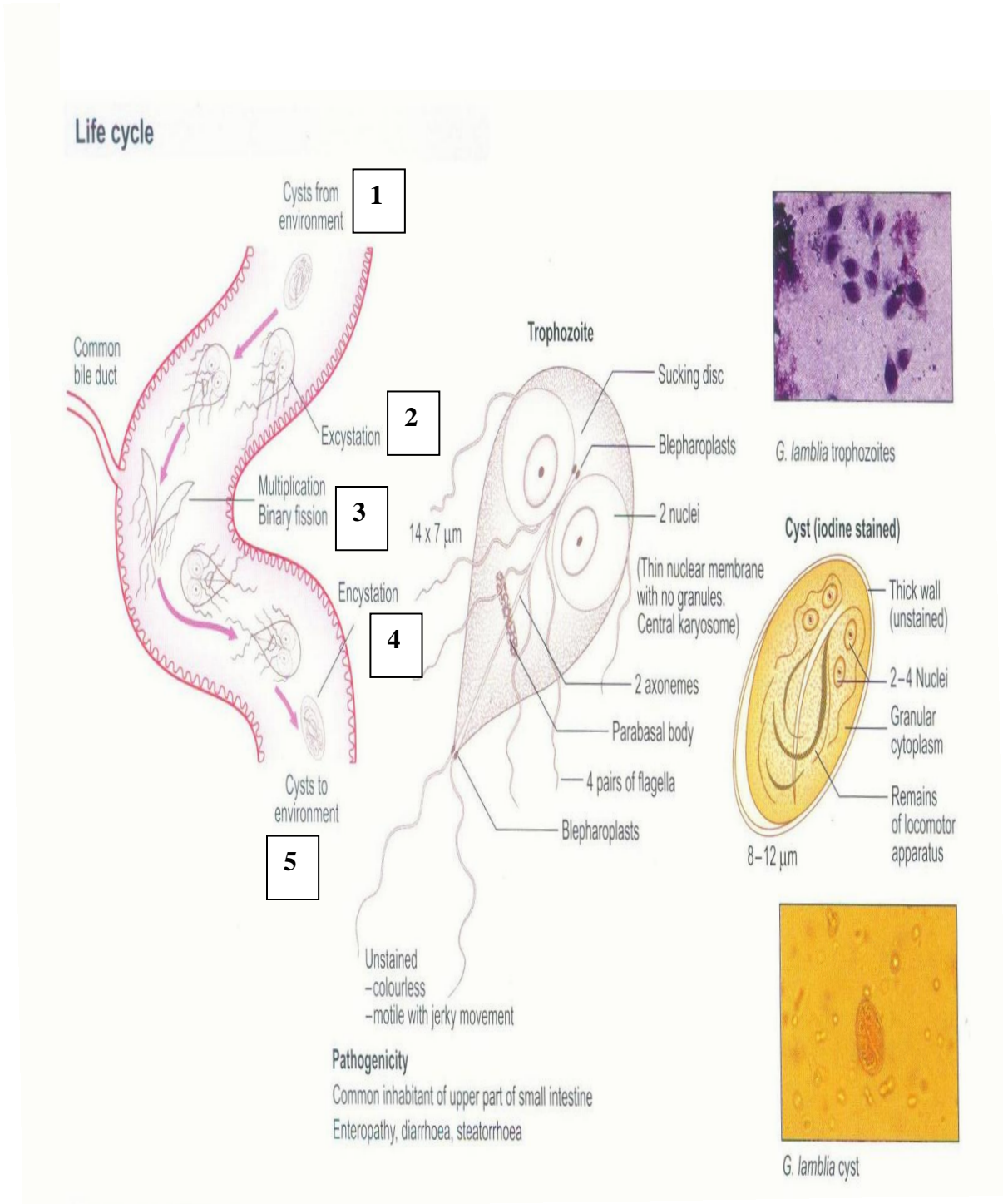


Fig. 2.2 Life cycle of *Giardia lamblia* in man (Adopted from Chiodini *et al.*, 2001)

2.2.2 Legend of the life cycle of *Giardia lamblia* in man

- (1) Viable cysts of *Giardia lamblia* are ingested with contaminated food or drink or by person-to-person contact through contaminated fingers..
- (2) The cysts excyst in the duodenum, jejunum and the ileum producing immature trophozoites (vegetative or invasive stages or forms).
- (3) The trophozoites invade the intestinal mucosa causing fatty diarrhoea.
- (4) Encystation of the trophozoites occurs in the colon and rectal region.
- (5) The infective cysts are voided in stools, as shown in Figure 2.2.

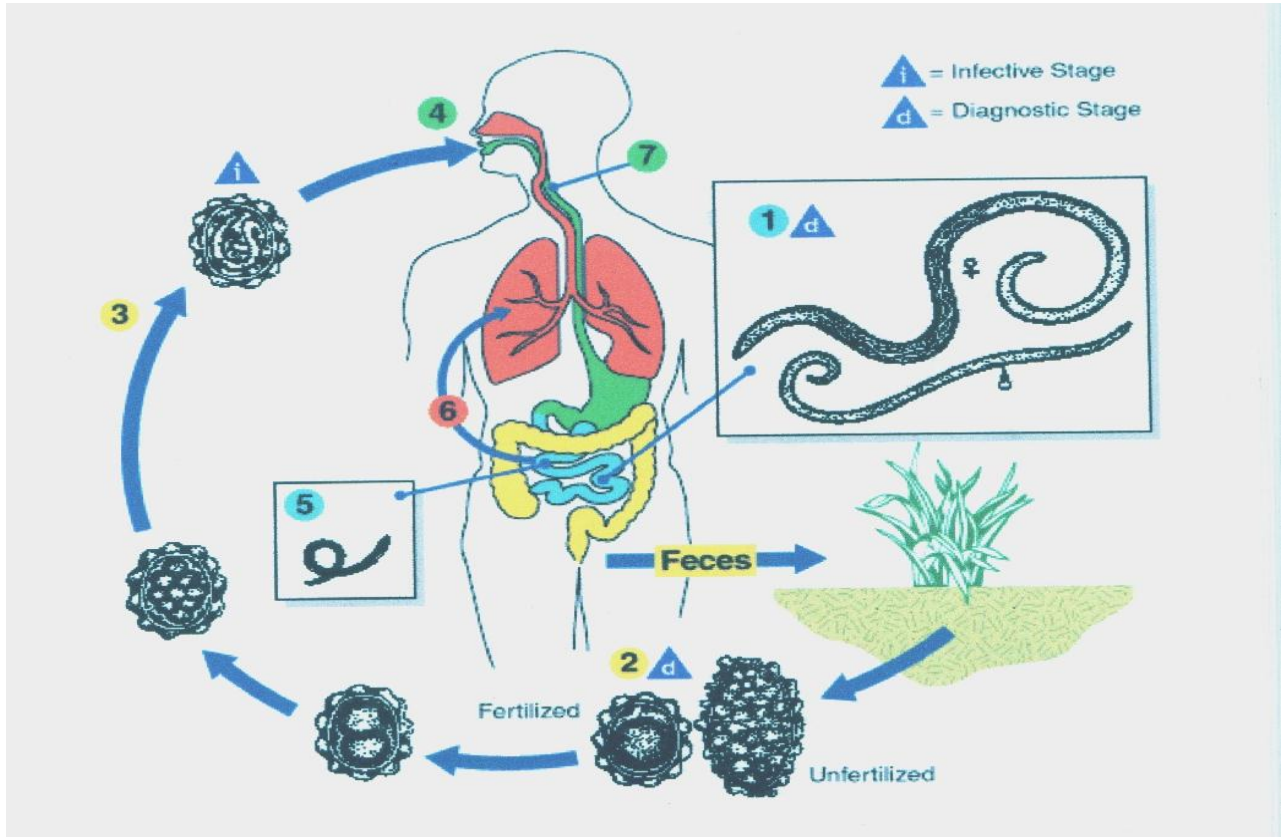


Fig. 2.3 Life cycle of *Ascaris lumbricoides* in man (Adopted from CDC, 1999)

2.2.3 Legend of the life cycle of *Ascaris lumbricoides* in man

1. Adult worms live in the lumen of the small intestine. A female may produce up to 240,000 eggs per day, which are passed with the faeces.
2. Fertile eggs embryonate and become infective after 18 days to several weeks depending on the environmental conditions (Optimum: moist, warm, shaded soil).
3. After infective eggs are swallowed, the larvae hatch, invade the intestinal mucosa, and are carried via the portal, then systemic circulation to the lungs.
4. The larvae mature further in the lungs (10 to 14 days), penetrate the alveolar walls, ascend the bronchial tree to the throat, and are swallowed.
5. Upon reaching the small intestine, they develop into adult worms.
6. Between 2 and 3 months are required from ingestion of the infective eggs to oviposition by the adult female. Adult worms can live up to 2 years (CDC, 1999).

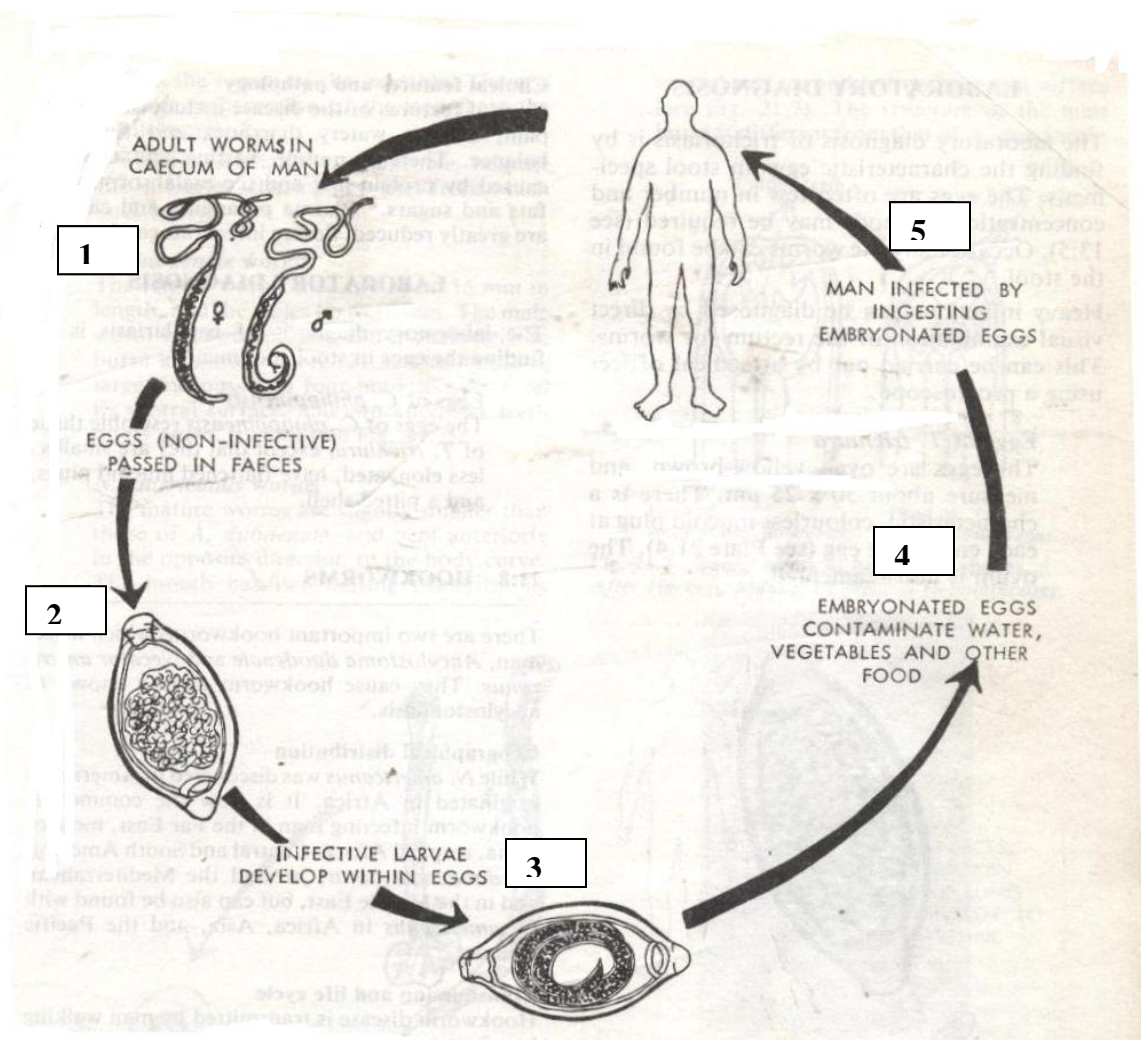


Fig. 2.4 Life cycle of *Trichuris trichiura* in man
(In part, courtesy of H. Purse, London School of Hygiene and Tropical Medicine)

2.2.4 Legend of the life cycle of *Trichuris trichiura* in man

- (1) Adult male and female *Trichuris trichiura* copulate in the caecum of man and the gravid female oviposits non-infective eggs in the caecum and appendix.
- (2) The non-infective eggs containing immature larvae are voided together with the faeces into the external environment.
- (3) The eggs undergo an embryonation process resulting with the development of infective larvae within the eggs.
- (4) Embryonated (infective) eggs contaminate the water, vegetables and other foods.
- (5) Man acquires infection by ingesting contaminated vegetables or food or drinking raw water as shown in Figure 2.4.

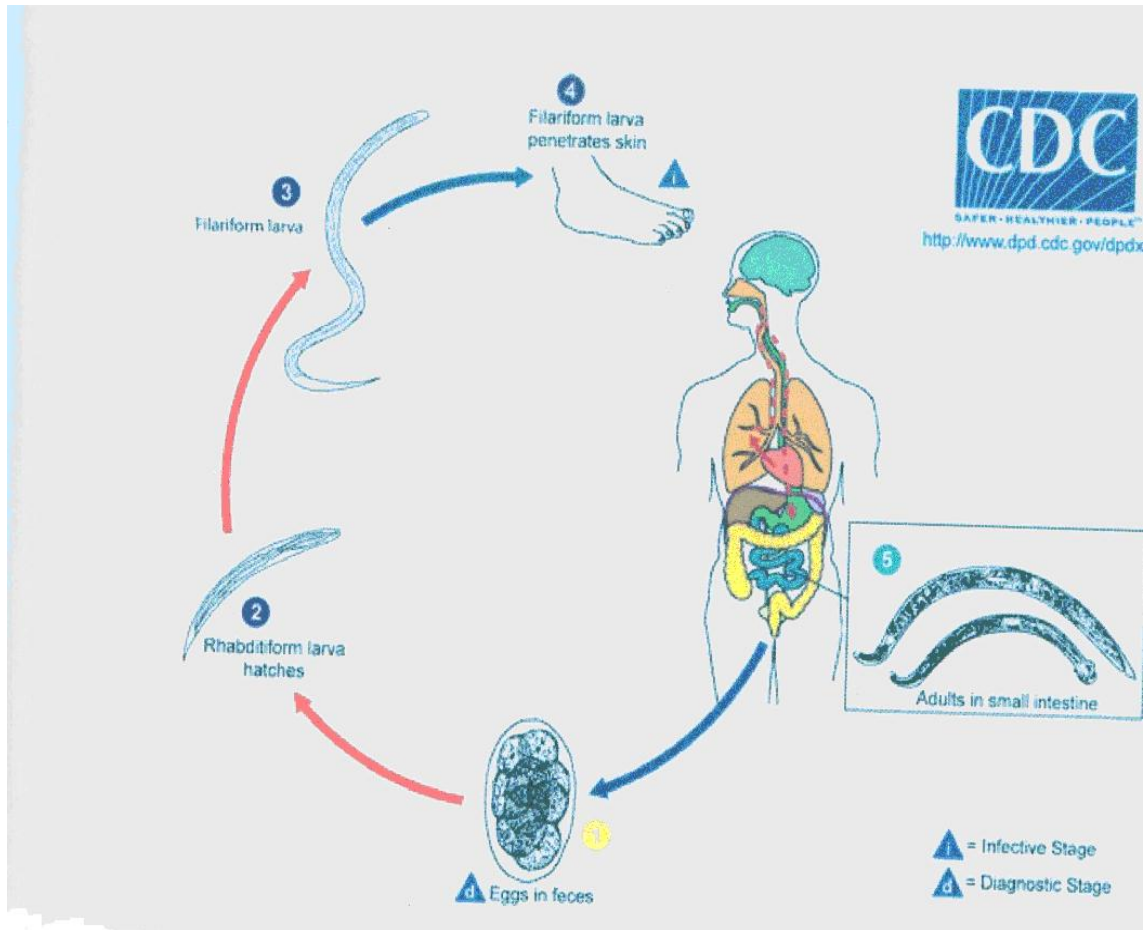


Fig. 2.5 Life cycle of Hookworm in man (Adopted from CDC, 1999)

2.2.5 Legend of the life cycle of Hookworms in man

1. Eggs are passed in the stool and under favourable conditions (moisture, warmth, shade), larvae hatch in 1 to 2 days. The released rhabditiform larvae grow in the faeces and/or the soil.
2. After 5 to 10 days (and two moults) they become filariform (third-stage) larvae that are infective.
3. These infective larvae can survive 3 to 4 weeks in favourable environmental conditions. On contact with the human host, the larvae penetrate the skin and are carried through the veins to the heart and then to the lungs. They penetrate into the pulmonary alveoli, ascend the bronchial tree to the pharynx, and are swallowed.
4. The larvae reach the small intestine, where they reside and mature into adults. Adult worms live in the lumen of the small intestine, where they attach to the intestinal wall with resultant blood loss by the host.
5. Most adult worms are eliminated in 1 to 2 years, but longevity records can reach several years. (Adopted from CDC, 1999)

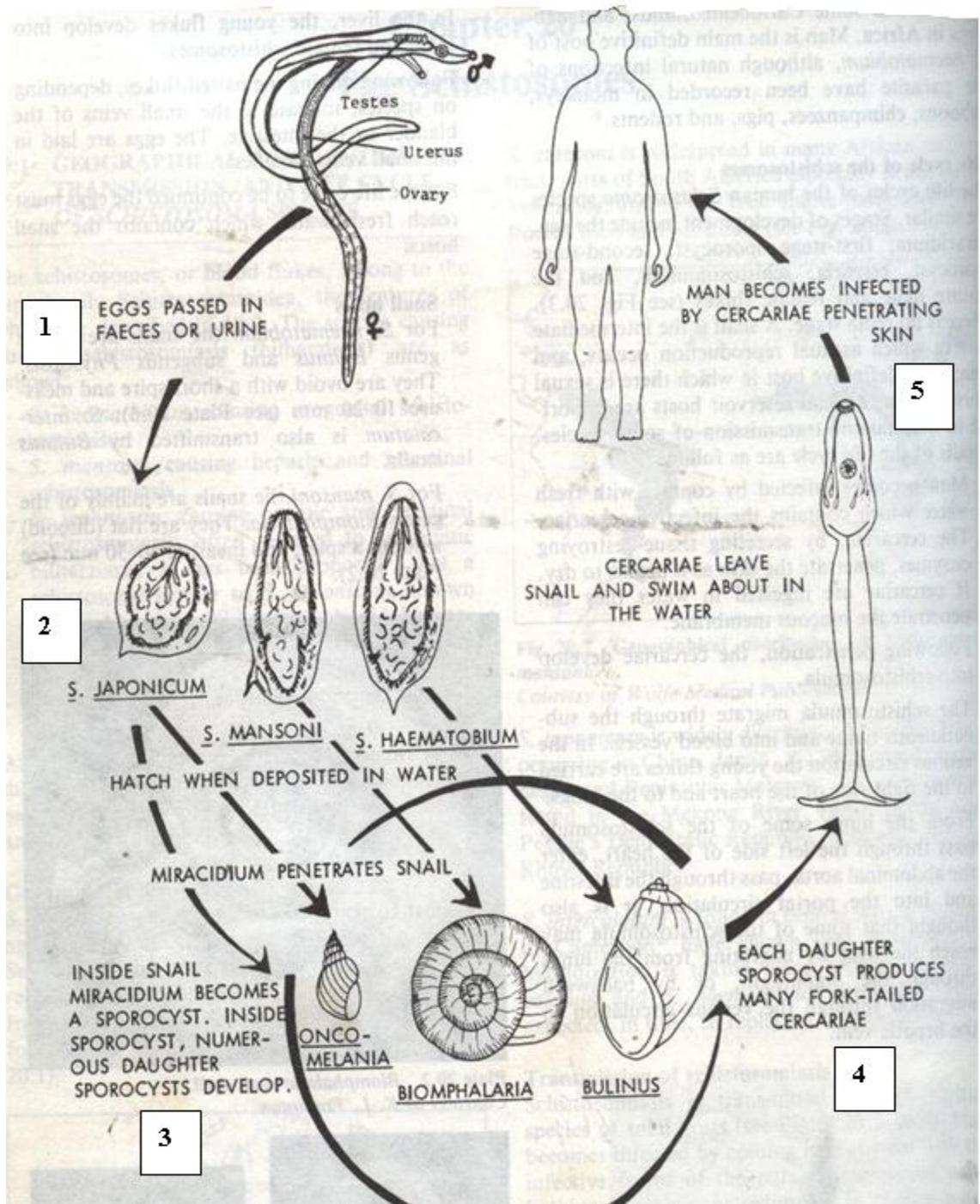


Fig. 2.6 Life cycle of schistosomes in man
(In part, courtesy of H. Purse, London School of Hygiene and Tropical Medicine)

2.2.6 Legend of the general life cycle of Schistosomes in man

- (1) Embryonated (mature) eggs are oviposited in the lumen of the blood vessels and find their way into stool or urine.
- (2) The eggs hatch on reaching water and release immature forms called miracidia which search for the appropriate snail species and penetrate them.
- (3) When inside the snails, the miracidia transform into sporocysts which later transform into numerous daughter sporocysts.
- (4) Each daughter sporocyst produces many infective stages called cercariae into the surrounding water.
- (5) Man acquires infection when infective cercariae penetrate the unprotected skin, as shown in Fig. 2.6.

2.3 Epidemiological factors that contribute to prevalence of intestinal parasites

Various factors indicated below contribute to the prevalence of intestinal parasites

2.3.1 Lack of adequate or proper sanitation facilities

Lack of or availability of poor sanitation facilities in many environments, both in rural and urban localities account for a large number of intestinal infections on a global scale. For example, *Entamoeba histolytica* is thought to infect 10% of the world's population and to produce more deaths than any other parasite, except those caused by malaria and schistosomiasis. Although it has a worldwide distribution, infection rates are highest in warm climates and exceed 50% in areas where the level of sanitation is low, for example, in city slums. For reasons apparently unrelated to exposure, symptomatic amoebiasis (amoebic dysentery) is less common in women and children than men (Plorde, 1994). Poor sanitation also leads to the endemicity of such infections as ancylostomiasis, ascariasis, trichuriasis, giardiasis, balantidiasis, necatoriasis and coccidiosis among other intestinal infections (WHO, 1964; Plorde, 1994; Lucas, 1995; Montessor, 2001)

2.3.2 Communal and personal hygiene

Poor communal and personal hygiene habits are also accountable for the transmission of many protozoan and helminthic infections. For example, symptomatic amoebiasis is usually sporadic, the result of direct person-to-person faecal-oral spread under conditions of poor personal and communal hygiene brought about by the contamination of water and food by infected persons who are carriers of infective cysts and who do not wash hands after visiting the toilets and before eating food. Thus, man acquires amoebiasis by ingesting food or water contaminated with viable, mature, infective cysts derived from infected human carrier faeces, since there are no known animal reservoirs.

Venereal transmission appears to be particularly common among male homosexuals, presumably the result of oral-anal sexual contact. Food- and water-borne spread occur, occasionally in epidemic form. Such outbreaks, however, are seldom as explosive as those produced by pathogenic intestinal bacteria (Cheesbrough, 1981; Plorde, 1994; Chiodini *et al.*, 2001). The exposure event is related to the host's behaviour and the household environment, which are further influenced by the cultural and economic circumstances of the community (Kightlinger *et al.*, 1998). It was noted that intestinal nematodes are distributed in tropical and sub-tropical regions though not evenly but reflect prevailing socio-economic and sanitary conditions of affected areas (Freedman, 1992). Intestinal cestode infections are generally high due to difficulty in carrying out adequate inspection of beef carcasses (Kaethe, 1992), use of raw sewage as fertilizer and consumption of undercooked cooked beef.

2.3.3 Socio-economic factors

The high prevalence of worm infections, for example, has been attributed to many factors involving the interaction of biotic and abiotic factors (Magambo *et al.*, 1998) and socio-economic factors. In a study carried out in Sri Lanka, the prevalence of *Ascaris lumbricoides* and *Trichuris trichiura* were seven to ten times higher in children living in overcrowded conditions than in children attending rural primary schools twenty miles away (Atukurola *et al.*, 1999). In the tropics, toilet construction and usage have been suggested as effective control measures (Cheesbrough, 1998) but this still calls for further research as this has been found not to be very protective especially when the environment is faecally contaminated (Haswell-Elkins *et al.*, 1989).

In circumstances where the toilets are not easy to clean (Chadiwana *et al.*, 1989), the water table is high (Muchiri *et al.*, 2001) and when the toilet is provided and not used (Faecham *et al.*, 1983) the transmission of helminthic infection is not effectively controlled through provision of toilets.

2.3.4 Geographical factors

In addition, several other factors have been attributed to rapid transmission of helminthic and protozoan infections where they occur. Geographical factors such as the presence of natural features like lakes have been found to influence distribution of intestinal helminthes. In Busia (Kenya), proximity of schools to Lake Victoria was indicated to increase infections with *Schistosoma mansoni* (Brooker *et al.*, 2000). Other factors such as those related to the environment play a major role in epidemiology of soil-transmitted helminths (Katz and Hotez, 2004).

These include rainfall, temperature, humidity, soil-type and altitude (Brooker and Michael, 2000). The difference in tolerance of humidity usually affects the distribution of *Ascaris lumbricoides* and *Trichuris trichiura* while prevalence of hookworm infections has been found to be negatively associated with altitude (Jamaneh, 1998). Soil texture and porosity affects the distribution of hookworm infections. Sandy soils harbour more infective eggs of hookworm than clay soils (Vinayak *et al.*, 1979). These variations in the epidemiology of worms make generalizations of indicators of helminthic and other intestinal infections difficult (WHO, 1964).

2.3.5 Socio-cultural differences

Ethnic differences have been found to determine levels of prevalence and infection intensity due to various reasons. In Malaysia, for example, striking cultural differences between the Chinese, Malayi and Indians were attributed to observed differences in prevalence and intensity of infection between the groups (Kan *et al.*, 1989). This could also be due to lifestyle differences between the groups as found in a study carried out in Madagascar (Kightlinger *et al.*, 1998).

2.4 Clinical manifestations of intestinal parasites

The clinical manifestations produced by infections with pathogenic intestinal parasites include: anaemia, general malaise, headache, stomach pains, blood in stool and diarrhoea (Plorde, 1994; Katz and Hotez, 2004).

2.4.1 Anaemia

This is a frequent sequela of several manifestations brought about by a sustained blood loss especially in heavy infections with *Ancylostoma duodenale*, *Necator americanus*, *Trichuris trichiura* and in some instances, severe infections with *Strongyloides stercoralis* (WHO, 1964; Katz and Hotez, 2004). In addition, Stephenson (1993) and Crompton (2000) noted that among parasitic infections, malaria, trichuriasis and schistosomiasis caused by *Schistosoma haematobium* are known to contribute to poor iron status and iron-deficiency anaemia. Further, these infections, singly or in combination, often occurred concurrently with hookworm, in the same individual person. Moreover, major agencies recognized the health risks to pregnant women caused by iron-deficiency anaemia (WHO, 1996; World Bank, 1999; ACC / SCN, 2000).

2.4.2 Diarrhoea

Acute bloody diarrhoeic episodes are common in intestinal infections with, for example, *Entamoeba histolytica* (Plorde, 1994; Lucas, 1995), *Trichuris trichiura* and in certain severe infections with *Strongyloides stercoralis* (WHO, 1964) and *Heterophyes heterophyes* (Plorde, 1994). Fatty steatorrhoeic stools are also passed in acute infections with *Giardia lamblia* (Plorde, 1994; Lucas, 1995; Katz and Hotez, 2004).

2.4.3 Electrolyte imbalances

Diarrhoea exacerbates malnutrition and upsets the acid-base balance of the body causing hypokalaemia, hyponatraemia and hypochloraemia with serious consequences on the nervous system function.

These disturbances are associated with seizures and periodic paralysis (Prensky, 1996) in affected patients, especially with prolonged presence of worm infections which go untreated (WHO, 1964; Katz and Hotez, 2004).

2.4.4 General malaise

Generalized malaise often accompanied by headaches, nausea and abdominal pains is a condition frequently associated with several protozoan and helminthic infections, especially when the infections are heavy and in a chronic state. It occurs in amoebiasis, giardiasis, ancylostomiasis, necatoriasis, ascariasis, trichuriasis, strongyloidiasis, entrobiasis, taeniasis, hymenolepiasis and in fasciolopsiasis and heterophyiasis (Plorde, 1994; Heyneman, 1998). Strongyloidiasis and trichuriasis infections are also often accompanied by headache, stomach pains and diarrhoea, especially when heavy worm burden is reached (WHO, 1964; Katz and Hotez, 2004).

2.4.5 Malnutrition

It has been shown that the presence of 26 adult *Ascaris lumbricoides* worms in a child deprives as much as 1/10 (One tenth) of the total protein content of the child (Bundy and Drake, 2004). *Strongyloides stercoralis* impairs fat digestion and also causes defective absorption of protein and fat-soluble vitamins, specifically vitamins A, D, E and K and Folic Acid.

This results in diarrhoeic episodes and the subsequent gross loss of these vitamins with stools to the environment. Sustained infections, especially in hyper-infective states, could cause malnutrition. Diarrhoea exacerbates malnutrition in strongyloidiasis and trichuriasis (WHO, 1964).

Ascaris lumbricoides has also been shown to impair protein digestion and causes defective absorption of proteins, vitamin A and resultant stunting and sub-nutrition states in school-age children (WHO, 1964). *Ancylostoma duodenale* and *Necator americanus* are both associated with the loss of Iron, Folic Acid (Pteroyl glutamic acid) and vitamin B₁₂ (Cyanocobalamin) from the bowel (WHO, 1964). *Giardia lamblia* has also been shown to produce malnutrition as a result of impaired fat digestion that leads to stunted growth in children (Katz and Hotez, 2004).

2.5 The Public Health Problems caused by intestinal infections

2.5.1 Socio-economic implications

The public health and socio-economic implications of infections with intestinal parasites are enormous, especially in third world countries (Rao, 2002). Indeed, in these countries, many hours of productive working life of workers and employees are lost while they seek treatment or through absenteeism from workplaces (World Bank, 1999). This is due to the general malaise and other ill-health effects produced by infections with intestinal parasites (Cheesbrough, 1981). Infections with intestinal parasites cause a vicious cycle, especially in endemic areas such as slums (Katz and Hotez, 2004). Infected persons have lowered output and, thus, cannot either pursue education or engage in gainful employment to improve the standard of living or maintain a healthy state. This leads to further poor health and vulnerability to other infections (Monto *et al.*, 1991; Florde, 1994). Human communities in tropical regions of the world where soil-transmitted helminthic infections are endemic are seldom afflicted by just one species.

Indeed, it is common for several soil-transmitted helminths to be present in the community concurrently and for the greatest number of subjects to carry simultaneously, at least two species (Chunge *et al.*, 1995; Kightlinger *et al.*, 1998). Studies have shown that for some parasites, egg counts are likely to be higher among subjects carrying mixed infections than in subjects carrying single species infections (WHO, 1964). Individuals with mixed infections are at a higher risk of morbidity and in extreme circumstances, mortality. The prevalence of *Ascaris lumbricoides* and *Trichuris trichiura* infections among school going children living in overcrowded conditions in Colombo, Sri Lanka, was found to be seven times higher than that among children attending rural schools approximately 20 miles [30 kms.] away (Atukurola and Laneroole, 1999).

Moreover, another study carried out in Malaysia suggested that urban slum children are at greater risk of mixed *Ascaris* and *Trichuris* infections than their rural counterparts (Henry, 1988). Several intestinal parasitic infections co-exist together within a community and a great number of individuals carry simultaneously at least two species (Kvalsvig *et al.*, 1991; Brooker *et al.*, 2000; Tchuem-Tchuente *et al.*, 2003;). A study carried out in Busia, Kenya found 5.9% of school children were harbouring four different species of intestinal helminths: *A. lumbricoides*, hookworms (*A. duodenale* and *N. americanus*), *T. trichiura* and *S. mansoni* (Brooker *et al.*, 2000).

The study reported a prevalence of 26% mixed infections with the three soil-transmitted helminths among children. Indeed, this phenomenon has also been observed in other studies. For example, in Madagascar where the prevalence of *Ascaris lumbricoides* was 93%, *Trichuris trichiura* 55% and hookworms 27% (Kightlinger *et al.*, 1998).

In Cameroon, 34.3 % children had two infections of intestinal helminths, 27.4% carried three infections and 1.1% were infected with four species of intestinal helminths (Tchuem-Tchuente *et al.*, 2003). Indeed, children with multiple infections have also been indicated to carry heavy loads of each parasite species. In a study carried out in Tanzania, children infected with two or more species of intestinal helminths had generally heavier infections of each species than children carrying single specie infections (Booth *et al.*, 1998; 1998b), and those carrying multiple infections were reported at high risk of severe morbidity and in extreme circumstances, even mortality (Tchuem-Tchuente *et al.*, 2003).

In addition, some pathogenic intestinal protozoa, specifically *E. histolytica* and *G. lamblia* cause significant morbidity in developing and developed countries (Monto *et al.*, 1991). Greenwood (2002) indicated that infection with pathogenic protozoa exacts an enormous toll of human suffering. This is mostly attributed to the increased costs of seeking clinical consultation and treatment, convalescence and social rehabilitation of affected persons (Plorde, 1994; Rao, 2002). Farthing *et al.* (1992) indicated that intestinal infections continue to challenge clinicians and public health services on a global scale. This is due to the increased indirect costs of treatment, control and prevention of protozoan and helminthic infections.

In addition, other indirect costs are incurred in the improvement of infrastructures and human resources involved in maintaining health, especially among the poor, crowded and disadvantaged communities living in slums. Intestinal infection (Farthing *et al.*, 1993) is the most common affliction of the gastro-intestinal tract worldwide and prevalence is higher in developing countries (Logan *et al.*, 2002).

Amongst the most common of all human infections are the geohelminths; indeed, Chan *et al.* (1994) showed that more than one-quarter of the world's population are infected with one or more of the round worm *Ascaris lumbricoides*, the hookworms (*Necator americanus* and *Ancylostoma duodenale*) and the whipworm *Trichuris trichiura*. Anderson and Medley (1985) showed that whilst the majority of the hosts harbour few or no worms, a few hosts harbour a much larger numbers of parasites. This observation has clinical consequences for the host, as it is the intensity of infection that is the central determinant of the severity of morbidity (Stephenson, 1987; Cooper and Bundy, 1988). Indeed, Stephenson (1987) showed that maximum intensity for hookworms is usually not attained until 20-25 years.

2.5.2 Harmful effects of intestinal parasites

Although intestinal protozoa and helminths may cause general physical damage or abnormal changes in the sites of the body in which they live and which can lead to local inflammation, general malaise and loss of appetite, each species also has specifically recognized effects (Katz and Hotez, 2004). Thus, some specific clinico-pathologic manifestations include the following.

2.5.2.1 Spoliative effect leading to malnutrition states

Infections with intestinal parasites, especially in heavy and acute states are associated with protein-energy malnutrition with resulting in serious health consequences.

These effects are especially serious and more pronounced in young children and pregnant women. Indeed, infections with hookworms (*Ancylostoma duodenale* and *Necator americanus*) are associated with the impairment of protein digestion in infected persons and Iron-deficiency anaemia. In addition, *Ancylostoma duodenale* and *Necator americanus* and *Ascaris lumbricoides* are associated with the impairment of absorption of fats, proteins and water-soluble vitamins especially vitamin B₁₂ (Cyanocobalamin), Folic Acid (Pteroyl glutamic Acid) and the fat-soluble vitamin A (WHO, 1964; (Katz and Hotez, 2004).

Stephenson *et al.* (1993) showed that heavy burdens of both roundworm and whipworm are associated with protein energy malnutrition (PEM). The United Nations estimated that 182 million pre-school children – 33% of those living in developing countries-are stunted when their height-for-age is compared with the norms for well-nourished children living in good environments (ACC / SCN, 2000). Underweight and stunted children are at greater risk of dying during childhood (Pelletier, 1994) and may not achieve their full potential in education and physical performance (Martorell and Scrimshaw, 1995). A child's height and weight are determined in part by the complex relationship between the child, the child's diet and the environment. Tomkins and Watson (1989) reported that a malnutrition-infection complex reduces food intake, leading to reduced growth rate, diarrhoea and reduced immune function. Malnutrition and parasitic infections occur concurrently where poverty ensures the persistence of poor housing, low levels of education and poor health services. In addition, poverty is also frequently associated with inadequate sanitation and lack of clean water (Crompton and Nesheim, 1982).

It is now accepted that parasitic disease is a major contributor to the etiology of the malnutrition-infection complex (Crompton, 1999; Katz and Hotez, 2004). Research has established that helminthic infections are accompanied by reduced growth rates during childhood and by impaired nutrient utilization; hookworm infections affect iron status, often to the extent where anaemia develops (Torlesse, 1999 ; Torlesse and Hodges, 2001). A study carried out in Ghana (Annan, 1985) indicated that a complex aetiology of malnutrition in rural areas affected adversely the pre-school children.

Familial and household characteristics, educational and economic standing of parents and the occurrence of intestinal parasitism in children were the factors that acted as possible determinants of poor nutritional status in rural pre-school children. In addition, it has been shown that intestinal infections with protozoa (WHO, 1981; Gupta, 1985) and helminths (Willet, Kilama and Kihamia, 1979 ; Stephenson *et al.*, 1980) can impair nutrition and growth in pre-school children, particularly when associated with low socio-economic status (Cere *et al.*, 1981).

2.5.2.2 Exsanguination

Several intestinal parasites, especially the nematodes actively take in blood to sustain their metabolism in the species.

These include *Ancylostoma duodenale* and *Necator americanus*, *Trichuris trichiura* and to some extent, especially during hyper-infections, *Strongylodes stercoralis*. It has been reported that *Strongylodes stercoralis* is also associated with an appreciable amount of blood loss (WHO, 1964, Plorde, 1994).

Hookworms feed on blood and cause iron-deficiency anaemia, especially when diets do not contain enough iron to replace the iron that is lost to the worms. Whipworms, however, cause blood loss through of a much smaller volume per worm than hookworms (Hall, 1993). Bundy and Cooper (1989) showed that intense whipworm infection in children may result in *Trichuris* Dysentery Syndrome, the classical signs of which include growth retardation and anaemia. Heavy hookworm burdens have long been recognized as an important cause of iron deficiency anaemia (IDA) (WHO, 1964; Katz and Hotez, 2004).

2.5.2.3 Blockage

Some intestinal helminths, for example, *Ascaris lumbricoides* adults have such powerful muscles that when excited or during fever states can move and physically force their way into various body orifices causing obstruction of air passages and the gastro-intestinal tract, especially during heavy worm burdens (Hall, 1993; Katz and Hotez, 2004).

2.5.2.4 Effect on cognitive functions

Persistent infections can inflame the lower bowel, cause diarrhoea and dysentery and retard growth and cognitive development. The larger roundworms-*Ascaris lumbricoides* have been shown to impair growth, affect the absorption of fat-soluble micro-nutrients such as vitamin-A and also depress appetite (Hall, 1993). The World Bank (1993) estimated that for girls and boys aged 5-14 years in low-income countries, intestinal worms account for 12 per cent and 11 per cent of the total disease burden.

Moreover, an estimated 20 per cent of disability adjusted life years (DALY'S) lost due to communicable disease among school children are a direct result of intestinal nematodes (Katz and Hotez, 2004). Since children suffer most at an age when they are both growing and learning, the entire development process is placed in jeopardy. Several investigators have shown that infection with worms constrain children growth and development and produce a detrimental effect on cognitive functions and educational achievement (Sternberg *et al.*, 1997). Worm infections constrain child development (Roche and Layrisse, 1966); indeed, many children in low-income groups underachieve and never realize their full potential.

In addition, Sternberg *et al.* (1997), Waite and Neilson (1991) and Nyabate (1997) showed that infection with worms may constrain intellectual development. Stolfus *et al.* (1998), while working in intervention studies showed that infection with as few as 10 roundworms is associated with deficits in growth and physical fitness in school-age children. Moderate infections with *Trichuris trichiura* can cause growth retardation and anaemia in children; even light hookworm infection can lead to iron-deficiency anaemia and this is evident not only in the adult population but also in pre-school and school children in certain populations. Cooper and Bundy (1988) showed that iron-deficiency anaemia (IDA) in infants and young children is associated with significantly lower scores on psychological tests. Moreover, these effects of IDA during infancy are associated with lower development test scores at 5 years of age. IDA was shown to lead to long-term deficits in cognitive functioning (Grantham-McGregor *et al.*, 2000).

Studies in Tanzania have shown that school children infected with worms achieved significantly lower scores in some tests of cognitive ability; the degree of deficit was related to the intensity of infection (Sternberg *et al.*, 1997). In addition, a study carried out in Kenya by Miguel and Kremer (2002) showed that intestinal worm infections may have an insidious and less overt impact upon the developmental process. Delays in the development of these abilities may leave a child lacking in the interpersonal and emotional skills vital to making positive life decisions. Abidin and Hadidjaja (2003) reported that research on the correlation between soil-transmitted helminthic infections (*Ascaris lumbricoides*, *Trichuris trichiura*) and hookworms (*Ancylostoma duodenale* and *Necator americanus*) and cognitive functions was focused on school-age children. Not only are these children the most vulnerable to helminths infections, they are also the population group most likely to experience the impact of infection on cognitive functions.

Further, Waite and Neilson (1991), Abidin and Hadidjaja (2003), in their review of literature, concluded that there is a correlation between soil-transmitted helminths infections and cognitive functions, but the mechanism by which worms affect cognitive functions remains to be clarified. Moreover, Nokes *et al.* (1991, 1991), Nokes and Bundy (1993), Nokes and Bundy (1994) showed that the fatigue and listlessness experienced by children suffering from worm infections may result in sub-optimal arousal levels and impaired performance tests and that further research is required in this area.

2.6 Prevention and Control of Intestinal Parasites

Infections with intestinal parasites can be prevented and controlled by applying an integrated approach, consisting of various approved methods and techniques. These include: appropriate treatment with appropriate broad-spectrum drugs and specific anthelmintics, observing personal and communal hygiene, practice of health maintenance activities and sustained health education practices (Rao, 2002; Katz and Hotez, 2004).

2.6.1 Treatment of intestinal parasitic infections

Protozoan infections such as amoebiasis and giardiasis can be effectively controlled by treatment with appropriate chemotherapeutic anti-protozoan drugs. However, helminthic infections are controlled by using broad-spectrum and specific anthelmintics. The aim of soil-transmitted helminth control programs is to keep the intensity of infections in individuals below a level that causes disease. The need for re-treatment will depend on the rate at which moderate to heavy worm burdens are re-acquired, which in turn, depends on exposure to the infective-stage larvae of the soil-transmitted helminths in the environment (Katz and Hotez, 2004). The rate of re-infestation determines the interval between treatments; indeed, in localities where the intensity of infestation in the target group rebuilds within 6-9 months to the levels observed before treatment, anti-helminthic treatment may be required twice a year; in other areas, annual treatment would be appropriate (Plorde, 1994). Currently, there are safe, effective and inexpensive drugs available for the treatment of helminthic infections (De Clereq *et al.*, 1997). Control is best-achieved using chemotherapy and hygienic interventions, especially among school-aged children (Arata and Hopkins, 1992).

About 50% prevalence of helminthic infections is the world Health Organization-recommended threshold for mass treatment (WHO, 2000). Mass treatment involves giving drugs to people without the prior diagnosis of current infections. Two types of mass treatment have been identified. Universal treatment, in which treatment is given to everyone in the community; and Target treatment, in which a specific group in the community is treated, such as school children (WHO, 1996). Greatest successes have been achieved through the development of single dose therapy and mass treatment (Stephenson, 1987). Integrated control programs for simultaneous treatment of multiple diseases have been found to be an efficient and cost-effective approach of addressing soil-transmitted helminths (Chunge *et al.*, 1995).

Globally, school-based drug treatment campaigns have been planned or initiated as a means of controlling intestinal helminthiases (Colley, 2000), through several partnerships such as FRESH (Focusing Resources on Effective School Health) by UNESCO, UNICEF, WHO, Education International and World Bank. The campaign aims at supporting the distribution of anthelmintics through schools (Aswasthi *et al.*, 2003). This will go a long way in improving the health and nutrition of school children and contribute to the global goal for “Good Health and Education for All”. Through the advent of broad-spectrum anthelmintic drugs that are cheap, safe and simple to deliver, intestinal helminth control has now become a viable option. Praziquantel is used to treat *Schistosoma mansoni* while *Ascaris lumbricoides*, *Trichuris trichiura* and hookworm infections are treated with albendazole, benzimidazole, levamisole, pyrantel and mebendazole (WHO, 1995; Aswasthi *et al.*, 2003; Montessor *et al.*, 2003).

These drugs can be safely and effectively combined where there are mixed infections (Olds *et al.*, 1999; Savioli *et al.*, 1997). In addition, periodic administration of anthelmintic drugs should be targeted at pre-school and school children to allow a normal growth spurt and stunt prevention (Andrade *et al.*, 2001) and to allow children to benefit from schooling (Kvalsvig *et al.*, 1991). This also helps to stop transmission cycle as it significantly reduces infection and worm burden of infected individuals (Jackson *et al.*, 1998) and is in line with global control strategy for soil-transmitted helminths (STH) and schistosomiasis. (Colley, 2000).

Furthermore, the global strategy has received a boost from global control strategy of lymphatic filariasis which uses Diethyl Carbamazine (DEC) or ivermectin in combination with albendazole (Albonico *et al.*, 1998). However, success in control of intestinal helminthic infections has been partially thwarted by high post-treatment rates of infection (Katz and Hotez, 2004).

2.6.2 Personal and communal hygiene

The practice of observing personal and communal hygiene prevents infections caused by both protozoa and helminthic worms afflicting individuals and communities. It also promotes the maintenance of good health (Katz and Hotez, 2004). In addition, the control of soil-transmitted helminths involves a combination of approaches. These include chemotherapy, improvement of sanitation, health education, community participation, monitoring and evaluation.

The choice of drugs for soil-transmitted infections control programme and how often treatment should be repeated to give maximum impact on infestation intensity and transmission, needs serious consideration. The issues of efficacy, availability of drug, cost and delivery system are important in determining the sustainability of a de-worming programme (WHO, 1996). Some recommended personal and communal hygiene practices include discouraging of the use of human faeces as fertilizer (Monto *et al.*, 1991), washing hands before eating meals, proper disposal of human faeces, wearing of shoes, avoidance of eating raw or improperly cooked foods, meat and teeth-peeling of fruits (WHO, 1964; Cheesbrough, 1981; Rao, 2002).

2.6.3 Health education measures

Health education measures create awareness of the dangers associated with exposure of persons to intestinal parasites. These measures include encouraging infected persons to seek early treatment, boiling water before drinking and adequate cooking of foods before eating. Health education also includes measures to read and write (WHO, 1964; Plorde, 1994; Rao, 2002). The use of human faeces as fertilizer is also discouraged (Cheesbrough, 1981; Monto *et al.*, 1991; Katz and Hotez, 2004).

2.6.4 Integrated control of intestinal helminths

The solution to declining benefit of treatment campaigns has been suggested by integrating several control measures that are well planned and carefully executed.

Public Health measures include improved health education, improved water supply and sanitation (Magambo *et al.*, 1998) and the control of intermediate hosts such as snails (Cheesbrough, 1998). In Kenya, such large-scale chemotherapeutic control programmes were carried out in Busia District, involving 75 schools (Brooker *et al.*, 2000) and in Bondo District (Muchiri *et al.*, 2001). Societal challenges including sanitation and public health, adequate housing, sustained funding and interest, have been identified as drawbacks to the success of such programmes (Colley, 2000; Katz and Hotez, 2004).

CHAPTER 3: MATERIALS AND METHODS

3.1 Research Design

A Cross-Sectional research design was used in this study. Stool specimens were collected and examined for intestinal parasites from children in classes 3-7 in 5 schools. Children identified to be infected with intestinal parasites were compared with an equal number of uninfected children in the same class based on age, sex, institution and nutritional status of the children and the socio-economic class of the parents. The immediate end- of-term scores and the preceding 3 terms examination scores were recorded to help establish the influence of intestinal parasites on academic performance among the infected and uninfected children. Hospital Hill primary school was situated in the high class area of Parklands while Parkroad and St. Teresa Girls' primary schools were situated in the middle-class areas of Ngara and Eastleigh, respectively. In addition, Kiboro primary school was situated in Mathare slum while Daniel Comboni primary school was located in Korogocho slums in Kariobangi North.

3.2 Variables

The independent variable in this study was the presence of intestinal parasites (infection) while the dependent variable was the immediate end-of-term examination result scores obtained at the end of the immediate school term and the preceding 3 school terms.

3.3 The study area

This study was done on a target population of randomly 5 selected primary schools within Nairobi Province.

These schools were situated in Parklands, Ngara, Eastleigh, Mathare and Starehe locations (Appendix 4). The study population was drawn from primary school children attending schools situated in these locations. Nairobi is the capital and largest city in Kenya (Latitude $1^{\circ} 30'$ S and $1^{\circ} 45'$ S) and (Longitude 36° E and 38° E). Nairobi province is about 1,700 metres above sea level and covers an area of approximately 696 square kilometres.

3.4 Target population

The target population was the children in classes 3-7 drawn from Hospital Hill, Parkroad, St. Teresa Girls', Kiboro and Daniel Comboni primary schools in Nairobi Province

3.4.1 Study population

The study population was the children attending classes 3-7 selected from the registers.

3.4.2 Inclusion criteria

This study included those children attending primary schools within Nairobi Province and whose parents or guardians agreed to give informed written consent through the request of the Head teachers.

3.4.3 Exclusion criteria

The children who were not allowed by their parents or guardians to participate in the study or who fall sick during sample recruitment were excluded in the study.

3.5 Sampling Technique and Sample size determination

The study sample was drawn at random from children attending primary schools in Nairobi province. Primary schools within four purposefully selected locations (Parklands, Ngara, Eastleigh, Mathare and Starehe) were considered in this study. The method of Fisher *et al.* (1998) was used to determine the sample size.

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

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

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

The minimum sample size required = 384

Proportional probability method was used to select the study subjects whereby the first child in the school register was selected followed by every other third child for each class up to class seven. The same procedure was repeated for all the five primary schools in Nairobi Province.

3.6 Pilot Study

This was carried out in 3 primary schools picked at random in Nairobi Province.

3.6.1 Validity

The laboratory) technique is the instrument (tool) selected for this study because it accurately measured the presence of intestinal parasites in the stools of primary school children.

3.6.2 Reliability

The empirical technique was selected because it has a high degree of reproducibility; this meant that it yielded more or less the same results every time the stools were examined in the laboratory.

3.7 Data collection

A total of 1,096 stool specimens were collected from children in the five primary schools. The stool samples were: 231 stool samples were from Hospital Hill, 201 from Parkroad, 199 from St. Teresa Girls', 224 from Kiboro and 241 were from Daniel Comboni Primary schools. The stool samples were later taken to the laboratory for microscopic examination.

3.7.1 Collection Method

Stool specimens were collected from school children in class 3 up to class 7 for laboratory analysis in all the 5 primary schools selected for the study.

This was done by screening all pupils who were triple the minimum determined sample size in class 3-7, using the modified Ridley's method shown in the appendix (Appendix 3).

3.7.2 Laboratory Investigation

The stool specimens were processed using the modified Ridley's method of stool concentration (Allen and Ridley, 1970). Stool examination was done using the ordinary light microscope (Appendix 3).

3.7.3 Term Test Scores

Aggregate performance scores for one immediate school term falling within the period when investigations commenced and the three preceding school terms were obtained from the class teachers. The results of the stool analysis were later compared with the end-of-term performance test scores.

3.8 Data Analysis

Data was collected and coded using the SPSS software. The data was analyzed using the Correlation Coefficient statistic to determine whether there is a relationship between the presence of pathogenic intestinal parasites and level of academic performance, the Chi square to determine whether infection status was dependent or independent of the sex of the children and the Odds Ratio (OR) or (Relative Odds) to determine if there the presence of parasites influenced the academic performance of the children.

The ANOVA was used to predict whether significant association existed between scores and intestinal infection with various parasites. The t-test was used to compare parameter estimates over all schools and determine whether female pupils performed better than male pupils from the average score obtained.

In addition, the t-test was also used to show whether the performance average score between the non-infected and those infected was significant.

3.9 Logistical and Ethical Considerations

Clearance to carry out this research was sought from the office of the director of research, Kenyatta University and the Ministry of Higher Education Science and Technology ethical committees. In addition, informed consent was sought from the parents and guardians of the school children. Further, no loss of benefit or harm came to participants of this study. In addition, confidentiality of data and information from this study was maintained. After completion of research, the head-teachers were informed of those children who are infected so that arrangements for their treatment could be made with the Medical Officer of Health in the study areas.

CHAPTER 4: RESULTS

4.1 Demographic profile

4.1.1 Distribution of the study subjects by sex

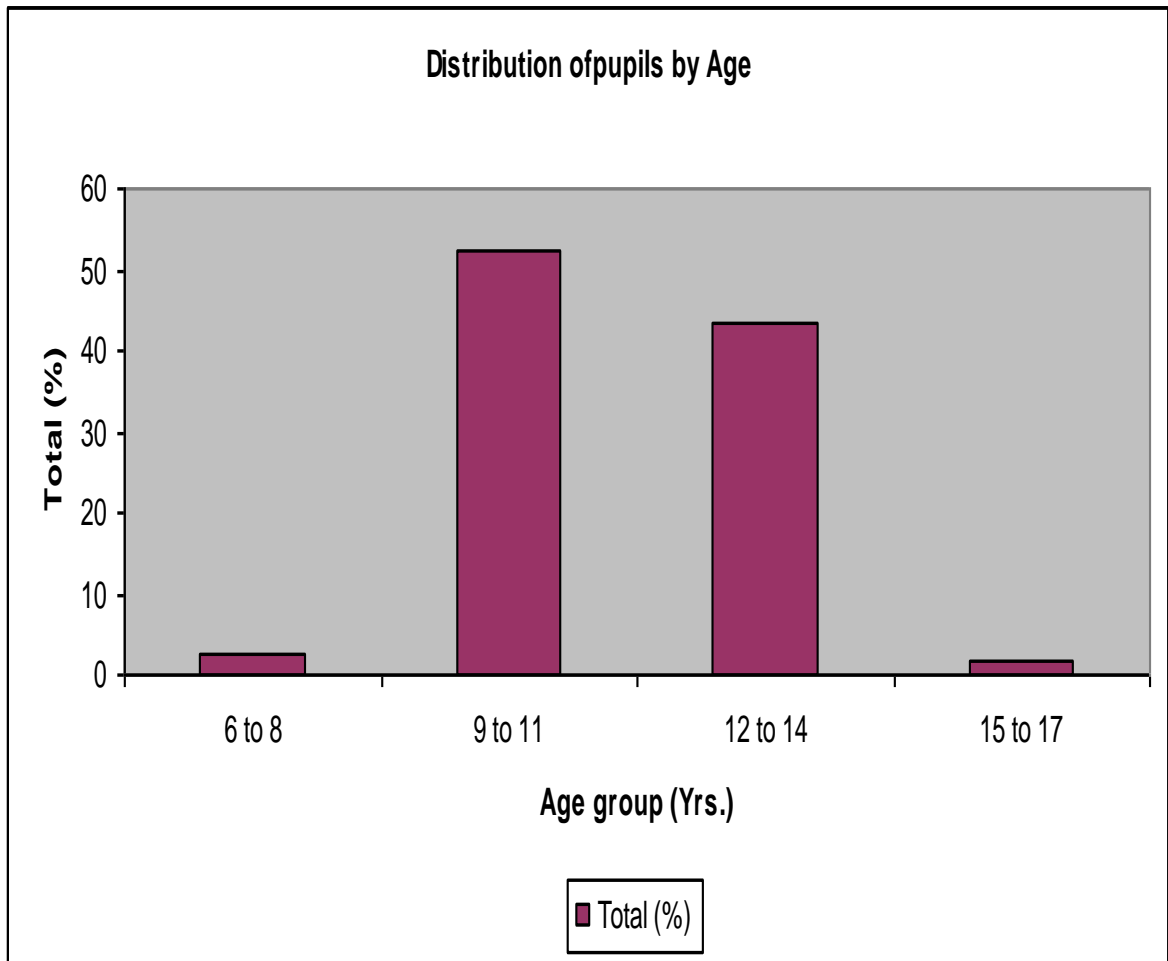
A total of 1,096 primary school children from 5 schools were examined for intestinal parasites. Daniel Comboni Primary school had the largest number of pupils at 241 (22.0%) while St. Teresa Girls had the smallest number of pupils at 199 (18.2%), as shown in Table 4.1.

Table 4.1: Distribution of the children by sex in five primary schools

| School | Sex | | Total |
|-------------------|-------------------|--------------------|--------------|
| | Male | Female | |
| Hospital Hill | 114 | 117 | 231 |
| Parkroad | 89 | 112 | 201 |
| St. Teresa Girls' | 0 | 199 | 199 |
| Kiboro | 108 | 116 | 224 |
| Daniel Comboni | 122 | 119 | 241 |
| Total | 433(39.5%) | 663 (60.5%) | 1,096 |

4.1.2 Distribution of pupils by age

The youngest child was 6 years while the oldest was 17 years. Pupils aged between 9 to 14 years of age were 1,050. The largest proportion of pupils were in the 9-11 years age category at 574 while the smallest proportion was within 15-17 years age category at 21, as shown in Fig. 4.1 below.

Fig. 4.1: Distribution of pupils by age

4.1.3 Distribution of pupils by classes

Class 3 had the largest number of children 287 (26.2%), followed by 264 (4.1%) in class 4, 202 (18.4%) in class 5, 185 (16.9%) in class 6 and 158 (14.4%) in class 7, as shown in Table 4.2 below.

Table 4.2: Distribution of pupils by classes in primary schools

| School | Number of Pupils | Classes | | | | |
|-------------------|------------------|------------------------|------------------------|------------------------|------------------------|------------------------|
| | | 3 | 4 | 5 | 6 | 7 |
| Hosp. Hill | 231 | 100 | 70 | 22 | 26 | 13 |
| Parkroad | 201 | 67 | 57 | 32 | 31 | 14 |
| St. Teresa Girls' | 199 | 7 | 45 | 51 | 50 | 46 |
| Kiboro | 224 | 45 | 44 | 48 | 46 | 41 |
| Daniel Comboni | 241 | 68 | 48 | 49 | 32 | 44 |
| Total | 1,096 | 287 (26.2%) | 264 (24.1%) | 202 (18.4%) | 185 (16.9%) | 158 (14.4%) |

4.2 Prevalence of intestinal parasites

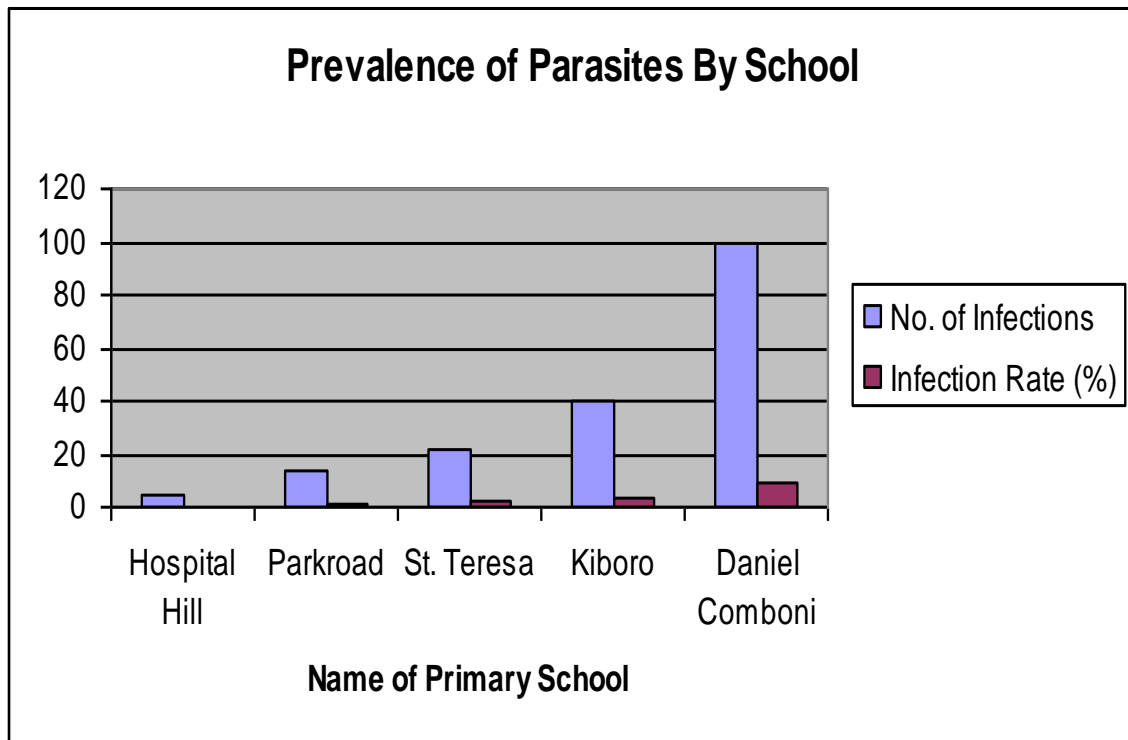
4.2.1 Prevalence of parasites by schools

Out of 1,096 children, the overall number of children found infected was 180(16.4%).

The largest number of infections occurred in Daniel Comboni primary schools at 99(9.0%) while the lowest occurred in Hospital Hill primary school at 5 (0.5%), as shown in Table 4.3 and Figure 4.2.

Table 4.3 Prevalence of intestinal parasites in schools

| Primary School | Number of infections | Infection Rate |
|----------------|----------------------|----------------|
| Hospital Hill | 5 | 0.5% |
| Parkroad | 14 | 1.3% |
| St. Teresa | 22 | 2.0% |
| Kiboro | 40 | 3.6% |
| Daniel Comboni | 99 | 9.0% |
| Total | 180 | 16.4% |

Fig. 4.2: Prevalence of intestinal parasites in schools

4.2.2 Prevalence of parasites by classes and sex

The highest number of infections were encountered in Class 3 at 45 (4.1%) and the lowest number of infections was in Class 6 at 28 (2.6%), as shown in Table 4.4 below.

Table 4.4: Prevalence of intestinal parasites by classes

| Sex | Infection Status | | | | |
|--------------|------------------|-----------------|-----------------|-----------------|-----------------|
| | Class | | | | |
| | 3 | 4 | 5 | 6 | 7 |
| Male | 3 | 0 | 0 | 0 | 0 |
| Female | 4 | 1 | 0 | 0 | 0 |
| Male | 18 | 17 | 6 | 1 | 1 |
| Female | 20 | 17 | 9 | 1 | 0 |
| Male | 0 | 4 | 10 | 7 | 7 |
| Female | 0 | 0 | 10 | 19 | 17 |
| Male | 0 | 0 | 0 | 0 | 10 |
| Female | 0 | 0 | 0 | 0 | 2 |
| Male | 21 | 17 | 16 | 8 | 18 |
| Female | 24 | 18 | 19 | 20 | 19 |
| Total | 45(4.1%) | 35(3.2%) | 35(3.2%) | 28(2.6%) | 37(3.4%) |

4.2.3 Prevalence of intestinal parasites by age

There were 12 (1.1%) infections within 6 to 8 year age category, 106 (9.7%) in 9 to 11 age category, 87 (7.9%) age category and 11 (1.0%) infections in the 15 to 17 age category, as shown in Table 4.5 below.

Table 4.5: Prevalence of intestinal parasites by age

| Age group (Yrs.) | Total |
|------------------|-------------------|
| 6 to 8 | 12 (1.1%) |
| 9 to 11 | 106 (9.7%) |
| 12 to 14 | 87 (7.9%) |
| 15 to 17 | 11 (1.0%) |

4.2.4 Prevalence of intestinal parasites by sex

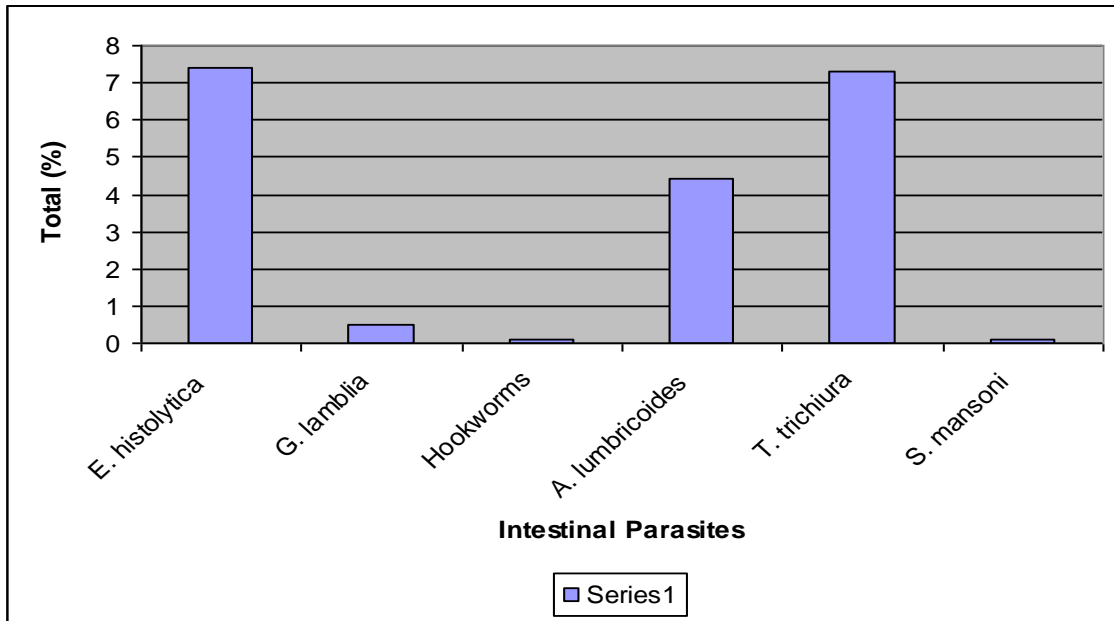
Overall, more females 127 (19.7%) were infected with intestinal infections compared to males 89 (20.6%) in the schools studied, as shown in Table 4.6.

Table 4.6: Prevalence of intestinal parasites by sex

| Sex | Total |
|--------------|--------------------|
| Male | 89 (20.6%) |
| Female | 127 (19.2%) |
| Total | 216 (19.7%) |

4.3 Types of intestinal parasites infecting children in primary schools

The highest number of infections were caused by *Entamoeba histolytica* at 81 (7.4%) while the lowest number of infections were caused by hookworms 1 (0.1%), and *Schistosoma mansoni* 1 (0.1%), respectively, as shown in Fig. 4.3. Co-infections occurred with *Entamoeba histolytica* and *Giardia lamblia* at 1 (0.1%) and with *Entamoeba histolytica* and *Trichuris trichiura* at 4 (0.4%) in Kiboro Primary school. Co-infections also occurred with *Ascaris lumbricoides* and *Trichuris trichiura* at 20 (1.8%) and with *Entamoeba histolytica* and *Trichuris trichiura* at 5 (0.5%) in Daniel Comboni Primary school.

Fig. 4.3: Types of intestinal parasites infecting school children

E. Histolytica = *Entamoeba histolytica*

G. lamblia = *Giardia lamblia*

Hookworms = *Ancylostoma duodenale* & *Necator americanus*

A. lumbricoides = *Ascaris lumbricoides*

T. trichiura = *Trichuris trichiura*

S. mansoni = *Schistosoma mansoni*

4.3.1 Types of intestinal parasites infecting children in specific schools

4.3.1.1 Types of parasites in Hospital Hill Primary School

The most prevalent intestinal infection was *Entamoeba histolytica* 4 (1.7%) while *Schistosoma mansoni* had 1 (0.4%), as shown in Table 4.7 below.

Table 4.7 : Types of parasites in Hospital Hill Primary school

| Parasite | Class | | | | | Total |
|-----------------------|----------|---|----------|---|----------|-----------------|
| | 3 | 4 | 5 | 6 | 7 | |
| <i>E. histolytica</i> | 3 (1.3%) | 0 | 1 (0.4%) | 0 | 0 | 4 (1.7%) |
| <i>S. mansoni</i> | 0 | 0 | 0 | 0 | 1 (0.4%) | 1 (0.4%) |

4.3.1.2 Types of parasites in Parkroad primary school

The most prevalent intestinal parasite was *Entamoeba histolytica* 10 (5.0%) while *Trichuris trichiura* had 4 (2.0%), as shown in Table 4.8 below.

Table 4.8: Types of parasites in Parkroad Primary School

| Parasite | Class | | | | | Total |
|-----------------------|----------|----------|----------|----------|----------|------------------|
| | 3 | 4 | 5 | 6 | 7 | |
| <i>E. histolytica</i> | 2 (1.0%) | 3 (1.5%) | 3 (1.5%) | 1 (0.5%) | 1 (0.5%) | 10 (5.0%) |
| <i>T. trichiura</i> | 3 (1.5%) | 0 | 1 (0.5%) | 0 | 0 | 4 (2.0%) |

4.3.1.3 Types of parasites in St. Teresa Girls' primary school

The most prevalent parasite was *Entamoeba histolytica* 20 (10.0%) while *Giardia lamblia* had 2 (1.0%), as shown in Table 4.9 below.

Table 4.9 : Types of parasites in St Teresa Girls' Primary School

| Parasites | Classes | | | | | Total |
|-----------------------|-------------|-------------|-------------|-------------|-------------|-------------------|
| | 3 | 4 | 5 | 6 | 7 | |
| <i>E. histolytica</i> | 1 (0.5%) | 0 | 6 (3.0%) | 6 (3.0%) | 7 (3.5%) | 20 (10.0%) |
| <i>G. lamblia</i> | 0 | 2 (1.0%) | 0 | 0 | 0 | 2 (1.0%) |

4.3.1.4 Types of parasites in Kiboro primary school

The most prevalent intestinal parasite was *Entamoeba histolytica* 27 (12.1%) while *Giardia lamblia* had 3 (1.3%), as shown in Table 4.10 below.

Table 4.10 : Types of parasites in Kiboro Primary School

| Parasite | Class | | | | | Total |
|-----------------------|-------------|-------------|-------------|-------------|--------------|-----------------------|
| | 3 | 4 | 5 | 6 | 7 | |
| <i>E. histolytica</i> | 4 (1.8%) | 5 (2.2%) | 3 (1.3%) | 2 (0.9%) | 13 (5.8%) | 27 (12.1%) |
| <i>G. lamblia</i> | 0 | 2 (0.9%) | 0 | 1 (0.4%) | 0 | 3 (1.3%) |
| <i>T. trichiura</i> | 1 (0.4%) | 3 (1.3%) | 2 (0.9%) | 3 (1.3%) | 5 (2.2%) | 14 (6.3%) |

4.3.1.5 Types of parasites in Daniel Comboni primary school

The most prevalent intestinal parasite was *Trichuris trichiura* 61 (25.3%) while hookworm had 1 (0.4%), as shown in Table 4.11 below.

Table 4.11 : Types of parasites in Daniel Comboni Primary School

| Parasite | Class | | | | | Total |
|------------------------|--------------|--------------|--------------|--------------|-------------|-----------------------------|
| | 3 | 4 | 5 | 6 | 7 | |
| <i>E. histolytica</i> | 6 (2.5%) | 3 (1.2%) | 3 (1.2%) | 4 (1.7%) | 1 (0.4%) | 17 (7.1%) |
| Hookworm | 0 | 0 | 0 | 0 | 1 (0.4%) | 1 (0.4%) |
| <i>A. lumbricoides</i> | 15 (6.2%) | 13 (5.4%) | 10 (4.1%) | 3 (1.2%) | 6 (2.5%) | 47 (19.5%) |
| <i>T. trichiura</i> | 19 (7.9%) | 12 (5.0%) | 15 (6.2%) | 10 (4.1%) | 5 (2.1%) | 61 (25.3%) |

4.3.2 Types of intestinal parasites by classes

Class 3 had the largest number of intestinal infections at 56 (5.1%) while Class 6 had the smallest number at 34 (3.1%), as shown in Table 4.12 below.

Table 4.12 : Types of parasites by classes

| Parasite | Classes | | | | | Total |
|------------------------|----------------------------|----------------------------|----------------------------|----------------------------|----------------------------|--------------------|
| | 3 | 4 | 5 | 6 | 7 | |
| <i>E. histolytica</i> | 19 (1.7%) | 12 (1.1%) | 15 (1.4%) | 13 (1.2%) | 22 (2.0%) | 81 (7.4%) |
| <i>G. lamblia</i> | 0 | 4 (0.4%) | 0 | 1 (0.1%) | 0 | 5 (0.5%) |
| Hookworm | 0 | 0 | 0 | 0 | 1 (0.1%) | 1 (0.1%) |
| <i>A. lumbricoides</i> | 16 (1.5%) | 12 (1.1%) | 10 (0.9%) | 4 (0.4%) | 6 (0.5%) | 48 (4.4%) |
| <i>T. trichiura</i> | 21 (1.9%) | 16 (1.5%) | 18 (1.6%) | 16 (1.5%) | 9 (0.8%) | 80 (7.3%) |
| <i>S. mansoni</i> | 0 | 0 | 0 | 0 | 1 (0.1%) | 1 (0.1%) |
| Total | 56 (5.1%) | 44 (4.0%) | 43 (3.9%) | 34 (3.1%) | 39 (3.6%) | 214 (19.5%) |

4.3.3 Types of intestinal parasites by age

The highest number of intestinal infections across all age groups occurred with *Entamoeba histolytica* 81 (7.4%) and the lowest occurred with Hookworms 1 (0.1%) and with *Schistosoma mansoni* 1 (0.1%), respectively. The highest number of intestinal infections occurred within the 9-11 years age category at 106 (9.7%) and the lowest at 11 (1.0%) within the 15-17 age category. Odds Ratio indicated that pupils had 6.2 times higher risk of infection with *Entamoeba histolytica* than with *Ascaris lumbricoides*, within 12-14 years age category, as shown in Table 4.13 below.

Table 4.13: Types of intestinal parasites by age

| Age group (Yrs.) | a^1 | a^2 | a^3 | a^4 | a^5 | a^6 | Total |
|------------------|--------------|-------------|-------------|--------------|---------------|-------------|------------------------------|
| 6 to 8 | 3 (10.3%) | 0 | 0 | 3 (10.3%) | 6 (20.7%) | 0 | 12 (1.1%) |
| 9 to 11 | 32 (5.6%) | 5 (0.8%) | 0 | 30 (5.2%) | 39 (36.8%) | 0 | 106 (9.7%) |
| 12 to 14 | 41 (8.7%) | 0 | 0 | 11 (2.3%) | 34 (7.2%) | 1 (0.2%) | 87 (7.9%) |
| 15 to 17 | 5 (25%) | 0 | 1(5%) | 4 (20%) | 1 (5%) | 0 | 11 (1.0%) |
| Overall | 81 (7.4%) | 5 (0.5%) | 1 (0.1%) | 48 (4.4%) | 80 (7.3%) | 1 (0.1%) | 216 (19.7%) |

a^1 = *Entamoeba histolytica*

a^2 = *Giardia lamblia*

a^3 = Hookworm (*Ancylostoma duodenale* & *Necator americanus*)

a^4 = *Ascaris lumbricoides*

$a^5 = Trichuris trichiura$

$a^6 = Schistosoma mansoni$

4.3.4 Types of parasites by sex in schools

Overall, more females were infected with *Entamoeba histolytica* 54 (8.1%) than males 27 (6.2%). Female pupils had 1.3 times higher risk of infection with *Entamoeba histolytica* than male children. Infection with *Entamoeba histolytica* was dependent on sex ($\chi^2_c = 36.3$; $df = 1$; $\alpha < 0.05$). More females 4 (0.6%) were infected with *Giardia lamblia* than males. Females had 2.6 higher risk of infection with *Giardia lamblia* than male children. Infection was independent of the sex ($\chi^2_c = 0.2$; $df = 1$; $\alpha < 0.05$). More females 46 (6.9%) were infected with *Trichuris trichiura* than males 34 (7.8%).

More males 25 (2.3%) were infected with *Ascaris lumbricoides* than females 2 (2.1%). Males had 1.7 times higher risk of infection with *Ascaris lumbricoides* than females. Infection with *Ascaris lumbricoides* was independent of the sex of the pupil ($\chi^2_c = 2.8$; $df = 1$; $\alpha < 0.05$). Female pupils had 0.9 times higher risk of infection with *Trichuris trichiura* than males. Infection was independent of the sex of the pupil ($\chi^2_c = 0.5$; $df = 1$; $\alpha < 0.05$). There was significant association between infection with *Ascaris lumbricoides* and gender infectivity ($\chi^2 = 4.55$; $df = 1$; $\alpha < 0.05$). Further, male pupils were found to be 1.6 times more likely to be infected with *Trichuris trichiura* compared to the female pupils. Gender infectivity was also significantly associated with *Trichuris trichiura* ($\chi^2 = 8.26$; $df = 1$; $\alpha < 0.01$). More females 46 (4.2%) were infected with *Trichuris trichiura* than males 34 (3.1%), as shown in Table 4.14.

Table 4.14: Prevalence of intestinal parasites by sex

| Sex | a^1 | a^2 | a^3 | a^4 | a^5 | a^6 | Total |
|--------------|----------------------------|---------------------------|---------------------------|----------------------------|----------------------------|---------------------------|------------------------------|
| Male | 27 (2.5%) | 1 (0.1%) | 1 (0.1%) | 25 (2.3%) | 34 (3.1%) | 1 (0.1%) | 89 (20.6%) |
| Female | 54 (4.9%) | 4 (0.4%) | 0 | 2 (2.1%) | 46 (4.2%) | 0 | 127 (19.2%) |
| Total | 81 (7.4%) | 5 (0.5%) | 1 (0.1%) | 48 (4.4%) | 80 (7.3%) | 1 (0.1%) | 216 (19.7%) |

a^1 = *Entamoeba histolytica*

a^2 = *Giardia lamblia*

a^3 = Hookworm (*Ancylostoma duodenale* & *Necator americanus*)

a^4 = *Ascaris lumbricoides*

a^5 = *Trichuris trichiura*

a^6 = *Schistosoma mansoni*

4.4 Factors contributing to prevalence of intestinal parasites in school children

The factors predisposing school children to intestinal infections include the following. Children's status on knowledge of the intestinal parasites' their attitudes towards infection with intestinal parasites, the prevailing practices and miscellaneous environmental factors existing at school and at home, all of which predispose children to infections with intestinal parasites. The highest prevalence of intestinal infections among all schools occurred with *Entamoeba histolytica* 81 (7.4%) compared with hookworms 1 (0.1%) with lowest prevalence. Odds Ratio indicated pupils had 87.4 times higher risk of being infected with *Entamoeba histolytica* than with hookworms. Infection status of the children significantly dependent on the type of parasite ($\chi^2_c = 79.1$; $df = 1$; $\alpha < 0.05$).

Odds Ratio indicated among all the schools studied that children had 86.2 times higher risk of being infected with *Trichuris trichiura* than with hookworms. Infection status of the children significantly dependent on the type of parasite infecting the children; the ($\chi^2_c = 78.0$; $df = 1$; $\alpha < 0.05$). Similarly, Odds Ratio indicated that among all the schools studied, children had 50.2 times higher risk of being infected with *Ascaris lumbricoides* than with hookworms. Infection status of the children significantly dependent on the type of parasite; the ($\chi^2_c = 44.2$; $df = 1$; $\alpha < 0.05$). Odds Ratio suggested that among all the schools studied, the children had 5.0 times higher risk of being infected with *Giardia lamblia* than with hookworms Infection status of the children was independent of the type of parasite ($\chi^2_c = 1.5$; $df = 1$; $\alpha < 0.05$).

4.4.1 Knowledge level predisposing children to intestinal parasites

4.4.1.1 Knowledge relating to transmission of intestinal parasites

Among children who answered pre-tested questionnaires on their state of knowledge of intestinal parasites, 10 (4.3%) were from Hospital Hill. In addition, 26 (12.9%) pupils were from Parkroad, 58 (25.9%) from Kiboro and 169 (70.1%) from Daniel Comboni. The children indicated having knowledge of some intestinal parasites, their mode of transmission and the symptoms and signs associated with intestinal infections such as diarrhea, vomiting, stomachache, headache, fever, blood in stools and passage of foul smelling stools. However, 7 (2.9%) children from Daniel Comboni indicated having no knowledge of intestinal parasites, their methods of transmission or signs and symptoms associated with intestinal infections.

No children from St. Teresa Girls' primary school were available to answer the questionnaire due to administrative difficulties, resulting in lack of access of data from the school, as shown in Table 4.15.

Table 4.15: Knowledge status predisposing children to intestinal parasites

| Knowledge | Schools | | | | |
|--|---------------|------------|---------------|------------|----------------|
| | Hospital Hill | Parkroad | St. Teresa | Kiboro | Daniel Comboni |
| Knew about some intestinal parasites | 10 (4.3%) | 26 (12.9%) | Not available | 58 (25.9%) | 169 (70.1%) |
| Knew about methods of transmission and symptoms | 10 (4.3%) | 26 (12.9%) | Not available | 58 (25.9%) | 169 (70.1%) |
| Had no knowledge of intestinal parasites | 0 | 0 | Not available | 0 | 7 (2.9%) |
| Had no knowledge of methods of transmission and symptoms | 0 | 0 | Not available | 0 | 7 (2.9%) |

4.4.2 Attitudes predisposing children to intestinal parasites

4.4.2.1 Attitudes relating to transmission of intestinal parasites

Indications of previous infections with intestinal parasites in Hospital Hill was 6 (2.6%), 25 (12.4%) in Parkroad, 58 (25.9%) in Kiboro and 144 (59.8%) from D. Comboni. However, 4 (1.7%) of the children in Hospital Hill, 1 (0.5%) in Parkroad, 11 (4.9%) in Kiboro and 25 (10.4%) in Daniel Comboni primary schools indicated that they did not recollect having ever been infected with or suffered from intestinal infections.

However, no children from St. Teresa Girls' primary school were available to answer the questionnaire due to administrative difficulties, resulting in lack of access of data from the school, as in Table 4.16 below.

Table 4.16: Attitudes predisposing children to intestinal parasites

| Attitudes | Primary Schools | | | | |
|--|-----------------|------------|---------------|------------|----------------|
| | Hospital Hill | Parkroad | St. Teresa | Kiboro | Daniel Comboni |
| Recollected having been infected previously with intestinal parasites | 6 (2.6%) | 25 (12.4%) | Not available | 58 (25.9%) | 144 (59.8%) |
| Had no recollection of having been infected previously with intestinal parasites | 4 (1.7%) | 1 (0.5%) | Not available | 11 (4.9%) | 25 (10.4%) |

4.4.3 Practices predisposing children to intestinal infections

4.4.3.1 Practices relating to the transmission of intestinal parasites

Prevalence of *Entamoeba histolytica* in H. Hill was 4 (1.7%), 10 (5.0%), Parkroad, 20 (10.0%), St. Teresa, 27 (12.1%), Kiboro and 17 (7.1%) in Daniel Comboni.

There were 2 (1.0%) infections with *Giardia lamblia* in St. Teresa Girls' and 3 (1.3%) infections in Kiboro primary schools. However, there were 4 (2.0%) infections with *Trichuris trichiura* in Parkroad, 14 (6.3%) in Kiboro and 61 (25.3%) in Daniel Comboni primary schools. There was 1 (0.4%) infection with hookworm in Daniel Comboni primary school and there were 47 (19.5%) infections with *Ascaris lumbricoides* in Daniel Comboni primary school.

The prevalence of these infections is explained by the observation that among the children who filled the pre-tested standard questionnaire, 10 (4.3%) were from Hospital Hill, 3 (1.5%) from Parkroad, 28 (12.5%) from Kiboro, 134 (55.6%) from Daniel Comboni primary schools indicated that they do not wash hands before eating food at home or at school. 8 (3.5%) of the children in Hospital Hill, 28 (13.9%) in Parkroad, 38 (17%) in Kiboro and 160 (66.4%) in Daniel Comboni primary schools indicated that they did not wash raw foods before eating at home or in school. However, 8 (3.5%) of the children in Hospital Hill primary school, 2 (1.0%) in Parkroad, 74 (33.0%) in Kiboro and 190 (78.8%) in Daniel Comboni indicated that they did not wear shoes always at home or in school. However, no children from St. Teresa Girls' primary school were available to answer the questionnaire due to administrative difficulties, resulting in lack of access of some data from St. Teresa Girls' primary school, as shown in table 4.17 below.

Table 4.17: Practices predisposing children to intestinal infections in schools and in home environments

| Practices | Primary Schools | | | | |
|---|-----------------|---------------|-----------------------------|---------------|----------------|
| | Hospital Hill | ParkRoad | St. Teresa | Kiboro | Daniel Comboni |
| Washing of hands before eating food at home or in the school compound | 10 (4.3%) | 3 (1.5%) | Children were not available | 28 (12.5%) | 134 (55.6%) |
| Washing of raw foods before eating at home or in the school compound | 8 (3.5%) | 28 (13.95) | Children were not Available | 38 (17.0%) | 160 (66.4%) |
| Wearing of shoes always at home or in the school compound | 8 (3.5%) | 2 (1.0%) | Children were not Available | 74 (33.0%) | 190 (78.8%) |

4.4.4 Environmental factors predisposing children to intestinal infections

Specific environmental factors predisposing children to intestinal infections at home and in the school environment include the presence of filthy toilets (latrines), the presence of uncollected garbage bins and the presence of *Fannia scalaris* (Latrine flies) in the toilets. These environmental factors were evaluated using an observation check-list in all schools, as shown in Table 4.18, 4.19 and 4.20 below.

Table 4.18: Frequency of cleaning of toilets in the 5 primary schools observed

| School | Type of Toilets | Number Available | Frequency of cleaning |
|----------------|-------------------------|------------------|-----------------------|
| | (Lavatories / Latrines) | | |
| Hospital Hill | Lavatories | 8 | Once a day |
| Parkroad | Lavatories | 8 | Once a day |
| St. Teresa | Lavatories | 5 | Once a day |
| Kiboro | Lavatories | 5 | Once a day |
| Daniel Comboni | Lavatories | 5 | Once a day |

Table 4.19: Frequency of garbage bins collection in primary schools studied

| School | Garbage bins collection |
|-------------------|-------------------------|
| Hospital Hill | Twice a day |
| Parkroad | Once a day |
| St. Teresa Girls' | Once a day |
| Kiboro | Once a day |
| Daniel Comboni | Once a day |

Table 4.20: Status of latrine flies in primary schools studied

| School | <i>Fannia scalaris</i> (Latrine flies) |
|-------------------|--|
| Hospital Hill | Absent |
| Parkroad | Absent |
| St. Teresa Girls' | Absent |
| Kiboro | Present |
| Daniel Comboni | Present |

4.5 Assessment of pattern of academic performance

4.5.1 Mean scores

4.5.1.1 Overall mean score for primary schools

The overall average score was computed using the formula below and data indicated in Table 4.21. The total count of the average scores for the 1,052 children whose scores were available in all the five schools is as follows:

$$\begin{aligned} \text{Overall average score} &= \frac{\text{Total average scores}}{\text{Total number of children whose scores were available}} \\ &= \frac{65,771.94}{1,052} = 62.5 \end{aligned}$$

Table 4.21: Total average scores for five primary schools

| Code No. | Primary school | Total average scores for five school terms |
|----------|-------------------|--|
| 1. | Hospital Hill | 19,091.04 |
| 2. | Parkroad | 13,173.00 |
| 3. | St. Teresa Girls' | 11,571.90 |
| 4. | Kiboro | 9,640 |
| 5. | Daniel Comboni | 12,296.00 |
| | Total | 65,771.94 |

4.5.2.2 Mean scores for primary schools

The computed mean score for Hospital Hill was 83.0, 65.5 for Parkroad, 71.0 for St. Teresa Girls', 44.4 for Kiboro and 62.0 for Daniel Comboni primary schools as shown in Table 4.22 below.

Table 4.22: Mean scores for five primary schools

| Primary school | Mean score |
|-----------------------|-------------------|
| Hospital Hill | 83.0 |
| Parkroad | 65.5 |
| St. Teresa Girls' | 71.0 |
| Kiboro | 44.4 |
| Daniel Comboni | 62.0 |

4.5.2.3 Infection status below and above the mean scores in schools

The assessment of the behaviour of the overall mean score in relation to the infection status of the school children required the knowledge of the number of infected children with scores below and above the mean and also the number of uninfected children with scores below and above the mean, as shown in Table 4.23 below.

Table 4.23: Infection status above and below school mean scores

| School | Mean score | Infected | | Non-infected | |
|---------------|-------------------|-------------------|-------------------|---------------------|-------------------|
| | | Below mean | Above mean | Below mean | Above mean |
| Hospital Hill | 83.0 | 1 | 4 | 11 | 215 |
| Parkroad | 65.5 | 5 | 9 | 88 | 99 |
| St.Teresa | 71.0 | 4 | 18 | 39 | 138 |
| Kiboro | 44.4 | 37 | 3 | 161 | 23 |
| D. Comboni | 51.4 | 62 | 37 | 109 | 33 |
| Total | | 107 | 71 | 408 | 500 |

4.5.3 Overall Odds Ratio for primary schools

Computation of the overall schools (Relative Odds) Odds Ratio (Gordis, 1996), requires the knowledge of the total number of infected children with scores below and above the overall mean (62.5) score and also the total number of uninfected children with scores below and above the mean score, as shown in Table 4.24.

Table 4.24: Overall Odds Ratio (Relative Odds) for primary schools

| | Mean Score (62.5) | | |
|------------------|--------------------|--------------------|--------------------|
| Infection Status | Below Mean | Above Mean | Total |
| Infected | 107 (a) | 71 (b) | a + b (178) |
| Non-infected | 408 (c) | 500 (d) | c + d (908) |
| Total | a + c (517) | b + d (555) | |

Overall, the ($\chi^2_c = 36.3$; $df = 1$; $\alpha < 0.05$) showed that the value of the mean score (62.5) was dependent on the infection status of the children in the primary schools. The overall Odds Ratio for all schools was obtained using the formula of Gordis (1996) as below:

$$\frac{ad}{bc} = \frac{107*500}{71*408} = \frac{53500}{24480} = \mathbf{1.8}$$

Odds Ratio indicated that infected pupils had 1.8 higher risk of performing better compared to the uninfected. A positive association existed between the presence of intestinal infections and academic performance.

4.5.2.1 Odds Ratios in primary schools

4.5.2.1.1 Odds Ratio of Hospital Hill Primary school

Odds Ratio indicated infected pupils had 4.9 times higher risk of performing poorly compared to uninfected children. The mean score (83.0) was independent of the infection status ($\chi^2_c = 0.24$; $df = 1$; $\alpha < 0.05$).

4.5.2.1.2 Odds Ratio in Parkroad Primary school

Odds Ratio indicated that infected pupils had 6.9 times higher risk of performing poorly compared to the uninfected. The mean score (65.5) was independent of the infection status ($\chi^2_c = 1.2$; $df = 1$; $\alpha < 0.05$).

4.5.2.1.3 Odds Ratio in St. Teresa Primary school

Odds Ratio indicated that infected pupils had 0.8 times higher risk of performing poorly in academic work compared to the uninfected children. The mean score (71.0) was independent of the infection status ($\chi^2_c = 0.5$; $df = 1$; $\alpha < 0.05$).

4.5.2.1.4 Odds Ratio in Kiboro school

Odds Ratio indicated that infected children had 1.8 times higher risk of performing poorly. The mean score (44.4) was independent of the infection status ($\chi^2_c = 0.4$; $df = 1$; $\alpha < 0.05$).

4.5.2.1.5 Odds Ratio in Daniel Comboni primary school

Odds Ratio indicated that infected pupils had 0.5 times higher risk of performing poorly compared to the uninfected children. The mean score (51.4) was dependent on the infection status ($\chi^2_c = 6.4$; $df = 1$; $\alpha < 0.05$).

4.5.2.2 Odds Ratios for classes 3 to 7 across primary schools

The assessment of behaviour of overall class mean in relation to the infection status of the pupils requires the knowledge of the nature of the children's scores

The number of the infected children with scores below and above each overall class mean score and also the number of uninfected children below and above the overall class mean score were as shown in Table 4.25.

Table 4.25: Infection status above and below respective class mean scores

| Overall Class | Overall mean score | Infected | | Non-infected | |
|---------------|--------------------|------------|------------|--------------|------------|
| | | Below mean | Above mean | Below mean | Above mean |
| 3 | 76.7 | 27 | 17 | 82 | 173 |
| 4 | 66.1 | 30 | 12 | 83 | 128 |
| 5 | 52.1 | 25 | 11 | 80 | 82 |
| 6 | 56.2 | 21 | 4 | 81 | 74 |
| 7 | 48.4 | 22 | 12 | 54 | 70 |

4.6 Mean scores versus infections in schools

The overall mean scores versus infections are as shown in Table 4.26. The Odds Ratios for Hospital Hill, Parkroad, St. Teresa Girls' and Daniel Comboni primary schools have a value approaching 1.0, which is interpreted to mean that an association does not exist; the risk to those who are infected is equal to the risk of those who are not suffering from an intestinal infection. However, there is a positive association between the presence of intestinal parasites and their harmful effect on academic performance among the children in Kiboro primary school.

Table 4.26 Mean scores versus infections in primary schools

| Primary School | Number of Infections | Mean Score | Odds Ratio (Relative Odds) | Interpretation |
|----------------|----------------------|------------|----------------------------|----------------------|
| Hospital Hill | 5 | 83 | 0.6 | No association |
| Parkroad | 14 | 65.5 | 0.6 | No association |
| St. Teresa | 22 | 71 | 0.8 | No association |
| Kiboro | 40 | 44.4 | 1.8 | Positive association |
| Daniel Comboni | 99 | 51.4 | 0.5 | No association |

4.6.2 Mean scores versus infections in classes across primary schools

The overall mean scores versus infections are as shown in Table 4.27. The computed Odds Ratios among all children in class 3, 4, 5, 6 and 7 have a value above 1.0. This indicates that no association exists between the presence of parasites and academic performance.

Table 4.27 Mean scores versus infections in classes across primary schools

| Overall class | Number of Infections | Mean Score | Odds Ratio | Interpretation |
|---------------|----------------------|------------|------------|----------------------|
| 3 | 44 | 76.7 | 3.4 | Positive association |
| 4 | 42 | 66.1 | 3.1 | Positive association |
| 5 | 36 | 52.1 | 2.3 | Positive association |
| 6 | 25 | 56.2 | 4.8 | Positive association |
| 7 | 34 | 48.4 | 2.4 | Positive association |

4.7 The independence of the infection status on the sex of the children

The Null hypothesis was that the infection status was independent of the sex of the school children. The total number of children who were infected in the study population were 180. The ($\chi^2_c = 1.14$; $df = 1$; $\alpha < 0.05$) showed that the infection status of the school children was independent of their sex in the study population.

4.8 The Correlation Coefficient Test result

There was a highly significant correlation between infections with *Entamoeba histolytica* (9.9%), *Ascaris lumbricoides* (10.2%), *Trichuris trichiura* (16.8%) and performance scores of the children. Correlation was significant at the 0.001 level (2-tailed).

4.9 The Odds Ratio (Relative Odds) Result

The Odds Ratio (Relative Odds) is a close approximation of Relative Risk in Epidemiological cross-sectional studies. In this study, the overall Odds Ratio was computed by counting the total average scores available for all school children included in this study, for all the five school terms and computing the final average score which was equal to 62.5. The numbers of infected children with average scores below and above the computed mean score of 62.5 were computed. The numbers of non-infected children with average scores below and above the mean score of 62.5 were also computed. The Odds Ratio (Relative Odds) was computed by dividing the value of ad by the value of bc .

Thus:
$$\frac{ad}{bc} = 1.8$$

4.9.1 The implication of the Odds Ratio (Relative Odds) value

When the Odds Ratio is greater than 1 (> 1), it means the Risk in Exposed persons (Infected) to disease is greater than Risk in Unexposed (Uninfected) persons, resulting in a positive causal association. If the computed Odds Ratio has a value of 1.0 ($= 1.0$), there is no association between the infected persons and academic performance and the risk to the exposed (infected) is equal to the risk in the unexposed (uninfected). However, if the computed Odds Ratio had a value less than 1.0 (< 1) a negative association exists, possibly protective. Thus, in this study the overall Odds Ratio result in all primary schools studied indicates that the presence of intestinal parasites among the primary school children had a significant overall negative influence on their academic performance of the school children.

However, the Odds Ratio can only be a close approximation to Relative Risk (Excess Risk) of a disease in a population if three epidemiological conditions are met. According to Gordis (1996), these conditions, specifically, are that the cases (infections) studied should be representative with regard to the history of exposure of all people with the disease in the population from which the cases were drawn. Further, the controls (non-infected) studied should be representative, with regard to the history of exposure of all people without the disease in the population from which the cases were drawn. In addition, the disease being studied should be rare or occurs infrequently.

4.10 Performance scores versus specific parasite infections

4.10.1 Performance scores versus infections with *E. histolytica* and *T. trichiura*

Due to sparsity of data on *Giardia lamblia*, Hookworm, *Ascaris lumbricoides* and *Schistosoma mansoni*, only *Entamoeba histolytica* and *Trichuris trichiura* had sufficient data for detailed analysis.

4.10.1.1 Performance scores versus infections with *Entamoeba histolytica*

The response variable used was the percentage score which represented the performance of the pupils. Analysis of variance on variable scores with *Entamoeba histolytica*, as a predictor alone, showed significant association between scores and *Entamoeba histolytica* infection ($F = 10.2$, $\alpha = 0.001$). Parameter estimates showed that those who were not infected scored higher marks (6.759) compared to those who were infected. However, this was before correcting for the effect of school, class and sex, which were all important and confounding ($t = 3.2$, $\alpha = 0.001$).

The effect of school on performance was significant ($F = 246.9$, $\alpha < 0.0001$). The effect of *Entamoeba histolytica* on performance was significant ($F = 1.042$, $\alpha = 0.31$). Analysis of variance results showed that when the effect of school was corrected, infection by *Entamoeba histolytica* was no longer significant. Basically, it showed significantly that the type of school the pupil attended seemed to affect performance than infection by *Entamoeba histolytica*. From the parameter estimates it showed that the best performing schools were: Hospital Hill, followed by St. Teresa Girls', Parkroad, Daniel Comboni, and Kiboro, coming last.

Parameter estimates for performance was = 1.59 which showed non-significant difference between those who were infected and non-infected ($t = - 1.02$, $\alpha = 0.31$). ANOVA analysis showed that after correcting for gender effect ($F = 14.3$, $\alpha < 0.0001$), the effect of infection by *Entamoeba histolytica* on performance was still significant ($F = 10.4$, $\alpha = 0.001$). From the parameter estimates over all schools, females tended to perform better than males by an average score of 4.849 ($t = 3.8$, $\alpha < 0.0001$). In addition, after controlling for the gender effect, those who were not infected tended to score significantly higher by an average of 6.78% ($t = 3.2$, $\alpha = 0.001$).

4.10.1.1 (a) Estimated Marginal Means

The mean scores for non-infected was 63.01 and for the infected was 56.2, respectively. From the Analysis of variance the class has a significant effect on percentage score ($F = 83.7$, $\alpha < 0.0001$). In addition, after controlling for the effect of class, infection by *Entamoeba histolytica* remained significant ($F = 13.5$, $\alpha < 0.0001$).

On overall schools, the performance was highest for students in class 3 followed by class 4, 6, 7 and lowest in class 5. After controlling for the effect of class, those pupils who were not infected tended to perform significantly better by an average score of 6.807 ($t = 3.7$, $\alpha < 0.0001$) above those who were infected.

4.10.1.1 (b) Estimated marginal means

The mean scores for non-infected was 61.2 and for the infected was 54.4, respectively.

After controlling for all effects, infection by *Entamoeba histolytica* was no longer significant at all. However the effect of school, class and sex on performance were all overwhelmingly significant. The mean scores for females was 62.8 and 60.6 for the males, respectively. Females performed better than males. The mean scores for non-infected was 61.4 and for the infected was 62.0, respectively. Those who are positive performed very slightly better but not significantly better. The best schools were Hospital Hill (Mean = 77.4), St. Teresa (Mean = 74.4), Parkroad (Mean = 62.0), Daniel Comboni (Mean = 49.9) and Kiboro (Mean = 44.6). Class 3 were best performers than classes 4, 6, 7, 5.

4.10.1.2 Performance scores versus infection with *Trichuris trichiura*

Trichuris trichiura (alone) was significantly associated with performance ($F = 29.8$, $\alpha < 0.0001$). Those who were infected with *Trichuris trichiura* performed significantly lower compared to those who were not infected, by 9.253 lower; in other words, those who were not infected performed better by 9.253 ($t = 5.5$, $\alpha < 0.0001$). All this was before correcting for the effect of other variables like school, class and gender.

4.10. 1.2.1 Estimated Marginal Means

After controlling for the effect of school, infection by *Trichuris trichiura* was no longer significant. But school was extremely significant ($F = 0.08$, $\alpha = 0.78$). This showed that the school a pupil attended had a significant effect on the performance.

The mean scores for the non-infected was 63.9 and for the infected was 55.0, respectively. The mean scores for females was 61.6 and for males was 57.0.

The best schools were Hospital Hill (Mean = 83.2), St. Teresa (72.3), Parkroad (65.8), Daniel Comboni (51.6) and Kiboro (44.5). After controlling for the effect of class, infection by *Trichuris trichiura* still remained significant ($F = 38.2$, $\alpha < 0.0001$).

From the parameter estimates, those who were not infected performed significantly better than those who were infected by an average of 9.109% ($t = 6.2$, $\alpha = 0.0001$).

The Mean for class three was (73.7), class 4 (63.3), class 5 (49.3), class 6 (51.6) and class 7(49.6). The mean scores for the non-infected was 62.0 and for the infected was 52.9, respectively. After controlling for the effect of gender ($F = 14.0$, $\alpha < 0.0001$), infection by *Trichuris trichiura* remained significantly associated with performance ($F = 27.0$, $\alpha < 0.0001$).

Females performed significantly better ($t = 3.4$, $\alpha = 0.001$) than males, and those who were not infected performed highly significantly better than those who were infected by 8.853% ($t = 5.2$, $\alpha < 0.0001$).

CHAPTER 5 : DISCUSSION

5.1 Prevalence of intestinal parasites among primary school children

The findings of this study showed that the common protozoan parasites (*Entamoeba histolytica* and *Giardia lamblia*) (Plorde, 1994; Lucas, 1995) and common intestinal helminthic infections-*Ascaris lumbricoides*, hookworms (*Ancylostoma duodenale* and *Necator americanus*) and *Trichuris trichiura* were endemic in the schools studied. However, infections with these parasites had varied prevalence, despite mounted, irregular and uncoordinated de-worming control programmes in the City Council primary schools which distorted the true natural prevalence situation. This picture has been observed in other endemic communities (Forrester *et al.*, 1988; Kightlinger *et al.*, 1998; Brooker *et al.*, 2000; Muchiri *et al.*, 2001). In addition, the prevalence varied with sex and age. This study revealed that male pupils were found to be 1.87 times more likely to be infected with *Ascaris lumbricoides* compared to the female pupils. Moreover, gender infectivity was significantly associated with *Trichuris trichiura* ($\alpha < 0.01$). Male pupils were found to be 1.61 times more likely to be infected with *Trichuris trichiura* compared to the female pupils. These higher infection rates observed in males in primary schools could have been contributed by several factors including behaviour as reported by Flores *et al.* (2001). These latter findings are in agreement with the results obtained from another study by Matemo (2006).

Overall, the highest number of intestinal infections occurred with *Entamoeba histolytica* 41 (3.7%) and the lowest occurred with *Ascaris lumbricoides* 11 (1.0%) within the 12 to 14 years age category. Infection status was dependent on the type of parasite ($\alpha < 0.05$) infecting the children.

The Odds Ratio indicated that the children had 6.2 times higher risk of being infected with *Entamoeba histolytica* than with *Ascaris lumbricoides*, within the 12 to 14 years age category. Observations showed that 95.8% (1050) of the pupils were between 9-14 years old. In relation to age the prevalence of intestinal infections observed in this study was within the range of what has been observed for tropical countries of 25% to 90% (Olsen, 1998) in areas which have been subjected to erratic and irregularly administered chemotherapy programmes. The infection rate observed in this study was also within the range of what has been observed in recent studies in Kenya, among school-going children of 10% to 90% (Brooker *et al.*, 2000; Muchiri *et al.*, 2001).

However, Ramdath *et al.* (1995) showed that despite these observations, children experiencing heavy infections as shown in previous studies, stand a higher risks of suffering from severe morbidity. Overall, *Entamoeba histolytica* had the highest rate of infection at 81 (7.4%), followed by *Trichuris trichuris* at 80 (7.3%), *Ascaris lumbricoides* at 48 (4.4%) and *Giardia lamblia* at 5 (0.5%). Hookworms (0.1%) and *Schistosoma mansoni* 1 (0.1%) had the lowest infection rate among all infections encountered in the 5 primary schools. According to the deputy head-teacher of Hospital Hill Primary school, the school had never benefitted from population or school-based de-worming programme for the last 22 years the teacher had been taught in this school. Further, information from the head-teacher at Parkroad primary school indicated that the children had been de-wormed with mebendazole, single dose, on early February, 2007, 4 months before onset of collection of stool samples for examination.

The children at St. Teresa Girls' had been de-wormed on February, 2006 (broad-spectrum anthelmintic administered was unknown to teachers upon further enquiry), sixteen months before stool collection began. However, no *Trichuris trichiura* infections were diagnosed in the school. Further, children in Kiboro had been de-wormed in early March, 2007, three months before the collection of stool samples (The broad-spectrum anthelmintic administered was unknown to the teachers upon further enquiry). However, children in Daniel Comboni had been de-wormed sometime in 2002 (The broad-spectrum anthelmintic administered was unknown to the teachers upon further enquiry), approximately 5 years before this study was initiated (The anthelmintic administered was unknown to the teachers upon further enquiry).

The presence of *Trichuris trichiura* infections in both Parkroad and Kiboro primary schools occurred about 3 months after administration of broad spectrum anthelmintic drugs. This suggested that *Trichuris trichiura* was more resistant to the available, broad-spectrum anthelminic chemotherapeutic drug regimens than *Ascaris lumbricoides* and hookworm. Nevertheless, both mebendazole and albendazole were still highly and equally effective (Katz and Hotez, 2004). However, single dose treatment was unlikely to clear *Trichuris* infection. The dose of mebendazole was 100 mgs taken twice daily for 3 days and albendazole 200mgs taken twice daily for 3 days. However, for symptomatic infections in children whose environment remained unchanged, re-treatment every 3 months was advisable. This observation was in agreement with the observations of Cooper (2004) that *Trichuris trichiura* was resistant to the current broad-spectrum anthelmintic drug regimens.

However, Plorde (1994) had reported that mebendazole was the drug of choice for *Trichuris* infection, although the cure rate was only 60% to 70% and more than 90% of the adult worms were usually expelled, rendering the patient asymptomatic. The overall low-prevalence of hookworm among the study population suggested that the anthelmintic drugs used in the last school-based treatment programme had been effective at Daniel Comboni where the only hookworm infection had been encountered, and possibly in other schools. However, re-infection with hookworm occurred in 2-3 months (Bundy and Drake, 2004) in endemic environments such as existed in Korogocho slums where the school was located, due to low levels of sanitation. However, this study could not explain the low-prevalence of hookworms occurring only in this school and not in others, since the last de-worming exercise was done 5 years prior to the onset of this study.

In addition, in this study, only one infection (0.1%) with *Schistosoma mansoni* was encountered in a male child in Upper Hill Primary school, whose parents reside in Upper Kabete, Nairobi. This occurrence of a low-prevalence rate in an urban environment was in agreement with the observations of WHO (1995) and those of Plorde (1994), Hagen (1992), Nash *et al.* (1982) and those of Strickland (1982) who identified some of the epidemiological determinants for the spread of schistosomiasis, as applies to the *Schistosoma mansoni* infection in this study. These epidemiological determinants include social unrest and civil strife, migration of people in search of work and employment or as refugees and effects of urbanization, such as overcrowding and poor standards of sanitation, personal and communal hygiene as applies to many parts of Kenya.

These situations result in persons previously infected at a young age in endemic areas (Plorde, 1994) moving with parents to far-away urban areas for better standards of livelihood. Thus, infected persons from schistosomiasis-endemic areas end up contaminating rural or urban water sources great distances far away; this happens especially under poor sanitary conditions and poor water resources management. The overall high prevalence of *Entamoeba histolytica* 81 (7.4%) encountered in this study was in agreement with the observations of Reed (1992), Spice and Acker (1992) and Plorde (1994) that *Entamoeba histolytica* is thought to infect 10% of the world's population and has a worldwide distribution. In addition, infection rates are highest in warm climates and exceed 50% in areas and environments where the level of sanitation was low, as was especially the case of the schools located in the slum areas involved in this study.

The overall highest rate of infection with *Giardia lamblia* occurring at 5 (0.5%) was encountered in St. Teresa Girls and Kiboro Primary Schools both of which were located in Mathare slum area. Giardiasis infection has a worldwide distribution and the prevalence was highest in areas with poor sanitation among, especially the crowded urban poor populations who were unable to maintain adequate personal hygiene, as was observed in St. Teresa Girls' and Kiboro primary schools where the infection occurred. These findings agree with the observations of Stevens (1985), Walzer *et al.* (1971) and Wolfe (1992). There was a high rate of infection observed with *Entamoeba histolytica* and *Giardia lamblia*, especially in the primary schools located within Mathare and Korogocho slums.

This was possibly due to lack of effective, well-coordinated school-based control programmes being directly practiced. Amoebiasis was treatable with metronidazole (Flagyl) while Giardiasis was treated with both metronidazole and albendazole (Plorde, 1994). Further, in this study, *Giardia lamblia* infections were encountered in St. Teresa Girls' and in Kiboro Primary schools which were located within Mathare slums and which were de-wormed in early February, 2006 and early March, 2007, respectively.

If the anthelmintic drug administered was albendazole (Plorde, 1994) in both schools, it was possible that the drug could also have lowered the prevalence of giardiasis among the school children involved in this study. These findings agree with those of Walzer *et al.* (1971), Stevens (1985) and Wolfe (1992). This means the current findings of the prevalence of *Giardia lamblia* do not reflect the true situation that existed before the irregular chemotherapeutic, school-based control programmes were implemented. Organized population-based or school-based programmes would, thus, benefit school children suffering from infections with *Giardia lamblia*, *Ascaris lumbricoides*, *Trichuris trichiura* and hookworm, either as single or mixed infections. The overall prevalence of *Ascaris lumbricoides* was 48 (4.4%); these infections occurred only in Daniel Comboni Primary School located in Korogocho slums. In Daniel Comboni, de-worming had been done in 2002, five years prior to the inception of this study. This level of prevalence could reflect re-infection in endemic environments such as those in Korogocho slums. This finding concurs with observations of Davis (1985).

Multiple infections co-existed in some study subjects, for example, *Ascaris lumbricoides* and *Trichuris trichiura* co-existed together at the highest rate of 20 (8.3%) in all classes while *Entamoeba histolytica* and *Trichuris trichiura* co-existed together at the rate of 5 (2.1%) in all classes at Daniel Comboni school in Korogocho slums (Table 4.12). However, the only co-infection in this study involved *Entamoeba histolytica* co-infection with *Giardia lamblia* 1 (0.4%) and co-infection of *Entamoeba histolytica* and *Trichuris trichiura* 4 (1.8%) at Kiboro primary school in Mathare slums. Co-infections occurring together within same host could have been due to social or behavioural factors that lead infection.

Indeed, acquisition of one specie infection increased the probability of infection with the other species. Several investigators suggest this may have far reaching effects on health of such an individual as they may suffer from multiple morbidity associated with disease (Booth *et al.*, 1998b; Brooker *et al.*, 2000; Tchuem-Tchuente *et al.*, 2003). Such children were known to have poorer academic scores compared with children with single infection (Kvalsvig *et al.*, 1991). This may have an effect on the type of drug used in the control programme. Such a drug must be broad spectrum for STH and effective against all the STH to reduce the burden of the disease associated with each of the parasites (WHO, 1995; Muchiri *et al.*, 2001; Aswathi *et al.*, 2003; Montessor *et al.*, 2003).

5.2 Types of parasites isolated from children in the study areas

The findings of this study showed that the common intestinal protozoa called *Entamoeba histolytica* and *Giardia lamblia*) and helminths (*Trichuris trichiura* *Ascaris lumbricoides*) were endemic in some study areas. However, these parasites occurred with varied prevalence, especially in the school and home environments situated around and within the slums. This had been observed in other endemic communities (Forrester *et al.*, 1988; Kightlinger *et al.*, 1998; Brooker *et al.*, 2000; Muchiri *et al.*, 2001). In this study, the parasites which were isolated from stool samples obtained from the school children were specifically *Entamoeba histolytica* and *Giardia lamblia* among the protozoan parasites. The intestinal nematodes seen were: *Ascaris lumbricoides* 48 (4.4%), *Trichuris trichiura* 80 (7.3%), Hookworms 1 (0.1%). An intestinal trematode-*Schistosoma mansoni* 1 (0.1%) was seen at Hospital Hill primary school.

According to the Head-Teacher, the last time the school children had been de-wormed was sometime in 2002 and no further de-worming exercises had ever been done by mid-2007, when the data collection process for this study commenced. Such a low prevalence of hookworms could only be explained by the fact that the haphazard and irregular de-worming programmes mounted by the Non-Governmental Organizations in primary schools seem to have had an effective therapeutic effect in the infected children. The infected children attend a school which is located deep into the Korogocho slums where the ideal conditions for the transmission of hookworm are suitable, such as indiscriminate defaecation of children and use of flying toilets and the habit of children walking bare feet in overcrowded environments with no proper sanitation facilities.

In addition, there was another case of *Schistosoma mansoni* diagnosed from a male child in Hospital Hill Primary school in Parklands, which is a high cost school. This study suggests that it was possible that the male subject had been exposed to cercariae-infested waters in the past, possibly after having lived or visited a schistosomiasis-prone and geographically distant area upcountry and later migrated with the parents to Nairobi province in search of work, since the child's father operates a taxi in Westlands areas.

5.3 Factors contributing to prevalence of infections among school children

The factors that contribute to the high prevalence of intestinal infections include failure to wash hands before meals and failure to wash raw foods before eating food. This habit promotes the ingestion of most of the viable and infective intestinal protozoan cysts (*Entamoeba histolytica* and *Giardia lamblia*) and also infective embryonated nematode ova (eggs) of *Ascaris lumbricoides*, *Trichuris trichiura*. Indeed, in some cases, infective larvae of *Ancylostoma duodenale* and *Strongyloides stercoralis* present in contaminated or raw or inadequately cooked foods and drinks. The prevalence of these infections in the schools showed that 10 (4.3%) from Hospital Hill, 3 (1.5%) from Parkroad, 28 (12.5%) from Kiboro, 134 (55.6%) from Daniel Comboni primary schools. The children indicated that they do not wash hands before eating food at home or at school. Further, 8 (3.5%) of the children in Hospital Hill, 28 (13.9%) in Parkroad, 38 (17%) in Kiboro and 160 (66.4%) in Daniel Comboni primary schools indicated that they did not wash raw foods before eating at home or in school. This was in agreement with the views of WHO (1964), Cheesbrough (1981), Plorde (1994) and Chiodini *et al.* (2001).

In addition, failure to wear shoes always at home and at school promotes entry of infective filariform larvae of *Ancylostoma duodenale*, *Necator americanus*, *Strongyloides stercoralis*. This was reflected by the fact that 8 (3.5%) of the children in Upper Hill Primary school, 2 (1.0%) in Parkroad, 74 (33.0%) in Kiboro and 190 (78.8%) in Daniel Comboni indicated in the questionnaire that they did not wear shoes always at home or in school; failure to wear protective attire also allows the infective cercariae of schistosomes to enter into the unprotected exposed skin of the human body, causing various infections (Plorde, 1994; Chiodini *et al.*, 2001). This study found, through the use of observation check-list, that the practice of using human faeces as a cheap source of fertilizer for growing crops such as vegetables was practiced in areas surrounding the slums of Mathare and Korogocho. These practices highly promote the prevalence of parasitic intestinal infections, especially in areas adjacent to slums.

Moreover, living in overcrowded urban environments also promotes the prevalence of intestinal nematode infections such as enterobiasis caused by *Enterobius vermicularis*. These observations were in line with the observation of Atukurola *et al.* (1999) that crowding enhances the transmission of intestinal parasitic infections. However, this study did not indicate whether the clustering of some of the parasitic infections in some schools and not the others was due to genetic factors or behavioural factors. However, similar results had been observed by Forrester *et al.* (1988) that the distribution of infections was not even in a given area but clustered within particular households or sections of the community. It was observed that children in slum primary schools had a greater disease burden than children in the medium-cost and elite schools.

This was in agreement with the findings of Henry (1988) and Holland *et al.* (1988) that socio-economic status can be used as a good predictor of intestinal helminthic infections. Indeed, in urban areas, economic status may be an important factor compared to the situation in rural areas where other factors such as rainfall and personal hygiene may play a major role in transmission (Rijpstra, 1975). The economic status has been indicated to exaggerate the already existing conditions which could be indicators of infection such as low sanitation, poor housing and lack of health education (Kightlinger *et al.*, 1998). Moreover, some of the children in the study population could have acquired intestinal infections from the practice of not washing raw foods such as fruits or peeling unwashed fruits with one's teeth or even eating certain water plants in a raw state. These raw fruits occasionally contain encysted metacercariae of certain trematodes that could infect children, especially those of *Fasciolopsis buski* which causes an intestinal infection called fasciolopsiasis.

5.4 Pattern of academic performance in Primary schools

Overall, the value of the mean score (62.5) was dependent on the infection status of the children in the primary schools ($\alpha < 0.05$). In addition, the Odds Ratio indicated that the infected children had 1.8 higher risk of performing poorly in their academic work compared to those children who had not been infected. This could be supported by the observation that during stool sample collection some teachers in Kiboro and Daniel Comboni primary schools reported having seen poorly performing children vomiting adult *Ascaris lumbricoides* worms through the mouth.

A positive association was, therefore, noted to exist among the school children, between the presence of intestinal infections and academic performance. However, the computed value of the correlation coefficient between the presence of intestinal infection among 180 children from the five primary schools showed that the presence of intestinal infections did not influence the academic performance of the children included in this study. Other confounding factors which were not identified in this study, such socio-economic factors, overcrowding and lack of access to health facilities and poor sanitation could also contribute to poor academic performance as has been explained by Gordis (1996). Mean performances were significantly different between schools ($\alpha < 0.001$). Mean scores for pupils in Kiboro and Daniel Comboni primary school were significantly lower than those of other schools. In addition, mean performances were significantly different between boys and girls ($\alpha < 0.001$). Mean score for boys was significantly lower than that of girls.

Also mean performances were observed to be significantly different between age groups ($\alpha < 0.001$). Performance deteriorated with advance in age. Further, mean performances were significantly different between classes ($\alpha < 0.001$). Moreover, Mean scores deteriorated with advance in class level. This study noted that the Odds Ratio was not an accurate predictor for evidence of an association because the children from Hospital Hill (Average score = 83), Parkroad (65.5) and St. Teresa Girls' (71.0) Primary schools had higher average performance end-of-term scores compared to those of Kiboro (44.4) and Daniel Comboni (62.0) primary schools both of which were located in the slums.

Thus, there is a wide disparity in the performance scores generated by the school children in different schools.

CHAPTER 6: CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

The overall prevalence of intestinal parasites in the schools studied was 16.4%.

The most prevalent parasite was *Entamoeba histolytica* (7.4%) among the Protozoans and *Trichuris trichiura* (7.3%) among the intestinal Helminths.

The most prominent factors predisposing school children to intestinal infections were the failure of the children to wash hands before eating food at home and in school and infrequent cleaning of toilets.

Toilets which were not frequently cleaned invited the breeding of latrine flies (*Fannia scalaris*) which transmit intestinal infections (Kitron, 1998).

The mean performance scores decreased from high-cost schools to low-cost schools. In addition, the infected children were twice at higher risk of performing poorer than uninfected children.

6.2 Recommendations

- (a) There is need to institute regular mass-treatment programmes. Further, the Ministry of Education and Ministry of Public Health and Sanitation should mount regular treatment programmes in all primary schools both in rural and urban areas.
- (b) Public Health education programmes should be emphasized in the schools curriculum.
- (c) The level of sanitation should always be kept high.

6.3 Recommendation for further research

It is recommended that sources of infection be investigated so that appropriate control strategies are instituted.

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SECTION TWO – (ATTITUDES)

- (1) Have you ever been infected with parasites ? Yes No

- (2) If Yes, which parasites infected you ?
 - (a).....
 - (b).....
 - (d).....
 - (e).....
 - (f).....

- (3) Have you ever been infected with intestinal parasites ? Yes No

- (4) If yes, which intestinal parasites infected you ?
 - (a).....
 - (b).....
 - (d).....
 - (e).....
 - (f).....

SECTION THREE – (PRACTICES)

- (1) Do you wash hands every time you eat food at home ? Yes No

- (2) If No, how often do you wash hands before you eat food at home ?
 - (a) Sometimes.....
 - (b) Rarely.....
 - (c) Never.....

- (3) Do you wash hands before you eat food at school ? Yes No

- (4) If No, how often do you wash hands before you eat food at school ?
 - (a) Sometimes.....
 - (b) Rarely.....
 - (c) Never.....

- (5) Do you eat raw foods at home ? Yes No

- (6) If Yes, how often do you eat raw foods at home ?
 - (a) Often.....
 - (b) Sometimes.....
 - (c) Rarely.....
 - (d) Never.....

- (7) Do you eat raw foods at school ?

- (8) If Yes, how often do you eat raw foods at school ?
(a) Often.....
(b) Sometimes.....
(c) Rarely.....
(d) Never.....
- (9) Do you wash the raw food at home ? Yes No
- (10) If No, how often do you wash the raw foods at home ?
(a) Sometimes.....
(b) Rarely.....
(c) Never.....
- (11) Do you wash the raw food at school ? Yes No
- (12) If No, how often do you wash the raw foods at school ?
(a) Sometimes.....
(b) Rarely.....
(c) Never.....
- (13) Do you wear shoes at home ? Yes No
- (14) If Yes, how often do you wear shoes at home ?
(a) Sometimes.....
(b) Rarely.....
- (15) Do you wear shoes at school ? Yes No
- (16) If Yes, how often do you wear shoes at school ?
(a) Sometimes.....
(b) Rarely.....

APPENDIX 2

Environmental health checklist

- (1) SCHOOL.....
- (2) Number of Latrines / Lavatories.....
- (3) Condition of Toilets W / C.....
- (4) Cleanliness inside Latrines / Lavatories.....
- (5) General Cleanliness of school compound:
 - (a) Presence of garbage heaps.....
 - (b) Presence of filth flies.....
- (6) Drainage System.....
- (7) Sewage Disposal System.....

APPENDIX 3**MODIFIED RIDLEY FORMOL-ETHER STOOL CONCENTRATION METHOD**

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 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 preparation was examined using x10 objective or x40 Objective and all the eggs and/o 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 4: THE MAP OF STUDY AREA

(Inset : Map of Kenya Showing Position of Nairobi Province)

