INTESTINAL PARASITE INFESTATION AND THE ANTHROPOMETRIC STATUS OF PRIMARY SCHOOL CHILDREN IN THE DELFT AREA, WESTERN CAPE.

A mini-thesis submitted in partial fulfillment of the requirements for the degree of Magister Scientiae in the Department of Human Ecology and Dietetics, University of the Western Cape.

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KEYWORDS

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Nematodes

Chronic malnutrition

Nutritional status

Primary school children

Protozoa

Socio economically deprived

Intestinal parasites

Productivity

Prevalence

DEFINITIONS

Malnutrition: In the context of this thesis the term is usually synonymous with chronic **undernutrition** and refers to the syndrome of inadequate intake of protein, energy and micronutrients, combined with frequent infections that result in poor growth and body size. Malnutrition is often linked to severe poverty and causes growth stunting and low weight-for-age which can lead to specific diseases such as protein-energy-malnutrition, kwashiorkor, rickets, xerolfthalmia and pellagra. Malnutrition can also refer to overnutrition associated with intake of too much energy in the form of fat and sugar, an insufficient intake of micronutrients and a sedentary lifestyle. This type of lifestyle, which is often associated with urbanization, causes nutritional diseases such as obesity, heart disease, type 2 diabetes mellitus, hypertension and cancer.

Chronic malnutrition or stunting: A condition of insufficient nutrient intake of long duration and can be measured by height-for-age of less than 90% of expected height-for-age or a height-for-age Z-score (HAZ) of <-2SD of a reference population.

Underweight: A condition of insufficient nutrient intake over a long period of time expressed in terms of weight-for-age less than 80% of expected of a reference population.

Standard deviation (SD): a measure of variation from the mean for normally distributed variables.

Chronic: With regard to disease this means of long duration, such as weeks, months, years, decades or permanently.

Helminth parasite: A worm having an obligatory requirement for a relationship with a living vertebrate host. Most of helminth parasites belong to the group of roundworms, which also includes some free-living species, but helminthes also include tapeworms, schistosomes, other flukes and filariod worms.

Nematodes: unsegmented helminths that are commonly called or roundworms of which *Ascaris lumbricoides, Trichuris trichiura* are the most prevalent in South Africa.

Cestodes: Segmented flat worms such as the tapeworms *Taenia solium* and *Taenia saginata.*

Parasite: A parasite lives in or on a host that is usually larger and provides protection and nourishment to the parasitic organism.

Infection: Invasion of the body of the host by parasites (or other organisms) that have potential to become disease.

Infestation: Infection of a host by helminthic parasites.

Intensity: The number of adult helminths present in the intestine of a host. Egg counts are used to estimate intensity.

WHO: World Health Organisation.

UNICEF: United Nations International Children's Emergency Fund.

NCHS: National Centre for Health Statistics.

HAZ: Height-for-age z-score.

WAZ: Weight-for-age z-score.

WHZ: Weight-for-height z-score.

ABSTRACT

Infestation by intestinal helminths is a disease that is chronic, insidious and usually silent. Acute signs and symptoms are not characteristic, nor is the disease manifested as sudden outbreaks. Instead, it is typically associated with poverty, being a disease of the poor and socioeconomically deprived and therefore it is often ignored and neglected. Infestation by intestinal helminthes and malnutrition usually occur together in the same areas, leading to a double burden in the already deprived. Reports in the literature on the effects of treating children for intestinal parasites vary widely. Some studies found no beneficial effects, while others report significant improvements in nutritional status, growth, anemia, cognitive function, school attendance and behavior. Previous studies in the Western Cape have shown infestation between 70% and 90% among schoolchildren. The aim of this study is to determine the prevalence and the relationship between malnutrition, the prevalence of worm infestation and the intensity of infestation in an economically deprived area in the Western Cape, in primary school children. A cross-sectional study of 235 children, randomly selected from four schools was undertaken. Faecal specimens were examined by microscopy using standardized methods, and anthropometrical measurements were taken. In this study the mean prevalence for parasite infestation was 47.7%. No relationship was detected between the anthropometrical status and infestation by intestinal parasites. The prevalence for stunting in school 3 (the informal settlement) was 23%, 75% were infected with parasites and 25% infected with protozoa, the highest for all the schools. The possibility of a prospective interaction was not determined.

DECLARATION

I declare that

INTESTINAL PARASITE INFESTATION AND THE ANTHROPOMETRIC STATUS OF PRIMARY SCHOOL CHILDREN IN THE DELFT AREA, WESTERN CAPE

is my own work, that it has not been submitted for any degree or examination at any other university, and that all sources I have used or quoted have been indicated and acknowledged by complete references.

Elsabe Nel
November, 2002

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CONTENTS

CHAPTER 1

INTRODUCTION

James P Grant of UNICEF (1982)(1) said that: "invisible malnutrition touches the lives of one quarter of the children in the developing world. It quietly steals away their energy, gently restrains their growth and gradually lowers their resistance, which is both sharpened by malnutrition and aggravated by parasite infestation".

Infections of humans by helminths are associated with a low case fatality rate but causes massive morbidity on a global scale (1). Helminthiasis has always been a major disease of mankind. Currently about one out of three persons in the world is infested, even though we have known how to prevent and treat helminthic infection for decades. Worm infestations lower the energy of populations, result in chronic morbidity and silently retard the development of each generation of children. True potential cannot be reached in poor communities if these conditions remain so common (1). During the last decade a lot has been done about child survival, but little that addresses common helminthic infections. The ever-increasing pressure on the medical curriculum leaves little time allocated to the study of protozoan and helminthic infestation in humans (2). The synergy that exists between malnutrition and infections is well known, but emphasis has been placed on viral and bacterial infections and not much consideration has been given to the relationship between malnutrition and intestinal parasite infestation (3).

According to the National Food Consumption Survey (NFCS) (4) and the South African Vitamin A Consultative Group (SAVACG) (5), malnutrition is a serious problem in South Africa that needs to be addressed. Chronic malnutrition seems to be of a more serious nature than acute malnutrition with one in five children stunted and one in ten children underweight. A third of children have sub-clinical Vitamin A deficiency and one out of five children are iron deficient (5). The effects of anemia, stunting, reduced cognitive function and in particular the number of school years completed, have potentially long-term consequences for productivity in adulthood (6). A study done to investigate the synergy between undernutrition and parasite infestation has shown that where parasite infestation is low to moderate it is difficult to demonstrate any detrimental consequence of infestation in terms of nutritional status in South Africa (7).

Intestinal parasites reach their peak incidence in the impoverished parts of the developing world and are usually the same areas where undernutrition occurs. Cooper *et al* found that maximum intensity of worm infestation occurs in children who are 5-10 years old (8). This is also the age where learning may be largely lost. Studies in the Western Cape among poor communities have shown parasite infestation of between 75% and 90% (9,10).

Giardia duodenale (*G.lambia*) is a recognized pathogen and a major cause of diarrhea in children (11). The association between *G.lambia* infestation and chronic diarrhea has been recognised, particularly in malnourished children (2). Urbanization, overcrowding and unhygienic living conditions contribute to the increase of endemicity and intensity of giardiasis (11). Two-thirds of the primary school children with *Giardia* infections in a West Coast community were concomitant with other soil-transmitted helminth infestations (11).

The aim of this study is to investigate the prevalence of parasite infestation and the nutritional status of primary school children in the Delft area, a peri urban area near Cape Town. The community is impoverished and deprived to the extent that overcrowding (or living conditions) and parasitic infestation are likely to worsen the effect of malnutrition. No recent information is available on the relationship between malnutrition and parasite infestation in this area.

The question of whether we are still feeding a wormy world (12) is relevant to intervention such as the Primary School Nutrition Program (PSNP) and the Protein-Energy Malnutrition Scheme (PEM) (4,5).

CHAPTER 2

LITERATURE REVIEW

PARASITES and PARASITISM.

"Parasites to the ancient Greeks were those who sat at another's table and paid for the meal with flattery"(3).

The intestinal parasites of human importance are contained in five or more major phyla. The single-selled Protozoa and the Aschelminthes and Platyhelminthes contains the most important classes that can paratise man (2,13). Only these will be discussed (Table 1).

Table 1

Classification of important parasites related to malnutrition

PHYLA	*Protozoa*	*Aschelminthes*	*Platyhelminthes*
CLASS		*Nematoda* 1. *Trichuris trichiura* 2. *Ascaris lumbricoides* 3. Hookworm (Species *Necator americanus*)	*Cestoda* 1. *Taenia saginata* 2. *Taenia solium*

Phylum Aschelminthes, Class nematoda: also known as roundworms are elongated, cylindrical and frequently attenuated at both ends. They can be intestinal or tissue inhabiting.(2,13)

Soil-transmitted helminthes (STH) are amongst the most common parasitic infections (14,15). The most prevalent STHs globally are *Trichuris trichiura, Ascaris lumbricoides* and the hookworms (14,15). Infections caused by nematodes are amongst the most prevalent communicable diseases of humankind and children are in particular susceptible to severe infestations by these parasites and consequently suffer greater mortality and morbidity (13). See Figure 1 (a), (b) and (c) for the lifecycles of *Ascaris lumbricoides*, *Trichuris trichuira*, and the hookworm (2).

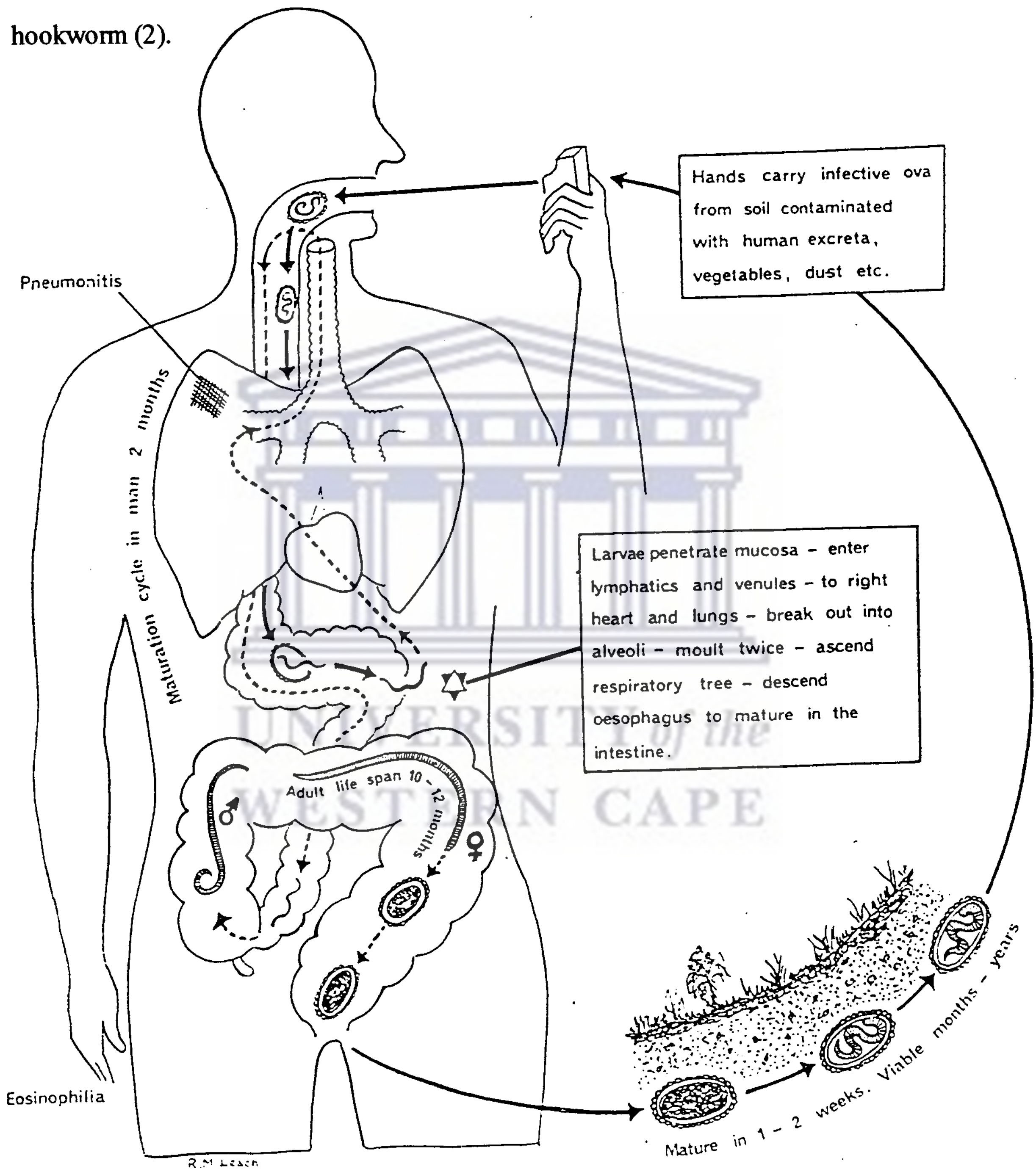

FIGURE 1(a) The lifecycle of *Ascaris lumbricoides* (copied from reference 2 with permission)

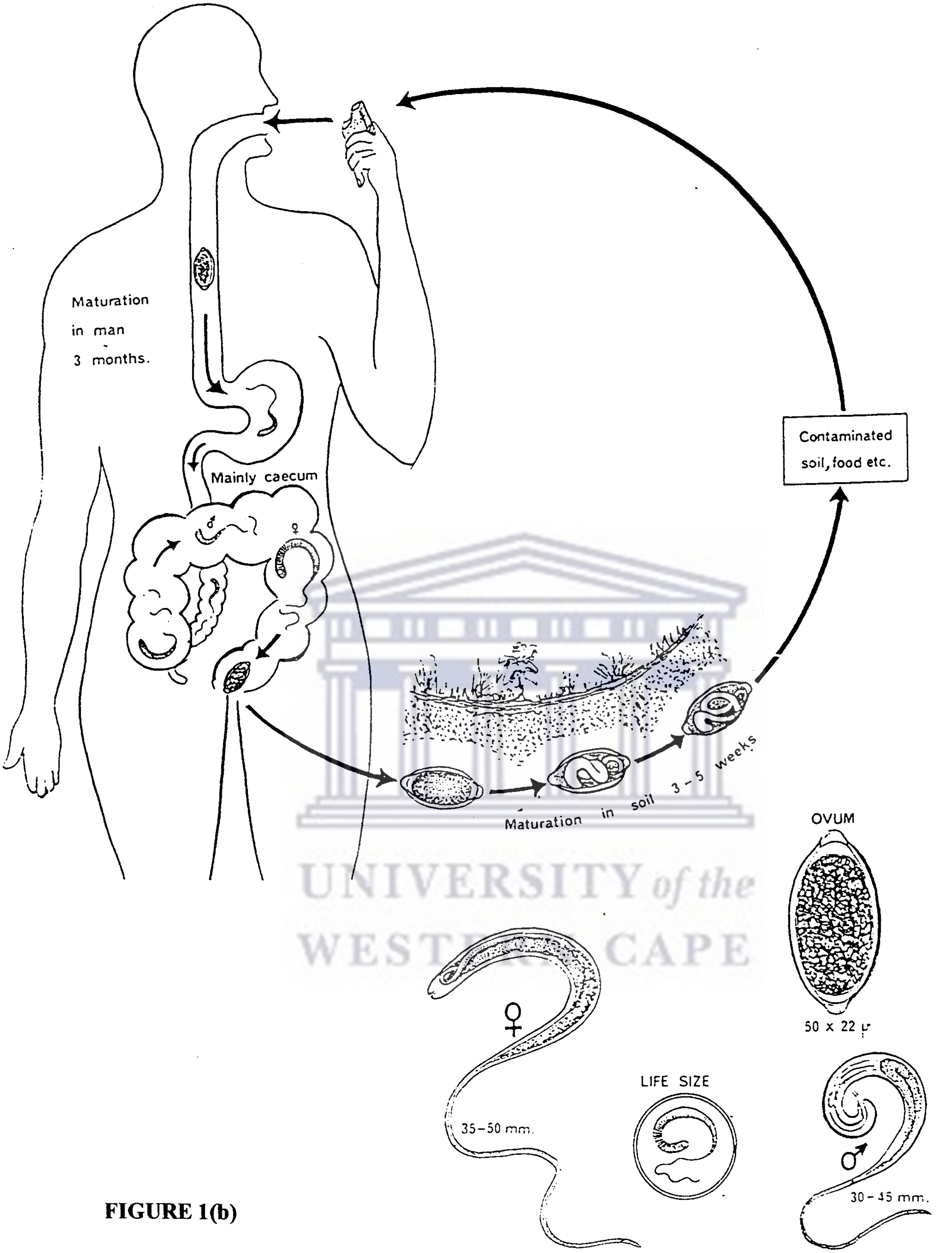

FIGURE 1(b)

The lifecycle of *Trichuris trichiura* (copied from reference 2 with permission).

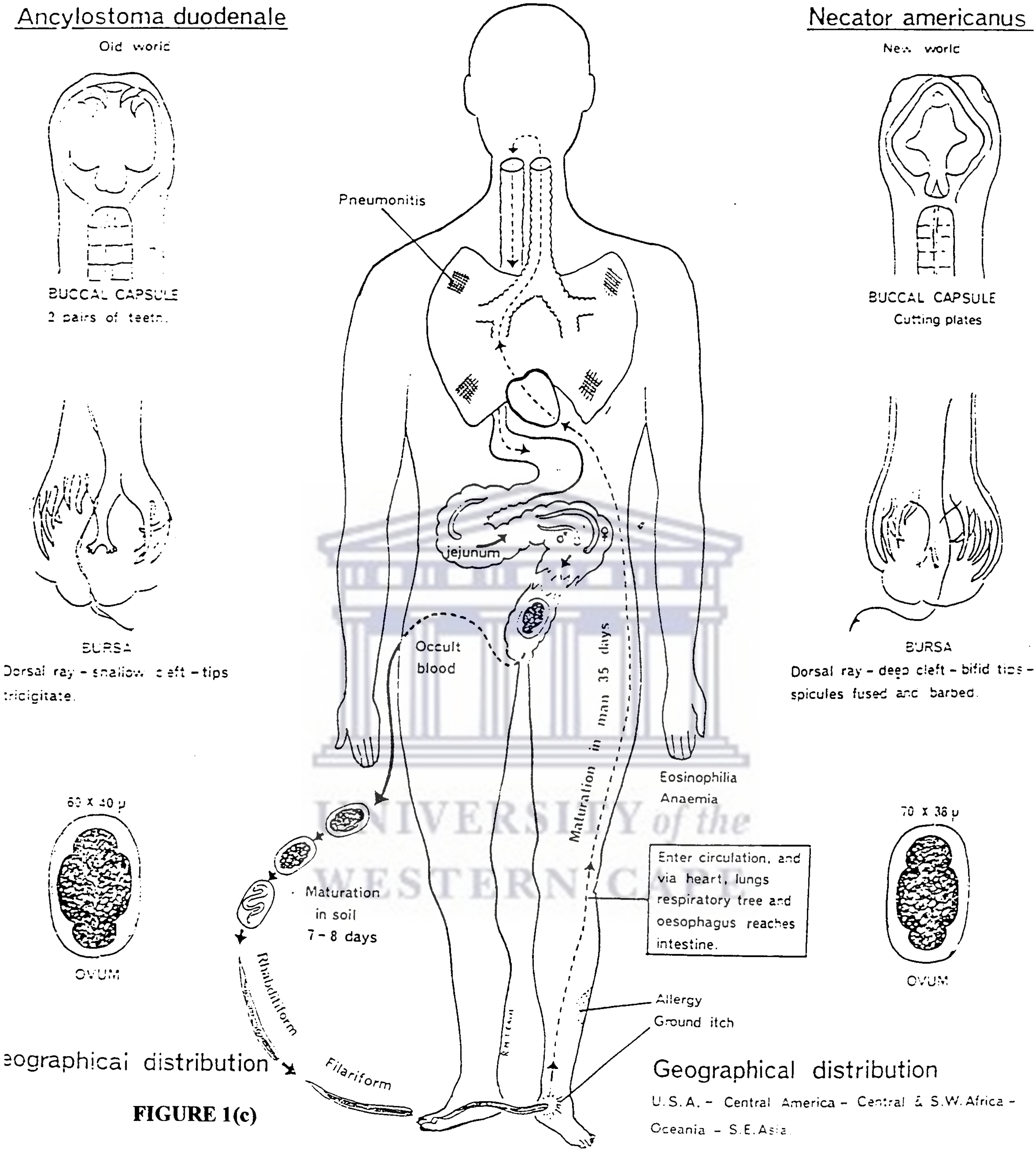

FIGURE 1(c)

The lifecycle of the hookworm (copied from reference 2 with permission).

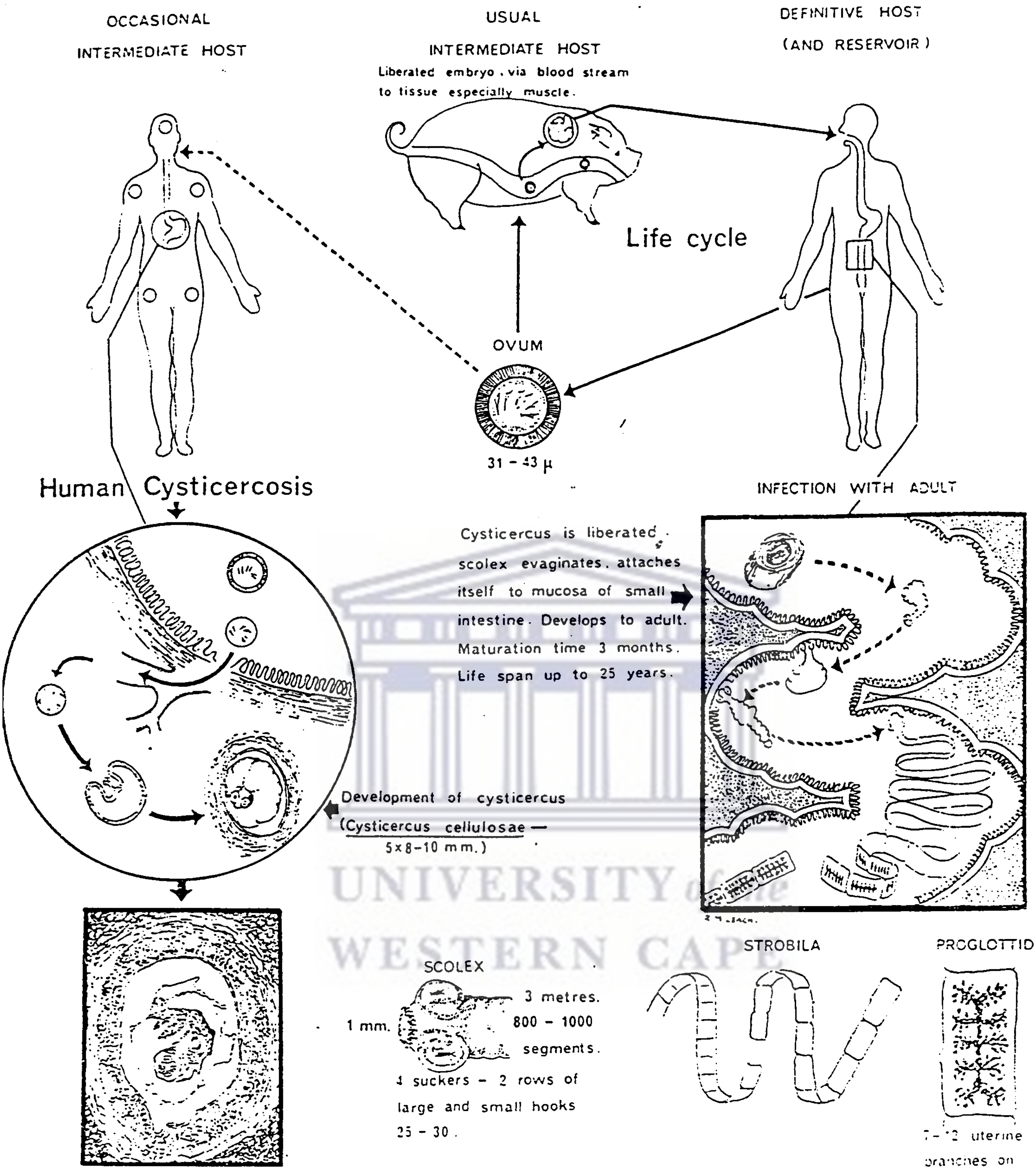

FIGURE 1(d)

The lifecycle of *Taenia solium* (copied from reference 2 with permission).

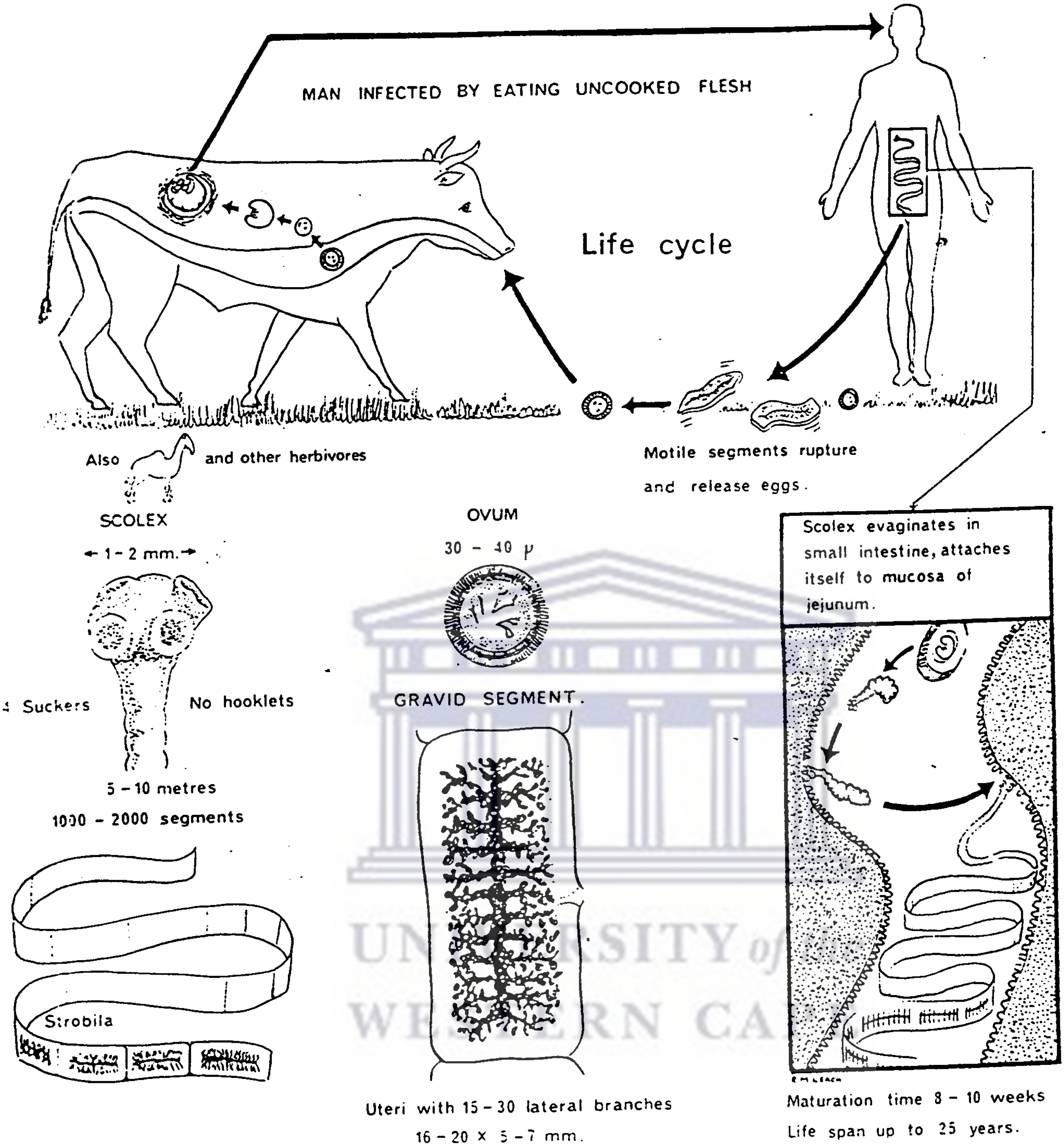

FIGURE 1(e)

The lifecycle of *Taenia saginata* (copied from reference 2 with permission).

Figure 1(f). The dwarf tapeworm (*Hymenolepis nana*) utilises humans and rats as definitive hosts. When rats have access to human food they inevitably pollute it with faeces that may contain eggs of the worm and other pathogens. This tapeworm has also been called *Vampirolepis nana* (20). Reproduced with permission.

Ascaris lumbricoides lives in the upper part of the small intestine and can reach a length of 30cm. The female *Ascaris* is one of the most prolific producers of eggs in the animal kingdom (one female discharges between 200000 to 240000 eggs per day) (2,13,14). However, only 2 (male and female embryos) eggs are needed to infect a person in order to keep the population of *Ascaris* reasonable stable (14). Embryonation of the eggs take place in the soil and humans contract ascariasis by ingestion of these through faecal contamination of food, water, fingers and pica (pica is a form of deprived appetite that refers to eating soil (earth) and can also be called geophagia). These eggs hatch in the small intestine and liberate larvae which burrow through the mucosa, are carried via blood or lymph to the liver, where they roams for a few days before being carried by blood returning to the heart, and then to the lungs. The entire process takes 2 to 3 months (2,13,17,14). See figure 1(a). The adult worms secrete anti-trypsins, which enable them to compete for protein ingested by the host (13). Elevated levels of IgE have been widely reported in *Ascaris*-infected persons however; the relationship between *Ascaris,* asthma and allergy is still unclear. Asthma, bronchospasm and bronchitis are sometimes worsened by interactions with intestinal parasites (18). Fincham (19) reported that a healthy human immune system responds to helminthic infection with an overall result of major amplification of the inflammatory response. This includes helminth-spesific immunoglobulin-E secreted by the plasma cells. The healthy child with a competent immune response could kill adult helminthes and larvae efficiently (19). The fact that a single worm can cause serious or even fatal disease by obstruction or by migrating into the liver or pancreas shows the importance of treatment (18). Hepatitis and pancreatitis are regular sequels to blockage of the respective ducts by migrating (18).

But what is the extent of malnutrition in infected people? Even if the effects on the average infected persons were small, the total impact on communities with high prevalence could be substantial (17).

Trichuris trichiura, known as whipworm has a cosmopolitan distribution. According to Hirst et.al. (15) the whipworm is responsible for 1287 Disability Adjusted Life Years (DALYS). DALYS represent a measure of disease burden over a lifetime per infected person (15). The whipworm lives in the caecum, colon and rectum of humans where it matures and lays between 3000 and 5000 eggs per day. The larva does not migrate to other organs as is done by *Ascaris* (3,13,14,17). The eggs can survive for several years after embryonating under suitable conditions. Humidity, sandy soils and a warm temperature (20-30 degrees Celsius) favor embryonation that takes about 18-25 days (2,13). Infection is acquired by swallowing the embryonated egg which hatches in the small intestine and developes to the adult in to the caecum,colon or anus. See figure 1(b). A larvae tunnel into the intestinal mucosa and part of the adult is permanently embedded therein. This and associated inflammation can be associated with blood loss and anemia, which is less severe than hookworm anemia (2,8,13). Heavily infected children can present with dysentery and chronic colitis, which causes severe diarrhea with blood and mucus. Chronic infestation can lead to typical symptoms of inflammatory bowel disease and cause chronic loss of nutrients, stunting and anemia (8,16). The severity of the disease does not only depend on the intensity of infestation and its location in the gastro-intestinal tract but also on the health status of the host. The complete syndrome is associated with a burden of over 500 adult worms and can include dysentery, rectal prolapse, anemia and clubbing of fingers (2,8,13). Moderate infestation can cause gastro-intestinal symptoms like diarrhea, abdominal pain and vomiting that lead to a decreased food intake. For the already protein-energy compromised child, this means even more vulnerability to disease (2,8,13,17). Infestation can be associated with pica of fecael-contaminated soil in communities where sanitary facilities are inadequate (17).

Low height-for-age was more strongly associated with trichiuriaris than weight-for-age (17). Since iron defiency anemia can reduce appetite and whipworm causes anemia in heavily infected children; there is some explanation of how that whipworm infestation can cause chronic growth impairment (17). Treatment can result in dramatic catch-up growth (13). Mebendazole or albendazole are the treatments of choice.

It has been stated stated that "Hookworm is never spectacular like some disease, but essentially insidious; year after year, generation after generation, it saps the vitality and undermines the health and efficiency of whole communities"(2). According to Hirst et.al (15) hookworm is responsible for 1698 DALYS/1000 people per annum. Initial infection occurs through the skin and therefore prerequisites to widespread hookworm infestation will be where most people defecate directly onto the soil and do not wear shoes (2). Hookworm infestation is different to the other helminths in the sense that it tends to peak in adolescent or adults (2,13,21). Hookworm was not implicated in this study.

The Phylum Platyhelminthes, Class cestoda: also known as tapeworms, are flat and divided into segments (proglottids).

Adult tapeworms are the longest human parasites and can reach up to 10m and are segmented with a special attachment organ, the scolex. They inhabit the small intestines and require an intermediate host for larvae development (2). The life cycles of the tapeworms *Taenia solium* (pig tapeworm), *Taenia saginata* (beef tapeworm) and *Hymenolepis nana* (dwarf tapeworm) are shown in Figure 1(d), (e) and (f).

Humans become infected by *Taenia* tapeworms through ingesting raw or undercooked infected beef or pork that harbours the larva (cysticercus) (13). Tapeworms consist of segments (proglottids). The last proglottids contain the eggs and these break off and migrate actively within the intestinal lumen to reach the anus. When people do not have toilets the proglottids are passed in human faeces into grazing areas utilized by cattle and pigs. The proglottids come to rest in grazing areas where cattle or pigs ingest it and the eggs are released after ingestion (2,13,21). Cysticercosis is more serious than infestation by adult worms because the cystericus or bladderworm invades human tissues after tapeworm eggs are swallowed (2,13,21). Cysts that lodge in vital areas such as the brain, the eye or the spinal cord can cause serious disease or death (2,13,21).

PROTOZOA

Protozoa are free-living, unicellular animal found in almost every environmental niche. Unlike helminths they replicate to produce hundreds of thousands of their kind in the host. The species *Giardia duodenalis*(=lambia) is a flagellated protozoa and is one of the most common flagellate of the human digestive tract (11,21). *Giardia duodenalis* exits as two stages; the cyst and trophozoite. The cysts are ingested and transmitted from one individual to another by water and food contaminated by faeces (11,21). The cyst is the infective stage because the trophozoite cannot survive stomach acid. A stool in a moderate infection may contain 300 million cysts, so one infected individual can can be a major source of infection (11,21). Malabsorption syndrome is characteristic of giardiases. A number of mechanisms have been proposed; most refer to mucosal damage or injury. The immune status of the host appears to play a major role in the pathogenesis of giardiasis. Deficiency of immunoglobulin A (IgA) leads to longer and heavier infections (13). Diarrhea is the most common symptom and if untreated can lead to steatorrhea, micronutrient loss and fatigue. Other symptoms are weight-loss, nausea, anorexia and epigastric pain. Giardiasis can also be an opportunistic re-emergent infection in AIDS (11). The disease is not fatal but can be intensely discomforting. Children are more frequently infected than adults (2,11). Giardiasis is highly contagious; therefore prevention depends on a high level of sanitation (2,11,21). Surveys showed that two thirds of *Giardia* infections were concomitant with other soil-transmitted helminths infestations. Both are indicator-organisms of faecal contamination (11).

INTENSITY OF HELMINTHIC OR WORM INFECTION

Intensity refers to the number of worms per infected person. Prevalence is also of importance because it influences population regulation of the parasite and the morbidity and mortality associated with the disease. Studies on the intensities of *Ascaris* has shown that frequency of numbers of worms per host is over dispersed so that a few people of the community harbour most of the worms, while most people only have a few worms each (14). Crompton and Tulley (14) suggested that if 1 out of 50 people have a high worm burden then about 3 million people in

Africa might be at risk of a life-threatening condition. According to Stephenson, the definitions of intensity of infections are as indicated in Table 2 (17).

Table 2: Definitions of intensity of infection

Parasite	Intensity of infection	Egg count [eggs per gram(epg)]
Ascaris	Light	under 5000-7000 epg
	Moderate	7000-35000 epg.
	Heavy	over 35000 epg.
Trichuris	Light	under 1000 epg.
	Moderate	5000-20000 epg.
	Heavy	over 20000 epg.

MALNUTRITION AND NUTRITIONAL STATUS

Malnutrition as defined causes sub-optimal nutritional health and is widespread amongst disadvantaged groups. The consequences can be severe and long lasting. Despite the broad acceptance of the dual causality between malnutrition and parasite infection, attempts in the past to improve child survival have focused more on managing infectious diseases than on addressing malnutrition (22). Malnutrition impairs functional, physical as well as cognitive and behavioural performance.

Stunted growth reflects a process of failure to reach linear growth potential as a result of poor, health, and/or nutritional conditions. High levels of stunting on a population basis are associated with poor socio-economic conditions. The age of the group modifies the interpretation. In the age group below 2-3 years there is a failure to grow (or stunting) and older children are said to have failed to grow (or are stunted) (22).

According to the NFCS (4) 21,6% South African children aged one to nine years are stunted (<-2SD height for age), 10% are underweight (WAZ <-2 SD weight for age) and 4% are wasted (WHZ <-2SD weight for height) (4). Children in rural and commercial farming areas were worse off at the time of the survey. The fact that one out of five children are stunted makes this the most common nutritional disorder. The Health Review 2000 by province for stunting in the Western-Cape is 13.8%, underweight is 12% and wasting 2.8% (4). According to the WHO classification for malnutrition, stunting and underweight are moderate and wasting low. In the Western-Cape stunting is low (<20%) and underweight (10-19%) is moderate (22). See Table 3 for the WHO-classification for malnutrition. Trends in developing countries during 1995 estimates the prevalence of stunting on 31.1% and globally on 34% (22).

Table 3. WHO-Classification for the prevalence of malnutrition according to z-scores for WAZ, HAZ and WHZ.

	WAZ %	HAZ %	WHZ %
LOW	< 10%	< 20%	< 5%
MODERATE	10 – 19%	20 - 29%	5 – 10%
HIGH	20 – 29%	30 –39%	> 10% (severe wasting)
VERY HIGH	> 30%	> 40%	-

There is strong evidence that poor growth is associated with impaired development, poor school performance and intellectual achievement. Child stunting leads to a significant reduction in adult size and one of the main consequences is reduced work capacity that in turn has an impact on economic productivity (22). The Food and Agriculture Organisation (FAO) suggests that by decreasing malnutrition by half in 2015 it would gain $120 billion-worth a year in longer, more productive lives (23). If such assessments are valid, malnutrition is not only a symptom of poverty but a cause too (23). Small maternal size caused by stunting during childhood shows a strong association with low birth weight (LBW). LBW babies born to stunted mothers contribute to the intergenerational vicious cycle by which small mothers predisposes to LBW babies, which predisposes to growth failure leading to small adults (22).

Weight-for-age or underweight reflects body mass relative to chronological age and is influenced by the height of the child and short-term changes in weight. World trends are similar to those of stunting.

Wasting or thinness indicates in most cases a recent and severe process of weight loss and is associated with starvation or severe disease (22).

Low prevalence in populations does not imply the absence of other nutritional problems. According to the SAVACG study in1994 for children aged six months to six years, one out of three children is Vitamin A deficient and one out of five is iron deficient (5). Worldwide it is estimated that half of children and women and a quarter of men are iron deficient.

Although not all anemias are caused by iron deficiency, where prevalence exceeds 30%-40%, iron deficiency is usually implicated. Low consumption of iron-containing foods and the consumption of foods that interfere with iron absorption are the main causes of iron deficiency (22). According to the South African National Food Consumption survey, 41%-63% of children had an iron intake of less than half the recommended intake (4). It is also known that the poor availability of iron in largely cereal-based diets of children in developing countries is one of the major causes of iron deficiency (24). One out of five children in S.A. are anemic even before entering school (5).

Vitamin A deficiency predisposes individuals to severe infection and a higher risk of mortality in children. The regulatory roles of vitamin A in maintaining epithelial cell differentiation and function and immune competence provide biologic plausibility to its importance in decreasing severity and mortality of infectious disease (23).

PARASITES AND MALNUTRITION

UNICEF estimated in 1998 that 25% of the global population are infested by intestinal worms (1). The majority of people affected are the poor. The WHO estimates that 100 000 deaths per annum were caused by *Ascaris* (14). *Ascaris* and *Trichuris* are mostly found in urban slums in developing countries (25). Helminthes and malnutrition usually occur in the same geographical areas and often in the same persons (17). The contribution of parasite infestation to malnutrition depends on many factors, including the intensity of infection, nutritional status and the presence of other illnesses (6).

It has been suggested that there may be two possible routes to nutritional impairment (26). The first is direct via the physiological effects of the parasite itself, which results in a reduction of functional efficiency. The second is indirect via malnutrition, which is known to have influenced cognitive functions (26). Crompton of the WHO mentioned 4 types of complex interactions between helminth infection and host nutrition (27). Firstly, helminthes are ingested through a range of foodstuffs. Secondly, the hosts provide, in some or other form, energy and nutrients to the helminthes either through food sharing or at the expense of their own tissues. Thirdly, host food metabolism may be impaired through the course of infestation. Fourthly, the helminth's lifecycle depends on the quality and quantity of food metabolism by the host. The situation is made even more complex by the fact that the host's resistance to infection is affected by nutritional factors (27).

Hookworm is well known for its growth-stunting potential and contribution to iron-deficiency anemia that is caused by loss of appetite and increased nutrient-loss through bleeding, vomiting and diarrhea. These effects can lead to or aggravate protein-energy malnutrition, anemia and other manifestations of malnutrition (17).

Ascaris-infected children showed a decline in protein utilization, which can be especially important, when protein intake is low and where protein-energy malnutrition already exists (28). Fat absorption decreases and may worsen the effects of already existing protein-energy malnutrition and Vitamin A-deficiency. A study done in Indonesia showed that *Ascaris* infection and low dietary fat intake might affect the utililisation of dietary sources of vitamin A. The combination of added dietary fat and deworming was nearly as effective in raising serum retinol as additional dietary beta-carotene sources, especially in children with high worm egg counts (28). Lactase activity in the small intestine is also reduced and lactose and milk intolerance can develop in children infected by *Ascaris* (17).

Treatment of trichuriasis or whipworm infestation showed increased serum albumin, decreased diarrhea and a reduction in protozoan infections (17). Two studies done in Indonesia showed anthelminthic treatment reduced the intensity of *Ascaris* infection, which was associated with a height increment (25,29). A decrease in *Trichuris* intensity showed an increase in mid-arm circumferences (25). The second study showed that treatment in school-aged children may increase growth, appetite, and activity levels, 6 months after treatment in areas where malnutrition and helminth infections are endemic (25).

PARASITES, MALNUTRITION AND PRODUCTIVITY

Several studies throughout the developing world have provided evidence of an association between stunting, absenteeism from school, school performance and slow school grades progression (the difference between expected and observed grade at a particular age). Estimates from a study in Ghana suggest that the cost of an average delay in schooling of two years could be equivalent to 6% of an individual lifetime wealth (6). One out of four children in S.A. is stunted and one out of five iron-deficient even before entering school (5). The effects of intestinal nematodes on anemia, stunting, cognitive function and school achievement in children have potential longer-term consequences for their productivity in adulthood (6). See Figure 2(a), (b) and 3.

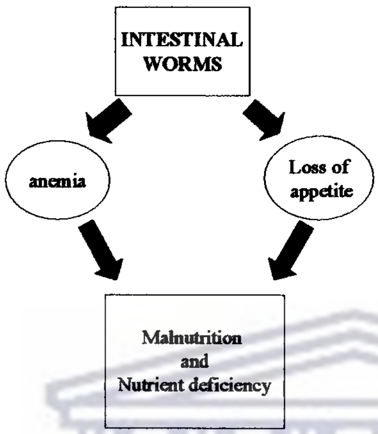

Figure 2(a)

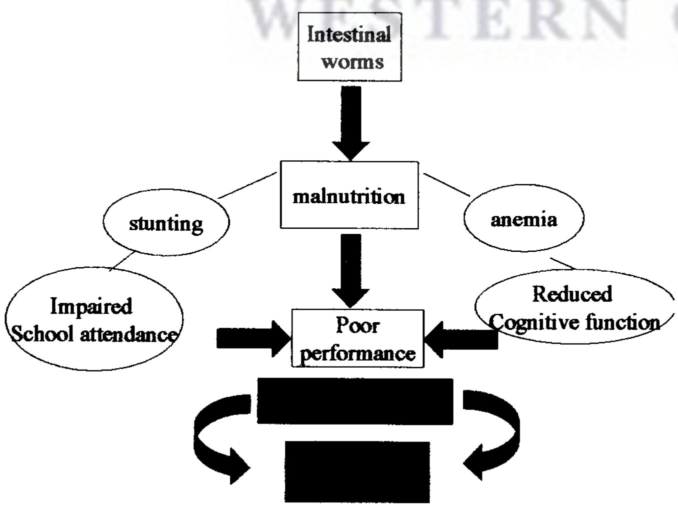

Figure 2 (b)

Figure 2 (a) and (b)

The impact of intestinal nematode infection in humans. (a) In adults and (b) in children (adapted from reference 6)

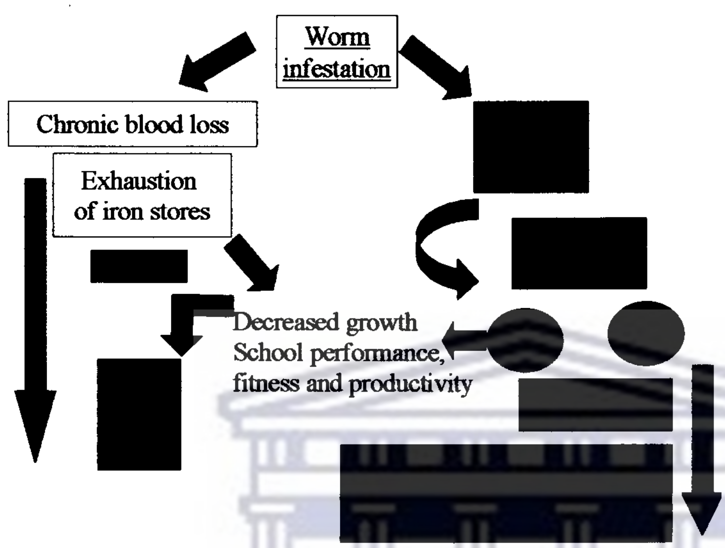

Figure 3

Pathways whereby helminthic and other infections depress growth, physical fitness, physical activity and cognitive ability (17).

The long delay between childhood and motherhood and the confounding effects of disadvantaged socio-economic circumstances complicate demonstrating the effects of early ill health in children on adult productivity. Stunted adults, as a result of chronic malnutrition, have been shown to reduce work output and wage-earning capacity. Parasite infestation has also shown to be associated with stunting, low weight-for- age (underweight), low weight- for- height (wasting), cognitve deficits and poor school achievement tests. Underweight and wasting were specifically associated with ascarisis (30). A number of studies have demonstrated an association between severe helminth infection and cognitive deficit even after controlling for confounders such as socioeconomic status (6). Iron deficiency anemia has an impact on cognitive function, ranging from attention problems to more complex learning problems, and is also related to stunting and general undernutrition. In this way anemia is also related to mental and cognitive development through its effects on physical growth and malnutrition (6). It is suggested that children with growth deficits and stunting, enroll later, make less progress at school and are grades behind. Absenteeism from school has been shown to be associated with whipworm infection and the time absent is related to the level of intensity. In a Jamaican school study children with the least academic ability were not only more likely to be infected with worms but were also those with high intensities of worm infestation. Worm infested children perform poorly and drop out from school prematurely, which will in the end affect their work prospects and their money earning capacity (6).

In a study where no relationship was found between performance and infestation, the result was attributed to social, environmental factors and a lack of high intensities of worm load (30). The best way to demonstrate the causal association between parasites, cognitive function, education and productivity seems to be through intervention. Studies found marked improvement in the performance of children who had received treatment as opposed to those who had received placebos (30). Evidence has also shown remarkable growth rates in children after antihelminth treatment despite the generally deprived environments in which these children continued to live. They also improved so that they were indistinguishable from children who were socio-economically much better off (8). Overstatement of the importance of primary schooling of children in the developing world is almost impossible as those few years of basic education may be their only education (30).

SANITATION, HYGIENE AND ENVIRONMENTAL FACTORS

Heavy faecal contamination of soil together with favourable environmental conditions for survival of worm eggs allows for repeated infestation. Although sanitation were better in the urban area, the prevalence of infestation between a study done in a rural and an urban area suggested extensive eggs contamination in the urban area as a reason for higher prevalence of infestation (10). A study done in an urban community in Brazil, a developing country, reported a new phenomenon called the "urbanisation" of rural intestinal parasites. The main reason for this phenomenon was rapid migration to cities and towns, where there was inadequate housing and sanitation (31). Determinants of *Ascaris* infestation in Africa have shown that if high prevalence persists even with installed sanitation, it shows that toilets are not used or maintained properly (14). Where overcrowding and limited sanitation exist, improved living conditions must be achieved in order to eliminate parasite infestation (9).

INTERVENTIONS AIMED AT ERADICATION OF INTESTINAL PARASITES

Despite the high prevalence of parasite infestation and the known detrimental effects, this issue is low priority in health care (7). Cooper and Bundy (8) suggests three reasons why trichiuriasis is seen as trivial:

1. Clinical effects depend not only on the presence of parasites but also on the intensity,

2. The disease is often under-reported. Stunting and chronic diarrhea, as opposed to acute, is not seen as a health problem that needs attention,

3. The pathogenesis of parasite infestation is complex (8).

Fincham et al (18) realised the importance of long term measures to address infestation, but deworming achieves immediate results. It was concluded that complications of worm infestation are serious, predictable, expensive and preventable (18). A study using data from numerous countries in Africa came to the conclusion that the prevalence of infection in school-aged children could provide a cost-effective predictive tool, which could be used at district or national level to provide information on community prevalence. This information could aid in decisions relating to treatment issues and to evaluate numbers at risk (32). But studies in Indonesia showed improvements in growth, appetite, and physical activity, and supported the WHO recommendations on deworming (25,29). The WHO recommendations are that prevention should target all schoolchildren when prevalence of infestation is 50% or more (33).

CONCLUSION

Andrew Hall from the WHO Collaborating Center for the Epidemiology of Intestinal Parasitic Infections said that the popular concept that the food stolen by intestinal worms is responsible for thin children provides a reasonable explanation for a direct effect on growth even without considering other even more important effects (34). According to Hall there are many reasons why studies often fail to show significant results:

1. The impact of intestinal worms in circumstances where diets and infection history vary will be hard to demonstrate in a cross-sectional study.
2. Intensity is as important as prevalence and is not randomly or evenly distributed (it is not unusual to find 70% of the worms in 20% of the people).

3. A longstanding worm burden is more likely to have an effect than a more recent infestation.
4. Catch-up growths can only resumes after growth failure, an adequate diet after treatment and an impaired nutritional status of the child before treatment, freedom from disease and if the child comes from a deprived setting.
5. Not all drugs are equally effective.
6. Some aspects of study design are often faulty.
7. Children aged from 5-15 years seems to harbor the most and heaviest burdens of worms (34).

In conclusion, from the literature it is clear the three most prevalent soil-transmitted helminthes important to humans are *Ascaris, Trichiaris* and hookworm. Infestation with any one of these may have got nutritional implications for the host with the most serious effect on height-for-age (stunting), which infers to chronic malnutrition. Several macronutrient and micro nutrient deficiencies especially protein, fat, iron and vitamin A may be caused by intestinal parasites. Seriousness of the disease and related symptoms depend strongly on the intensity of the infestation. A lot has been written about the relationships between stunting, iron deficiency, school performance and productivity. The protozoa *Gardia duodenalis* seems to be present in the same geographical areas and sometimes in the same persons as intestinal helminths. This can be a cause of chronic diarrhea especially in children. Both of these are indicator organisms of faecal soil contamination. Other factors such as socio-economic issues, urbanisation, sanitation, immunity, overcrowding, soil type and temperature should not be ignored during research and the eradication of intestinal parasites.

CHAPTER 3

RESEARCH DESIGN AND METHODOLOGY

BACKGROUND

Delft is a disadvantaged area that consists of formal as well as informal settlements. It has a population of more or less 92 000. The level of unemployment in the area is very high and many people supplement their income by allowing tenants to erect informal shelters on their properties for which they pay rent. In most cases there are no services to these shelters. Houses are sub-economic units. Overcrowding is prevalent and it creates serious health problems. The average occupancy in each habitable room is 7.7 people and in certain neighbourhoods it is much higher. There are 15 primary schools in the area. See newspaper article (Addendum A) for more information about services at one of the schools.

AIM OF THE STUDY

The aim of the study was to determine the prevalence and intensity of intestinal parasites and the relationship between infestation and anthropometric measurements in primary school children from Delft, Western Cape.

SPECIFIC OBJECTIVES

1. To determine the prevalence of parasite infestation in primary school children in the Delft area.
2. To determine the intensity of infestation by intestinal worms in the children.
3. To determine the prevalence of malnutrition (stunting, wasting and underweight).

4. To determine the relationship between the prevalence of infestation by worms and malnutrition.
5. To determine the relationship between the intensity of infestation by worms and malnutrition.

STUDY DESIGN

This was a cross-sectional study of the variables measured in children.

SAMPLING

A convenient sample of four primary schools in the Delft area, without using any distinguishing features, was used. The only distinguishing feature was that one school served an informal settlement and formal housing surrounded the other three. According to the WHO guidelines, 200-250 individuals should be adequate for each ecologically homogeneous area in order to evaluate prevalence and intensity of infection by intestinal parasites (33). The intention was, to obtain faecal samples and anthropometric measurements from a randomly selected group of primary school boys and girls. The reason for the choice of primary school children was that prevalence of helminthic infection tends to peak in school-age children, preferably 9-10 years of age (33). The four schools were Vergenoegd (school 1), Eindhoven (school 2), Greenpark (school 3) and Delft South Primary (school 4). Formal housing surrounds schools 1, 2 and 4 and School 3 is situated in an informal settlement.

Children were randomly selected from:

School 1: 25 boys and 25 girls in grade1-3 during August 2000.

School 2: 30 boys and 30 girls in grade 1-4 during September 2000.

School 3: 30 boys and 30 girls in grade 1-4 during October 2000.

School 4: 50 boys and 50 girls in grade 3-4 during March 2002

MEASUREMENTS

The headmaster of each school seconded a teacher with responsibility for the research project. An information letter was sent to all parents and guardians of children who participated in the study, and a signed letter of informed consent was obtained for each child (see addendum B and C following pages 54 and 55). It was also agreed that all participants would be de-wormed at the end of the survey. Each child who was selected attended an information session on how to collect and supply faecal samples in special containers as well as how research could help them. Containers were new and of 40ml capacity with threaded tops. A new wooden spatula was placed inside for manipulating a portion of fresh stool into the container. The request was to half-fill the container. Each child who returned a sample received an unique numerical code and the name, gender, date of birth, date of previous deworming and weight and height of the child were recorded.

STOOL ANALYSIS

Samples were taken to the Medical Research Council laboratories within 24 hours and processing started immediately. Samples were homogenized, weighed, graded for consistency and fixed in formalin. Further microscopy and processing were according to standard methods (35,36). Two hundred and thirty five (235) children supplied faecal samples (Table 7).

GENERAL INFORMATION

A questionnaire (Addendum D, see page 56) with general information: school, grade, age, sex, dewormed status and address, was completed for every participant.

ANTHROPOMETRY

Each child was anthropometrically examined by a trained and experienced field worker using standardised and internationally recognised methodology and included weight and height (37). Weight was taken to the nearest 0,1kg using an electronic scale. The same calibrated scale was used to weigh all the children. Standing height was measured to the nearest 0.1cm using an anthropometer. Children moved between measuring stations to which different information was gathered, as follows:

Station 1: general information using a questionnaire. See Addendum D

Station 2: stool sample collection.

Station 3: weight.

Station 4: height.

Station 5: each child was given a deworming tablet with water.

Station 6: each child received a packet of fruit and sweets.

Problems encountered were that some children who did not return their stool samples or gave samples that contained insufficient faeces. These children were allowed another day to hand in their samples.

All data were checked and missing information was sought from the school. To increase the validity of the research, a duplicate sample of each stool was sent to the Parasitology Research Programme at the University of the Witwatersrand for quality control.

Epi-info and Excel were used to analyse data. Means, Standard deviations and Z-scores were calculated. The height and weight measurements were evaluated using the percentiles of the National Center for Health Statistics (37).

STATISTICAL ANALYSES

The values of three children were excluded to minimise error because height or weight measurement errors were suspected in the basis of reference values. All children older than the age of 13 were also excluded from the study to eliminate confounding due to pubertal growth spurts.

Descriptive statistics were done for each school.

Parasite intensity was classified according to the WHO classification for intensities of parasite-load, measured in amount of eggs per gram. Comparisons were made between:

- the 4 schools for parasite intensities,
- schools and anthropometric status in terms of height-for-age, weight-for-age and weight-for-height as HAZ, WAZ and WHZ, respectively.

Relationships were drawn between;

- anthropometric measurements and worm egg counts (infection intensity).
- *Giardia* and worm egg counts.

The Spearman correlation coefficient was used to determine if there was a relationship between the parasite-load and the nutritional status of the children.

Possible limitations of the data set were the fact that absenteeism was not recorded, which could have been useful to describe any relationship between days absent and worm egg count. Information on socio-economic status could have defined differences between areas served by schools and have related to anthropometry.

ETHICAL APPROVAL

Permission for the study was given by the different headmasters, the Department of Education and the Department of Health.

Informed consent was obtained from all the selected children of the study. All information was treated confidentially.

After completion of the study, feedback in the form of a report was given to all four schools and the different Departments.

The Senate Higher Degrees Committee of the University of the Western Cape approved the study.

CHAPTER 4

RESULTS

PRESENTATION

A description of the data in this sample is presented in Table 4.

Table 4. Descriptive statistics for 235 children at 4 schools: gender, age and prevalence of infection by worms and *Giardia*.

	SCHOOL								
	1		2		3[a]		4		All schools
Variables	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls & Boys
Number tested	28	22	24	31	34	21	41	34	235
Mean age(SD)	7.9(1.0)	8.0(1.0)	9.0(1.0)	9.3(1.3)	8.7(1.7)	9.0(1.0)	9.0(1.0)	9.0(1.0)	8.7(1.7)
Worm positives	3	2	7	16	24	17	27	16	112
Worm prevalence %	10.7[c]	9.1[c]	29.2[b]	51.6[b]	70.6[c]	80.9[c]	65.9[c]	47.1[c]	47.7
Giardia positives [d]	9	7	4	5	9	3	11	11	59
Giardia Prevalence % [d]	32.1%	30.4%	17.4%	17.9%	26.5%	18.8%	22.4%	22.4%	23.6%

[a] This school served an informal settlement where families live in shacks with no toilets.

[b] Prevalence of worm infestation was significantly different between girls and boys in school 2 ($p = 0.0005$, Chi sq. = 10.97).

[c] Prevalence of worm infestation was significantly different between Schools 1 and 3 ($p = 0.0009$, Chi sq. = 12.29); and between Schools 1 and 4 ($p = 0.0005$, Chi sq. = 12.29).

[d] Note that Giardia cysts are passed sporadically in stools, so the number of positives and the prevalence will both be under estimates due to inevitable false negatives.

The p-value of 0.0005 shows a significant difference between the parasite infestation for the boys and girls of school 2.

The mean prevalence for parasite infestation was 47.7%. The highest infestation rates were from school 3 (the informal settlement) where 70.6% girls and 80.9% boys were infested.

Giardia infested a total of 23.6% children. The highest prevalence was the boys and girls in school 1 of 30.4% and 32.1% respectively.

ANTHROPOMETRIC INDICES

The mean height was 127.66cm. School 3 in the informal settlement had the shortest boys (mean123.10cm) and the shortest girls (mean123.41cm). The mean weight of the sample was 26.57kg. The children from School 2 weighed less than the children from schools 1,3 and 4 but were also younger than the rest of the children.

The mean values for anthropometric indices measured are shown in Table 5. According to the National Centre for Health Statistic (NCHS) (37) the children were more than 1SD shorter and almost 1SD lighter than international reference standards.. The children of school 3 in the informal settlement were the shortest for their age and the children of school 2 weighed less than the rest of the children for their age.

Table 5. Anthropometric indices for the total sample.(n=250)

	School 1		School 2		School 3		School 4		Mean
	Boys	**girls**	**Boys**	**girls**	**Boys**	**girls**	**Boys**	**girls**	**(SD)**
HAZ	-0.7	-0.52	-0.81	-0.93	-1.21	-1.06	-0.74	-0.76	-0.81
(SD)	(1.2)	(0.98)	(1.03)	(1.15)	(1.35)	(1.16)	(1.14)	(1.04)	(1.12)
WAZ	-0.69	-0.44	-0.76	-0.57	-0.47	-0.56	-0.6	-0.68	-0.59
(SD)	(1.15)	(1.10)	(0.96)	(1.01)	(1.05)	(0.81)	(0.74)	(1.05)	(0.99)
WHZ	-0.3	-0.1	0.02	0.25	0.66	0.35	-0.3	-0.09	0.03
(SD)	(1.07)	(1.11)	(1.31)	(0.93)	(0.99)	(0.91)	(0.9)	(1.12)	(1.09)

WAZ = weight-for-age Z-score
HAZ = height-for-age Z-score
WHZ = weight-for-height Z-score
SD = standard deviation within the sample for each school.

According to the WHO-Classification for malnutrition the mean prevalence for underweight, wasting and stunting are low. The prevalence for stunting (23%) in school 3 (the informal settlement school) is moderate. See Table (3) (pg.17) for the WHO-Classification for malnutrition.

Table 6 (pg.37) shows the number of children within the discreet WAZ, WHZ and HAZ values for the different schools in comparison to the NCHS reference standards.

Table 6

Discreet WHZ, HAZ and WAZ-values for boys, girls and per school.

WHZ

School		1 F	1 M	2 F	2 M	3 F	3 M	4 F	4 M	ALL
<=-2	freq	1	1	0	1	1		1		2
	%	4%	4%	0%	4%	3%	0%	2%	0%	1
>-2<=-1	freq	2	3		4	1		9	8	27
	%	7%	13%	0%	14%	3%	0%	18%	16%	11%
>-1<=0	freq	12	11	12	9	8	4	19	16	9
	%	43%	48%	52%	32%	22%	24%	39%	33%	4%
>0<=1	freq	11	6	8	9	19	8	13	19	93
	%	39%	26%	35%	32%	53%	47%	27%	39%	37%
>1<=2	freq	1		2	2	6	4	6	5	91
	%	4%	0%	9%	7%	17%	24%	12%	10%	36%
>2	freq	1	2	1	1	1	1	1	1	26
	%	4%	9%	4%	4%	3%	6%	2%	2%	10%
(blank)					2					5
(blank)				0%	7%					2%
Total frequency		28	23	23	28	36	17	49	49	253

HAZ

School		1 F	1 M	2 F	2 M	3 F	3 M	4 F	4 M	ALL
<=-2	freq	2	4	5	3	8	4	7	5	38
	%	7%	17%	22%	11%	22%	24%	14%	10%	15%
>-2<=-1	freq	6	6	5	11	10	6	13	17	74
	%	21%	26%	22%	39%	28%	35%	27%	35%	29%
>-1<=0	freq	11	8	8	8	11	5	17	15	83
	%	39%	35%	35%	29%	31%	29%	35%	31%	33%
>0<=1	freq	8	4	4	4	6	1	9	10	46
	%	29%	17%	17%	14%	17%	6%	18%	20%	18%
>1<=2	freq			1	2	1	1	3	1	9
	%			4%	7%	3%	6%	6%	2%	4%
>2	freq	1	1						1	3
	%	4%	4%					0%	2%	1%
(blank)										
(blank)										
Total frequency		28	23	23	28	36	17	49	49	253

WAZ

School		1 F	1 M	2 F	2 M	3 F	3 M	4 F	4 M	ALL
<=-2	freq	1	1	2			1	4	2	11
	%	4%	4%	9%	0%	0%	6%	8%	4%	4%
>-2<=-1	freq	11	10	6	12	12	4	20	15	90
	%	39%	43%	26%	43%	33%	24%	41%	31%	
>-1<=0	freq	7	8	8	12	13	7	9	21	85
	%	25%	35%	35%	43%	36%	41%	18%	43%	34%
>0<=1	freq	7	1	5	2	10	3	12	9	49
	%	25%	4%	22%	7%	28%	18%	24%	18%	19%
>1<=2	freq	1	2	2	1	1	2	4	1	14
	%	4%	9%	9%	4%	3%	12%	8%	2%	6%
>2	freq	1	1		1				1	4
	%	4%	4%	0%	4%			0%	2%	1%
(blank)										1
(blank)										0%
Total frequency		28	23	23	28	36	17	49	49	250

The prevalence of wasting is low. According to discreet values of the NCHS 10% of the children fall above +2SD for weight-for- height.
15% of the sample was stunted and 75% of all the children fell below the 50th percentile for height-for-age. In school 3, almost one quarter of the children were stunted. (<-2SD)and almost 90% were below the 50th percentile for height-for-age which were the highest for all the schools. School 2 were the second highest with 22% stunted girls.
Almost 50% of all the children fell below –1SD for height-for-age.
4% of the sample was underweight. 75% of all the children fell below the 50th percentile for weight-for-age. In school 4, 6% of the children were underweight (<-2SD) weight-for-age) which was the highest for underweight.

PARASITE SCREENING

Table 7 shows the prevalence of the different intestinal parasites and protozoa. There were 47.7% children infected with intestinal parasites. School 1 had the lowest prevalence. School 3 in the informal settlement had the highest prevalence. 25% of children were infected with protozoa *(Giardia duodenalis)*.

Almost all parasite infestation was of low intensity. The highest egg count was 2828 eggs/g from *Ascaris* and 2199 eggs/g from *Trichiaris.*

Table 7 Prevalence (%) and ratios of infestation of children by worms and *Giardia*.

	School 1 (n = 50)	School 2 (n = 55)	School 3 (n = 55)	School 4 (n = 75)	Total (n = 235)
Helminths All worms (% & ratio)	10(5/50)	42(23/55)	74.5(41/55)	57(43/75)	47.7
Trichuris trichiura (% & ratio)	2 (1/50)	22(12/55)	56(31/55)	53(40/75)	35.7
Ascaris lumbricoides (% &ratio)	6 (3/50)	9 (5/55)	56 (31/55)	55 (41/75)	37.0
Dual *Trichuris/Ascaris* infection (% & ratio)	-	2 (1/55)	36.4(20/55)	48(36/75)	24.3
Taenia sp(% & ratio)	-	2(1/55)[a]	1.8(1/55)[a]	-	0.85
Hymenopelis nana (% & ratio)	-	9 (5/55)	5.5(3/55)	-	3.4
Trichostrongylus sp (% & ratio)	2 (1/50)	-	-	-	0.4
Protozoa *Giardia duodenalis(G.lambia)* (% & ratio)	32(16/50)[b]	16(9/55)[b]	22(12/55)[b]	29(22/75)[b]	25.1
No worm eggs in stool (% & ratio)	90(45/50)	58(32/55)	25.5(14/55)	43(32/75)	52.3

[a]Taenia prevalences are under estimates because most stay in gravid segments and are not detected in a single faecal sample.

[b]Giardia prevalences are under estimates because cysts are shed intermittently. This means that some of the negatives will be false.

There was no significant difference in the anthropometric status of the children with or without intestinal parasites. See Table 8 (pg.40).

Table 8

A description of the anthropometric indices between those children with or without helminthic infections.

		HAZ		WAZ		WHZ	
		F	M	F	M	F	M
ZERO *epg	Frequency	72	54	72	53	72	52
	Mean of HAZ	-0.76	-0.74	-0.55	-0.81	0.07	-0.17
	SD	1.03	1.23	0.97	0.94	0.96	1.1
	Min	-3.45	-2.87	-2.61	-2.7	-2.43	-2.16
	Max	1.68	2.91	2.57	2.29	3.67	4.78
1-200 *epg	Frequency	36	28	36	28	36	28
	Mean of WAZ	-0.93	-0.87	-0.53	-0.052	0.25	0.17
	SD	1.12	1.16	10.4	1.07	1.14	1.08
	Min	-3.1	-3.77	-2.24	-2.5	-20.5	-2.44
	Max	1.34	1.94	1.35	1.81	4.24	2.76
>200 *epg	Frequency	21	20	21	20	21	20
	Mean of WHZ	-0.67	-0.96	-0.59	-0.42	-0.1	0.4
	SD	1.33	0.93	0.87	0.74	1.03	0.94
	Min	-3.77	-3.13	-1.95	-2.08	-2.3	-1.09
	Max	1.86	0.18	1.3	1.08	1.54	3.38

*** Intensity of worm infestation in eggs per gram (epg).**

There were no significant difference between the children with parasites and *Giardia* and those without at the 5% level.

When using the logarithms of the values there were no relationship between the parasite infestation and the anthropometric indices of HAZ, WAZ and WHZ.

DISCUSSION

According to Hall, prevalence is an insensitive indicator of any potential nutritional problems (34). The United Nations Subcommittee on nutrition and the World Health Organization endorsed the recommendation that in areas where there is widespread helminthic infestation and more than 25% mild to moderate underweight, priority should be given to deworming programmes (33).

In this study underweight was mild but stunting moderate, which means more chronic malnutrition than acute malnutrition was present. This study confirmed the presence of under nutrition in a relatively large proportion of Delft primary school children. Almost three quarters of all the children were less than the 50th percentile for height-for-age and for weight-for-age. In schools 2 and 3 stunting (<-2SD height-for-age) were more than 20%.

According to a national survey, 21.6% children between the ages 1 and 9 were stunted which confirmed the prevalence of 22% at school 3 (4). In school 3 almost 90% of the children were below the 50th percentile for height-for-age which is a cause for concern. The prevalence of chronic malnutrition (height-for-age) under the 50th percentile was almost 90% for the sample and should be considered as important. The most immediate determinants of chronic malnutrition are poor diet and infections. Underlying determinants are unemployment, household food insecurity, wrong caring practices, a lack of education, sanitation and hygiene. The basic cause of malnutrition is poverty (22).

Chronic malnutrition leads to a compromised immune system, which makes these children more susceptible to parasite infestation, infectious diseases and HIV (18,22). LBW babies born to stunted mothers contribute to the intergenerational vicious cycle by which small mothers predisposes to LBW babies, which predisposes to growth failure leading to small adults (24). According to Stephenson (17) small adults size can lead to decreased productivity.

The prevalence of stunted growth in school 3 was double that of school 1 where infestation was also much lower. A West Indian study showed height differences between low and higher parasite intensities only after controlling for socio-economic status, gender, age and school (38). It was also found that socio-economic status; and the presence of *Ascaris* infection were significant independent predictors of school attendance (38). There were many factors in the Jamaican study that were associated with poor school achievement, however the association between infection and poor school achievement persisted after controlling for socio-economic status (38). Several studies have shown that intestinal parasite infestation has effects on anemia, stunting, cognitive function and school achievement in children, which have potential long-term consequences for their productivity in adulthood (6,16,17,26,30). In studies where no relationships were found it was related to low intensities (30). Remarkable growth rates were shown in children after antihelminthic treatment despite the generally deprived environments in which these children continued to live. After deworming they were also indistinguishable from children who were socio-economically much better off (8,39). In studies done by Cooper and Nokes et al (8,30) the best way to demonstrate the association between parasites, malnutrition, school performance and productivity are through intervention studies.

The sample sizes within schools were small and in a narrow age range. It is possible that larger samples that include younger children might show more serious growth impairment, as well as relationships to nutrition, intestinal parasites and other infectious diseases.

The prevalence of overweight (Weight-for-Height = > +2SD) was 10% for this study, which is more than the national average (7.5%) for urban areas, which were found in the NFCS (4). This measure of undernutrition and overnutrition prevalent in a community can be related to the hypothesis of Professor David Baker (40) that intra-uterine and early infancy undernutrition leads to greater susceptibility to morbidity and mortality related to lifestyle diseases. From this point of view, a transition in one generation from in utero and early life deprivation in developing countries, to *luxus* consumption in adult years could power the way to the onset of chronic diseases of overnutrition (40). Possible reasons can be that energy expenditure tends to be lower in urban areas than in rural settings and high fat empty calorie foods are also more accessible (40).

According to the WHO it is a public health problem when the prevalence of soil-transmitted helminthes is 50% or more (33). The prevalence of gender-based parasite infestation in this study was between 9,1% and 80,9% with a mean value of 47,7% (Table 4). These figures demonstrate a big difference from a study done by Vermeulen et.al. in the Northern Province, where infestation was of low endemicity prevalence (<20%) (7). This study compares well with figures from 7 surveys conducted in the Western Cape, where prevalence ranged from 12% to 92% (16). Six of these 7 studies were of public health concern with a prevalence of greater than 55% parasite infestation. More recent studies have shown 75% infestation with trichuriasis amongst 6 year olds in a West coast community and 36% Ascaris infestation. In the Khayelitsha study 25% children had more than 10 000 eggs per stool and prevalence of between 80% and 96% infestation. Surveys conducted since 1996 in the Western Cape has shown serious problems in terms of prevalence of trichuriasis (16).

In this survey schools 3 and 4 are of major concern because prevalence of intestinal parasites and chronic malnutrition prevalence were (>55%) the highest. There was a significant difference between parasite infestation of schools 1 and 3 and also between schools 2 and 3. Confounding factors such as socio-economic status, type of soil, sanitation and the type of housing should be taken into consideration when interpreting the data. School 3 is situated in an informal settlement, with no sanitation facilities in the community. Housing is informal and the surrounding environment is sandy with almost no vegetation. Average temperatures are higher in these sandy and no vegetation conditions, which are more favourable for worm egg embryonation (2,13,21,39). In addition, rapid urbanization, the absence and the wrong use and maintenance of sanitation facilities may be important reasons for the high prevalence of parasite infestation and malnutrition in Delft. Most of the population in communities like Delft, migrated recently from rural areas into urban slums, which are densely populated. The process is continuing and housing and services cannot meet the demand. The initial movement was often into areas that were relatively clean because few or no people lived there. This may mean that the conditions are deteriorating with regard to environmental pollution by human excreta, infestation by intestinal parasites and other infectious diseases. The wide range in prevalence of worm infestation between four schools could be a reflection of this trend (Tables 4 and 7). In this situation, there should be regular monitoring of the kind described in this thesis.

All helminth infections were of light intensity. The egg count in the heaviest *Ascaris* infection was 2828 eggs per gram faeces in a child of school 3 and the heaviest *Trichuris* infection was 2199 eggs per gram (epg) faeces from a child in school 2. Both are regarded as light infestation intensities (3). Other studies in the Western Cape have shown low to moderate intensities, ranging between 3 epg to 12536 epg (16). Surveys in Khayelitsha informal settlement have shown higher egg counts (unpublished).

When intensities are as light as were seen in this study it is difficult to demonstrate any detrimental consequences (7). Studies around the world have shown that the worm burden is relatively low when the prevalence is below 60% and may vary greatly when the prevalence is above 60% (34). The fact that no significant difference was found at the 10% level between those with and those without parasites and *Giardia* could be due to the low intensities of the infections (34). In investigating the relationship between under nutrition and helminth infestation no causality can be proven due to the study design.

Giardia gender-related prevalence was between 17.4 and 32.1%. The mean value for *Giardia* infestation is 23%, which is half of those who were infected with intestinal parasites. Evans et al. found that two-thirds of those with parasites were also infested with *Giardia* (11). Surveys done in 7 different disadvantaged communities showed prevalence of between 5-35% with a mean of 18% (11) which correlates well with the findings in this study. Singly or together *Giardia* and helminthes are indicators of faecal contamination. Once again it reflects overcrowding, unhygienic living conditions and urbanization (11).

Often people looking for a better life near the big cities move and live in the backyards of family and friends. These dwellings are unserviced and without running water. Safe water supplies and sanitation facilities become over-extended in these situations where up to 15-20 people stay at one dwelling. Serious faecal contamination of the environment takes place and runoff during rains or standing water eventually leads to contamination of underground water supplies (11). Giardiasis can lead to chronic diarrhea and fat malabsorption and subsequently causes a loss of fat, fat-soluble vitamins and energy (21). All of these have got implications for under nutrition and micronutrient malnutrition. With micronutrient deficiencies being a reality, especially Vitamin A, addressing giardiasis should be of major concern (4,5).

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

According to Hall, 1993 (34), the popular concept that food stolen from children by intestinal worms is responsible for thin children is a reasonable explanation for the complex effects on growth. Although some studies have shown a beneficial impact on growth after treating parasite infestation and some not, there are several reasons why no effects were detected (34). The first reason can be the fact that many infected children live in environments where they are exposed from birth to different species of intestinal parasites and protozoa and other viral and bacterial diseases as a result of overcrowding, contaminated food and water and inadequate sanitation and personal hygiene. Their nutritional status in these cases reflects not only recent episodes of infections, diet and infestation but also the history of previous episodes. If dewormed, re-infection could occur immediately should the child stay in the same environment.

Secondly, the severity of disease depends on the intensity of the infection, which in this study was of low intensity. The intensity to show morbidity is also related to many factors such as the health and nutritional status of the host. It was recommended that stratification of intensity should take place, which was done in this case.

The third point is the duration of infection that is a determinant of growth faltering. Hosts probably tend to be infected for long periods with a slowly fluctuating number of worms. The life spans of common helminths are between 1-4 years but there is currently no simple technique available to measure the duration of infection (34).

In conclusion it is difficult to demonstrate any detrimental consequences on the anthropometry where intensities are low. The prevalence of intestinal parasite infestation in this study in Delft was low and of low intensity. There was a significant difference between the schools. The infestation by intestinal parasites cannot be seen as infrequent as the gender-related prevalence varied between 9.1% and 80.9%. The mean prevalence of stunting, wasting and underweight was low for the whole sample. Over nutrition and under nutrition is prevalent in the same communities. Blanket deworming should be considered for all school entrants before any nutrition intervention is planned.

Effective antihelminthic interventions in developing countries thus appear to be important in our fight against malnutrition.

REFERENCES

1. Grant JP. The state of the World's children. United Nations International Children's Emergency Fund. UNICEF.1982 .
2. Markell EK, Voge M, John DT. Medical parasitology. Philadelphia 1986. W.B. Saunders.
3. Stephenson LS. Impact of helminth infections on human nutrition. Taylor and Francis. London,1987.
4. The National Food Consumption Survey (NFCS) in children aged 1-9 years: South Africa 1999. *Medical Update*. Vitamin Information Centre.2001;37.
5. The South African Vitamin A consultative group. (SAVACG) Labadarios D, Van Middelkoop A(eds). Children aged 6 to 71 months in South Africa, 1994: their anthropometric, Vit A, Iron and immunisation coverage status. *S.Afr.Med.J.* 1996;86:354-357.
6. Guyatt H. Do intestinal nematodes affect productivity in adulthood? *Parasitol. Today*. 2000;16:153-158
7. Vermeulen M, Steyn N, Nel H, ten Brink R, Lombard RH. The prevalence of gastro-intestinal helminthes and the nutritional status of rural preschool children in Northern province. *S.Afr.Med.J.* 1998; 88:1217-1222.
8. Cooper ES, Bundy DAP. Trichuris is not trivial. *Parasitol. Today.* 1988;4:301-306.
9. Millar AJW, Bans DH, Van der Merwe P. Parasitic infestation in Cape Town children. *S.Afr.Med.J.* 1989; 76:197-198.

10. Van Niekerk CH, Weinberg EG, Shore SC, de Heese H. Intestinal parasitic infestation in urban and rural Xhosa children. A comparative study. *S.Afr.Med.J.* 1979;55:756- 757.

11. Evans AC, Fincham JE. Giardia duodenale (G. lambia): A re-emergent pathogen? *Specialist Medicine* 1999;2(3): 81-82.

12. Bundy DAP. The wormy world – Then and Now. *Parasitol.Today.* 1997;13:407-408

13. Despommier DD, Gwadz RW, Hotex PJ. Parasitic Diseases, 3rd ed. New York. 1995 Springer-Verlag.

14. Crompton DWT, Tulley JJ. How much Ascaris is there in Africa? *Parasitol. Today.* 1987;3:123-127.

15. Hirst SI, Stapley LA. Parasitogy: The dawn of a new millennium. *Parasitol. Today.* 2000;16:1-3.

16. Arendse VJ. *Treatment and prevention of trichuriasis: efficacy of albendazole indisadvantaged children at Rawsonville Primary School, Western Cape Province, South Africa.* MscMedSci thesis, 2001, University of Stellenbosch

17. Stephenson LS. Helminthes parasites, a major factor in malnutrition. *World Health Forum.* 1994;15:169-172.

18. Fincham JE, Markus MB, Appleton CC, Evans AC, Arendse VJ, Dhansay MA, Schoeman S. Complications of worm infestation – serious, costly, predictable and preventable. *S.Afr.Med.J.* 1998; 88:952-953.

19. Fincham J, Markus M. HIV/AIDS, helminthes and eosinophilia. Issues in Prevention. *HIV &AIDS Current trends* 1999;5(3):9-11.

20. Roberts LS, Janovy J. Foundations of parasitology. 6th ed, 2000. McGraw Hill international biology series.

21. Semba RD, Bloem MD. Nutrition and health in developing countries. 1st ed. New Jersey. Humana Press. 2001.

22. Mann J, Stewart Truswell A. Essentials of Human nutrition. Oxford University Press. Oxford 1998.

23. Always with us. *Economist*. 6/5/2002 ;363:8277

24. Hudju V, Satriono, Abadi K, Stephenson LS. Relationships between soil-transmitted helminthiases and growth in urban slum schoolchildren in Ujung Pandang, Indonesia. *Int.J.Fd.Sci.Nutr.* 1997;48:85-93.

25. Kvalsvig JD, Cooppan RM, Connally KJ. The effects of parasite infections on cognitive processes in children. *Ann.Trop.Med.Parasitol.* 1991; 85:551-568.

26. Crompton DWT, Tulley JJ. Ascariasis and childhood malnutrition. *Trans.R.Soc.Trop.Med.Hyg.* 1992; 86:557-579.

27. Jalal F, Nesheim MC, Agus Z, Sanjur D, Habicht JP. Serum retinol concentrations are affected by food sources of beta-carotene, fat intake, and antihelmintic drug treatment. *Am.J.Clin.Nutr.* 1998;68.

28. Hudju V, Stephenson LS, Mohammed HO, Bowman DD, Parker RS. Improvements of growth, appetite and physical activity in helminth-infected schoolboys 6 months after single dose of albendazole. *Asia Pac.J.Clin.Nutr.* 1998;7:170-176.

29. Nokes C, Bundy DAP. Does Helminthic infection affect mental processing and educational achievement? *Parasitol.Today.* 1994;10:14-18

30. Ferreira CS, Ferreira MU, Nogueira MR. The prevalence of infection by intestinal parasites in an urban slum in Sao Paulo, Brazil. *J.Trop.Med.Hyg.*1994;97:121-127.

31. Guyatt HL, Brooker S, Donnelly CA. Can prevalence of infection in school-aged children be used as an index for assessing community prevalence? *Parasitol.*1999;118

32. Montressor A, Crompton DWT, Bundy DAP, Hall A, Savioli L. Guidelines for the evaluation of soil-transmitted helminthiasis and schistosomiasis at community level. WHO Document. WHO/CTD/SIP/98.1.Geneva: WHO 1998.

33. Hall H. Intestinal parasitic worms and the growth of children. *Trans.R.Soc.Trop.Med.Hyg.*1993;87:241-242.

34. Ash LR, Orihel TC. Parasites: a guide to laboratory procedures and identification. Chigago 1991. *American Society of Clinical Pathologists*, 1991,p.23.

35. Anonymous. Bench Aids for diagnosis of intestinal parasites. WHO. Geneva. 1994. Lea and Febriger.

36. Measuring change in nutritional status: Guidelines for assessing the nutritional impact of supplementary feeding programmes for vulnerable groups. WHO Document. Geneva:1983.

37. Simeon D, Callender J, Wong M, Grantham-Mcgregor S and Ramdath DD. School performance, nutritional status and trichuriasis in Jamaican schoolchildren. *Acta Paediatr.* 1994;83:1188-1193.

38. Beaver PC, Jung RC, Cupp EW. Clinical parasitology . 9 th ed. Philadelphia. Lea and Febriger,1984. p.313.

39. Solomons NW. Adult Nutrition and Cities - An International perspective. *Afr.J.Clin.Nutr.2000*. Supplement. S1-S48.

ADDENDUM A: Newspaper article

School decides to stage sit-in

By JOHNSON MESI

THE principal of Mkhangeli primary school in Greenpark, an informal settlement near Drift-Sands, says his teachers, parents and community committee have decided to march to the Western Cape education department and stage a sit-in at their offices on September 14 because the department has failed repeatedly to meet their school's requirements.

Principal Vusi Mangindana claims that neither he nor his staff members have received a salary for the past four years.

The school, which teaches from grade 1 to 6, consists of three shelters that have no stationery, furniture, chalk, blackboards, textbooks, library or school desks. It depends on neighbouring schools to lend them textbooks for study purposes.

Mangindana said the school has about 300 learners and five teachers including himself.

"The whole school has only six desks and learners have to stand on their feet for hours while being taught. We have no computers, telephones, electricity and not even a single globe in the classrooms," said a disraught Mangindana.

He said several attempts to contact the department of education had failed, but according to Tony Eaton, media spokesperson for the Western Cape education department, Mkhangeli primary school was denied registration by the education department because on inspection the school did not meet requirements.

These include proper accommodation, adequate equipment, toilets and a good environment.

After the school applied again for registration, departmental officials were sent to inspect, but found the same results as previously.

Eaton said that the officials found about 65 children at the school who could have been "accommodated at nearby existing state schools." For this reason he said the department cannot accommodate Mkhangeli.

"Our aims are that we are going to communicate with parents who have children at the school.

"We want to make sure they understand that whatever passing certificate their children get at Mkhangeli primary school has no official validity," he said with finality.

WHERE TO NOW: Dejected school principal Vusi Mangindana in the empty classroom shell at Mkhangeli primary school in Greenpark, Drift-Sands. The school is embroiled in an ongoing disagreement with the province's education department. Mangindana and his staff claim they have not been paid for 4 years.

Picture: Lulama Zenzile

ADDENDUM B: Information letter for parents or guardians.

University of the Western Cape
Human Ecology & Dietetics
Private Bag X17 **Bellville 7535** South Africa Telegraph: UNIBELL
Telephone: (021) 959-2760 Fax: (021) 959-3686 Telex: 52 6661

DIVISION: Dietetics

Ref: ....

April 2001

Dear Parent/Guardian

DEWORMING PROGRAMME

It is a known fact that worm infection is a problem in the Western Cape. The purpose of this programme is to establish the extent of worm infection among children in Grades 1-4, since these children are at risk. Work infestation can interfere with the child's normal growth and development and should therefore be addressed.

To make this programme possible, the Medical Research Institute and dietitians require a stool sample from your child as well as height and weight measurements. The stool sample must be returned to the school on the following day, upon which the child will receive a deworming tablet. Another stool sample will be taken in September.

Thank you for your willingness to cooperate.

Sincerely.

4th Year Dietetic Students
University of the Western Cape

....
Mrs. E. Nel
Lecturer

A Place of Quality, A Place to Grow

ADDENDUM C: Informed consent form.

INFORMED CONSENT FOR MINORS

1. I, ____ (PRINT NAME IN FULL), am the legal parent or guardian of the minors listed in the table below.

Names of Minors	Date of Birth	Permanent Numeric Code
1.		
2.		
3.		
4.		

2. I have been fully informed of the purpose and nature of the study and the procedures, as explained on the reverse side of this form and I understand what it says.

3. All routine procedures and medical examinations will be carried out by dietitians, medical technologists, medical scientists, doctors, nursing staff and teachers, as appropriate.

4. I understand that I can recall my consent on behalf of the child, or children, mentioned above at any time without prejudicing either myself or him/her with regard to receiving routine medical care.

5. All information will be treated as confidential.

Name of Parent/Guardian ________________________________ Code Number _______

Postal Address ____

Telephone Number ________________________ (H) ________________________ (W)

Signed at ____________________________ this ______ day of ______________ 2000.

Parent/Guardian ______________________________________

Person who informed parent/guardian ______________________

As witness ____

Have your child been dewormed during this year? Yes ☐ No ☐

ADDENDUM D: Questionnaire.

Delft School Parasite Survey

School

Code

Name of child ....

Surname ....

Address ....

....

Date of Birth

Sex

Age

Grade

Weight

Height

Progress

Last dewormed

Stool collected

Date

Dewormed

UWC
Dietetics
959-2237