INTESTINAL HELMINTHIASIS AND MALNUTRITION AMONGST SCHOOL CHILDREN IN HOMA BAY DISTRICT, KENYA

BY

DR. ELIJAH ODOYO JUNE

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DEPARTMENT OF FOOD TECHNOLOGY AND NUTRITION,
UNIVERSITY OF NAIROBI

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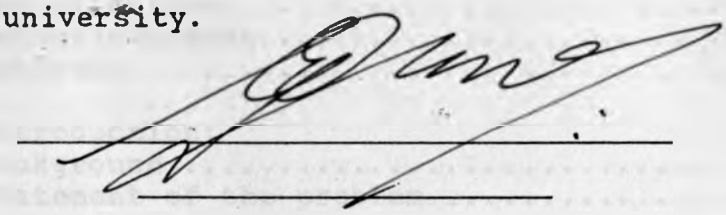
DECLARATION

I, Elijah Odoyo June hereby declare that this thesis is my original work and has not been presented for a degree or diploma in any other university.



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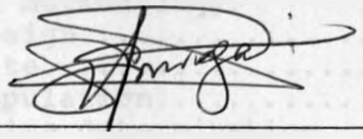
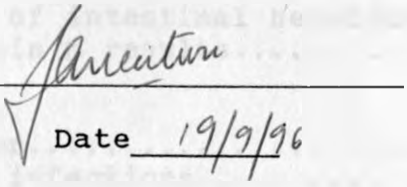


Date 19/9/96

Dr. Abuid M. Omwega, PhD.,

(LECTURER)



Date 19/9/96

Dr. Jane Muita, MMed., MPH., MBchB.

(LECTURER)

Applied Nutrition Programme

Department of food technology and nutrition,

University of Nairobi.

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ABBREVIATIONS

CBS	-Central Bureau of Statistics
DVBD	-Division of Vector Borne Diseases
HPLC	-High performance Liquid Chromatography
IDRC	-International Development Research Centre
NCHS	-National Centre for Health Statistics
OD	-Optical density (absorbance)
PEM	-Protein energy malnutrition
SD	-Standard deviation
SPSS	-Statistical Package for Social Scientists
TFA	-Trifluoroacetic acid
ug	-Microgrammes
UNICEF	-United Nations Children's Emergency Fund
USAID	-United States Agency for International Development
WHO	-World Health Organization

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ABSTRACT

This study examined the relationship between intestinal helminthiasis and nutritional status of primary school-children in Homa bay District in south western Kenya. Stool specimens from a representative sample of 659 children were examined for helminthic parasites and the results collated with anthropometric data. About 44% of the study population tested positive for at least one intestinal helminth, however the infections were generally of light intensities with only four children being classified as heavily infected. Multiple worm infestations were reported in 29.2% of the infected individuals. At a prevalence of 19%, *Ascaris lumbricoides* was the commonest helminthic infection followed by hookworm at 16.1%, *Trichuris trichuria* at 11.2%, *Schistosoma mansoni* at 11.1%, *Taenia ssp.* at 0.9% and finally *Enterobius vermicularis* at 0.8%. No association was demonstrable between intestinal helminthiasis and the anthropometric indices of nutritional status. The overall vitamin A status of the study population was satisfactory, but the mean serum vitamin A level for the ascaris infected children was significantly lower than that for the non-infected controls ($p < 0.01$) and a negative correlation was demonstrated between wormload and serum vitamin A. This shows that ascariasis can impair micronutrient status in the absence of any anthropometrically detectable adverse nutritional effect. It is therefore recommended that ascaris control be an integral part of vitamin A deficiency control programmes in areas where avitaminosis A and ascariasis co-exist.

CHAPTER I

INTRODUCTION

1.0 BACKGROUND

Since the reactivation of the programme for research and control of intestinal protozoa and helminthic infections by WHO in 1980, there has been considerable interest in the nutritional significance of these infections. In general, it has been assumed that intestinal helminthic infections adversely affect nutrition, but scientific inquiries into this subject have yielded conflicting results. Layrisse and Vargas (1975) observed that controversial results, such as ascribing to a parasite a detrimental nutritional effect by a group of investigators and a non-detrimental effect by others are not unusual. Moreover, in some cases malnourishment effects ascribed to a parasite have been denied after more careful studies. Nonetheless intestinal parasitic infections have been associated with anorexia, malabsorption and nutrient losses that can lead to malnutrition. It is also noted that the geographic distribution of the two conditions follow the same pattern and therefore the contribution of intestinal helminths to the aetiology of malnutrition is a strong possibility. Experiments with related parasites in laboratory animals have demonstrated the role of intestinal helminthiasis in animal malnutrition (Crompton, 1986) though these findings have not been replicated in human beings.

The fact that pair-fed uninfected hosts grow better than their infected partners points to the more efficient use of nutrients in the absence of infection (Crompton et al., 1981). Ascaris infection, which has been the subject of many scientific investigations, has been shown to be associated with reduced growth rate in children (Stephenson et al., 1980), disturbed nitrogen balance (Ventakachalam et al., 1953), malabsorption of vitamin A (Mahalanabis et al., 1976), abnormal lactose digestion (Carrera et al., 1984) and increased intestinal transit time (Taren et al., 1986). Hookworm is known to cause or predispose to iron deficiency anaemia because of its mode of feeding that leads to chronic gastrointestinal blood loss (WHO Expert Committee Report, 1986; Latham, 1990; Crompton, 1986).

Intestinal helminthiasis is a major public health problem in many parts of the world, especially tropical and subtropical areas where control programmes have not been accorded sufficiently high priority to claim financial support from the scarce resources (Crompton, 1984). The infections are particularly common in poor communities which also tend to have high proportions of children, (i.e, the most vulnerable group) constituting the majority in the demographic profile. Poor sanitary facilities coupled with high propensity of children to transmit the infections encourage high prevalence.

Since many children from these communities are already marginally nourished, helminthic infestations are likely to cause a large number of fatalities and disabilities amongst them. The contribution of intestinal helminthiasis towards the high morbidity and mortality currently attributed to malnutrition needs to be quantified. But this cannot be possible unless the exact nature of the relationship between these two conditions is fully understood.

The clinical manifestations of these infections are usually mild, but can occasionally be gross as is seen in mechanical intestinal obstruction due to ascaris, congestive cardiac failure due to hookworm induced anaemia or rectal prolapse associated with heavy trichuris infestation. The public health importance of these infections however rests on the fact that they take an insidious course and tend to be constantly present, affect children and their prevalence is deeply rooted in poor sanitation, ignorance and poverty which are difficult to change (Zbigniew et al,1984).

Intestinal parasitic infections can interfere with economic and social wellbeing of a country through direct and indirect mechanisms. Direct mechanisms involve production of specific pathological lesions which lead to disease and is reflected as high morbidity and mortality in national statistics.

Indirect mechanisms include economic and social consequences of compromised mental and physical development of children, reduced work capacity among adults and high cost of medical care due to conditions attributable to these infections (WHO, 1981). The multifactorial aetiology of malnutrition, coupled with its widespread economic consequences calls for a multidisciplinary approach trying to reduce its prevalence.

As in many other tropical and subtropical countries, intestinal helminthiasis and moderate forms of protein energy malnutrition are widespread in Kenya. Despite promises, hopes and national health plans to achieve health for all by the year 2000, six years from today, the prevalence of intestinal helminthiasis in Kenya has essentially remained the same and in absolute terms the affected population continues to swell. After a detailed literature review Chunge et al., (1985) concluded that there had been no significant changes in prevalence of intestinal worms in Kenya between 1900 and 1983. The situation is not any better today.

The overall prevalence of intestinal helminthiasis in Kenya is estimated to be 25% (Director of Medical Services, 1991). Pockets of very high endemicity are to be found in the Coast and Nyanza provinces which also form pockets of highest malnutrition rates in the country.

Countrywide, malaria and intestinal helminths, especially ascaris, hookworm, whipworm, pinworm and schistosomes constitute some of the most important parasitic diseases due to their widespread distribution and high prevalence. As opposed to malaria, these worms have received disproportionately little attention. This is partly because intestinal helminthiasis, like chronic malnutrition, is an undramatic process and may not be readily apparent unless specifically searched for.

1.1 STATEMENT OF THE PROBLEM

Review of survey reports and scientific publications shows that most studies so far done on the subject of parasitic infection and malnutrition have been conducted amongst preschool children, arbitrarily defined as those less than 60 months. Figures available on the prevalence of malnutrition in Kenya are also largely for this group. The justification for this has been that children at this age are the most vulnerable to the consequences of these afflictions. So while many excellent papers exist on this subject for preschool children, few have addressed this problem amongst older children. The truth could well be that older children suffer the consequences of these conditions just as do the preschool children, the only difference being that in older children the manifestation may not be growth failure and therefore preclude anthropometric detection.

The problem of parasitic infections and malnutrition amongst older children should therefore attract more scientific inquiry and other methods of nutritional assessment need to be considered along with anthropometry.

The need for accurate assessment of the nutritional situation of the older children is further strengthened by the fact that it would form a basis for evaluating the impact of intervention measures instituted to correct nutritional problems of preschool children. The current gaps are addressed, albeit only in part, by this study which is cross sectional in nature and therefore lacks the temporal component necessary in determining causal relationships.

In this survey, the prevalence of intestinal helminthiasis and malnutrition as well as their interrelationship were examined amongst school children. The relationship between Ascaris infection and serum vitamin A was also investigated. The main concern was to determine whether intestinal helminthiasis adversely affects nutritional status. This would in turn help in predicting whether the control of helminthiasis can improve nutritional status in addition to its direct effects on mortality and morbidity. A further question addressed in this study was whether the control of ascariasis has the potential of reducing xerophthalmia in places where both conditions are prevalent.

1.2 OBJECTIVES

The objective of this study therefore, was to determine the prevalence of intestinal helminthiasis, malnutrition and their interrelationship amongst primary school children in Homa bay District of Kenya.

The sub-objectives of the study were as follows:

1.2.1 To determine the prevalence of intestinal helminthiasis amongst primary school-children in Homa bay District.

1.2.2 To determine the prevalence of malnutrition amongst primary school children aged 6-10 years in Homa bay.

1.2.3 To determine the relationship between ascaris infection and serum vitamin A.

1.3 HYPOTHESIS

The underlying hypothesis in the study was that intestinal helminthiasis contributes significantly towards the aetiology of malnutrition in children.

1.4 EXPECTED BENEFITS

This study was designed to provide information to be used by the Ministry of Health and the medical fraternity in general, in making decisions that will help improve the health of children through formulation of more effective intervention strategies for the control of intestinal worms and its related problems. It is also expected to provide international lobby groups with objective scientific facts necessary for effective advocacy for a policy of regularly deworming children in vulnerable areas. A regular mass deworming programme would be expected to interrupt transmission cycle frequently thereby reducing the prevalence of helminth induced morbidity.

CHAPTER II

LITERATURE REVIEW

2.0 MALNUTRITION

Nutrition is the process by which the organism uses food, or anything normally ingested through digestion, absorption, transport, storage, metabolism and elimination for purposes of maintenance of life, growth, normal functioning of organs and the production of energy (McLaren, 1976). The state resulting from the balance between the supply of nutrients and the expenditure of the organism constitutes nutriture. Nutriture is therefore the physiological state which results from the cellular availability of nutrients whereas nutritional status is the expression of nutriture in a specific variable (Habicht et al.,1979).

Any disruption of the normal balance in the processes which constitute nutrition is likely to cause an imbalance between dietary intake and the body requirement for nutrients, which results into malnutrition. Malnutrition includes over nutrition (obesity), resulting from availability of excessive amounts of nutrients at cellular level, and undernutrition resulting from deficiency of nutrients. Undernutrition is the most common form of malnutrition in developing countries and in this thesis, the term malnutrition is used to describe nutritional inadequacy.

The four most common forms of malnutrition in the developing world today are Protein - Energy Malnutrition (PEM), iron deficiency anaemia, vitamin A deficiency and iodine deficiency (Crompton et al., 1984; Stephenson, 1987). Protein-energy malnutrition (PEM) is perhaps the most important public health problem in the third world today. It results from coincident lack of proteins and calories in varying proportions. It is most frequently noticed in growing children in association with infections. No age is immune, but the condition is less frequent and its manifestations much less obvious in older persons (Passmore, 1986). Single nutrient deficiencies are also common at all ages and produce deficiency diseases like anaemia (resulting from lack of iron), xerophthalmia (resulting from vitamin A deficiency) and goitre (a result of iodine deficiency) which are of regional public health importance (Stephenson, 1987).

Any nutritional deficiency results from a lack of nutrients at appropriate sites in the body. This shortage of nutrients can result when people eat too little food or food of inappropriate composition or when food intake, digestion and utilization are impaired during disease (Crompton and Nesheim, 1984). The cultural and socio-economic factors, especially poverty, which lead to low food production and consumption also predispose to intestinal parasitic diseases, hence the concomitant high prevalence of malnutrition and helminthiasis in poor communities.

Parasite activities deplete host resources and cause physical and metabolic damage (Crompton and Nesheim, 1984). Helminths may affect host nutritional status by causing a decrease in nutrient intake, an increase in nutrient loss or a decrease in nutrient utilization within the body (Stephenson et al., 1986). These changes in nutrient intake, excretion or utilization will only cause malnutrition if the hosts cannot replace the abnormal losses either through their dietary intake or from pre-existing body stores of the nutrients being lost. Thus, the most important nutrients to consider in relation to parasitism are those known to be limiting in human diets, and those which are known to prevent deficiency diseases that are already known to be most common on epidemiological, clinical, and biochemical bases. On global basis these are energy, protein and iron, which are public health problems in nearly all developing countries. Vitamin A deficiency and other micronutrient deficiencies are also important but are much more localized in geographical distribution (Stephenson, 1987). In this study, attention is focused on PEM and vitamin A status, the major concern being the contribution of intestinal helminthiasis towards the multifactorial aetiology of these nutritional problems. Intestinal helminthiasis is of particular interest because in some areas, it afflicts large numbers of symptom-free people who may all suffer insidiosly in case this relationship is adverse.

The adverse sequelae of malnutrition that justify its detailed understanding and subsequent control are multiple. "Malnutrition decreases an individual's ability to function in society. Protein-energy malnutrition in children (and its counterpart in adults, underweight or low weight for height) and iron deficiency anaemia are associated with mortality and various forms of morbidity including increased susceptibility to infections (Latham, 1975; INACG, 1977), decreased work capacity in adults (Latham, 1987; Basta et al., 1979; Brooks et al., 1979), poor school performance and reduced intellectual, psychological, and social development in children (Hutchison, 1952; Latham, 1974; Barret and Radke-Yarrow, 1985) and decreased reproductive ability in women (Calloway, 1982). Severe vitamin A deficiency not only causes high mortality rates in children but also decreases resistance to infection and leaves many survivors with a diminished capacity to perform in society because they are either blind or partially blind (WHO, 1982). A recent study suggests that even mild to moderate vitamin A deficiency increases morbidity and mortality, especially of gastrointestinal and respiratory infections (Sommer et al., 1984, 1986). The negative sequelae of malnutrition are best known for severe forms, but the functional consequences of mild or even moderate protein-energy malnutrition are still unclear (Latham, 1984).

In two major studies of case fatality rates in malnourished children, one study in Bangladesh found that the mortality rate in pre-school children was increased only in severe protein-energy malnutrition (Chen et al., 1980), whilst a study in India found that children with moderate protein-energy malnutrition also had a higher mortality rate and that there was an inverse linear relationship between fatality rates and anthropometric nutritional indices used to measure protein-energy malnutrition (Kielman and McCord, 1978).

The outcome of the balance between all the processes that constitute nutrition can be assessed anthropometrically, biochemically, clinically and by many other specialized techniques in a process usually referred to as nutritional assessment. In this study, two methods of nutritional assessment, namely anthropometry and biochemical determination of serum vitamin A, are used. Nutritional status as determined by anthropometry is an attribute of the human body which describes the position of an individual in relation to a reference population (in this case the American NCHS standards). The anthropometric indicators used here are weight and height, which take into account the distinction between acute and chronic malnutrition (WHO, 1977). Significant deficit in weight for height (wasting) is indicative of recent or present malnutrition whereas a similar deficit in height for age is reflective of chronic or past malnutrition.

The value of height for age deficit as an index of nutritional status is compromised in this study for two reasons. First, the study population consists of older children (6-10 years) in whom growth velocity is considerably low. Secondly, the index is derived from reported age which is error prone. Greater reliance is therefore put on weight for height. Anthropometric methods may however fail to detect nutritional problems that do not manifest as growth failure.

2.1 INTESTINAL HELMINTHIASIS.

Helminth is a general term for worms of the phyla *platyhelminth*, *nematoda* and *acanthocephala*, especially parasites. Helminths whose life cycle include a period of obligatory stay in the human gastrointestinal tract are collectively referred to as intestinal helminths (Crompton, 1984). During the period of their residence in the alimentary tract, the human host provides them with nourishment, shelter and conditions necessary for growth, a relationship known as parasitism. The state of harbouring one or more of these parasites is termed intestinal helminthiasis, whether it be associated with symptoms or not.

Intestinal helminths are capable of inducing functional and structural changes in the alimentary tract which can be of nutritional importance. Currently there are a variety of effective chemotherapeutic agents for treatment of intestinal helminthiasis.

"Successful treatment often results into expulsion of worms, which when large, can be seen either by the patient or by the parents of infected children, who will then be convinced of (a) his or her cure, (b) the usefulness of modern drugs and, (c) the undesirability of acquiring the infection again. Despite this scenario, and the fact that excellent curative drugs are available, intestinal infections still remain extremely common." (Davis, 1984).

Global estimates indicate that soil-transmitted helminths and schistosomiasis are among the commonest infections in the world (Stephenson, 1987). *Ascaris lumbricoides*, hookworm and *Trichuris trichuria* are the three most prevalent geohelminth infections in the world, each being estimated to infect 1/6 to 1/4 of the world's population (Stephenson et al., 1993). The exact prevalence of individual helminthic infection in Kenya are uncertain , but an overall prevalence of 25% has been reported (Director of Medical Services, 1990). Ascariasis is the most common intestinal parasitic infection worldwide, being present in about 25% of the human population (Pawloski, 1984). It is cosmopolitan in distribution, occurring in temperate as well as tropical and subtropical environments (Stephenson, 1987). "About 73% of *Ascaris lumbricoides* infections have been estimated to be present in Asia, while about 12% are thought to occur in Africa and 8% are present in Latin America (Peters, 1978)" (Stephenson, 1987).

Ascaris lumbricoides has been estimated to infect 25% of Kenyans (Stephenson, 1987). *Trichuris trichuria* also enjoys a cosmopolitan distribution, although it is most common in the warm moist tropical and subtropical countries, where prevalences can be as high as 90% (Holland, 1987). The two main forms of human hookworm, *Necator americanus* and *Ancylostoma duodenale*, infect approximately 800 million people worldwide (Latham, M.C.,1990). Their exact prevalences in Kenya are not known. The intestinal schistosome of public health importance in Kenya is *Schistosoma mansoni*. It is widely distributed but the areas most affected in terms of prevalence and intensity are Eastern Province, particularly Machakos, and the entire lake Victoria basin in the western region (Masaba, 1983).

2.2 MALNUTRITION AND INTESTINAL HELMINTHIASIS.

Malnutrition and intestinal helminthiasis have a strikingly similar geographic distribution with the same people experiencing both insults for much of their lives (Crompton,1986). The background against which these two conditions exist is usually that of poverty, poor environmental sanitation and illiteracy. In the context of potential nutritional impact, infections can arbitrarily be divided into two broad groups. The first group includes acute infections (e.g., measles) which tend to precipitate acute malnutrition and easily cause death if superimposed on malnutrition.

The other group consists of those subtle infections which tend to predispose to malnutrition or potentiate its consequences if already present. Intestinal helminths fall in this second group and are generally neglected because they take a relatively less dramatic course. Attention is focused on them here because they afflict large numbers of symptom free individuals.

Intestinal helminthic infections may be associated with reduced food intake, malabsorption, endogenous nutrient loss, anaemia and growth faltering (Tomkins & Watson, 1989). Many laboratory investigations have unequivocally established that host nutrition is in all its forms adversely affected by intestinal helminthiasis (Nasheim, 1984, 1985; Crompton, 1986). Reduction in food intake occurs (Sykes & Coop, 1977; Sykes, 1982; Symons, 1985; Crompton, 1984, 1986), absorption is impaired (Symons, 1976; Castro, 19781; Crompton, 1986) and there is inefficient use of nutrients (Crompton et al.,1981; Crompton, 1986).

A decrease in nutrient intake can occur in a variety of ways including through anorexia that either accompanies or results from a number of symptoms that are commonly reported in infections like abdominal and epigastric pain, fever, nausea, diarrhoea, vomiting and headache (Stephenson, 1980; Crompton, 1984).

Reduced food intake and reduced weight gain has been demonstrated in rats, mice, pigs, sheep and domestic fowl (Crompton, 1984). The extent to which helminthiasis interferes with human food intake is still not known even though decreased food intake has been a common finding in parasitic infections when it has been sought (Rosenberg & Bowman, 1984; Stephenson, 1987). The role of intestinal helminthiasis in reducing food intake in human hosts is supported by numerous clinical reports which have recorded or implied improvement in appetite following deworming (Crompton & Nasheim, 1984). In areas where the human hosts are already marginally nourished, this parasite induced reduction in food intake can worsen or precipitate malnutrition. This may be of public health importance in areas with high prevalence of these infections.

Most intestinal infections have been found to be associated with shortening and flattening of intestinal villi, which reduces the amount and integrity of surface membrane available for digestion and absorption (Crompton and Nasheim, 1984). Such alterations are associated with increased faecal nitrogen losses (Ventakachalam & Patwardhan, 1953), increased faecal fat loss (Crompton, 1984), reduced vitamin A absorption (Sivakumar & Reddy, 1975; Mahalanabis et al., 1976, 1979), and even impaired lactose digestion (Carrera et al., 1984; Taren et al., 1986).

Their adverse nutritional consequences aside, intestinal helminthic infections are responsible for a wide range of physiological and functional disturbances. Although mortality from these infections is relatively rare, complications are not uncommon and many cases need hospital care (WHO, 1987). In heavy infections digestive disturbances, abdominal pain, diarrhoea, restlessness and insomnia can occur (Latham, 1990). For example, serious surgical complications are known to occur in ascariasis. Mechanical intestinal obstruction occurs if a bolus of worms blocks the intestinal lumen while obstructive jaundice can follow ectopic migration of ascaris into the common bile duct. Acute appendicitis, perforation and peritonitis can occur if a worm lodges in the appendix (Latham, 1990). These surgical complications of ascariasis are associated with high mortality and high cost of medical care. Hookworm infection, on the other hand, causes chronic blood loss and depletion of the body's iron stores (WHO, 1987). The resulting iron deficiency anaemia, if severe, can lead to lassitude, poor growth, physical weakness, headache ,palpitations and even overt cardiac failure. *Trichuris trichuria* partially burrows in the wall of the large intestine and feeds on intestinal tissues causing irritation and chronic blood loss, which can lead to diarrhoea, iron deficiency anaemia, hypoalbuminaemia and rectal prolapse in extreme cases (WHO, 1981; Holland, 1987). *Enterobius vermicularis* causes anal pruritus accompanied by scratching which can lead to eczematous dermatitis, bleeding and secondary bacterial infection.

In some children, restlessness and insomnia are associated with enterobiasis, and these may interfere with performance at school and learning ability (WHO, 1987). Intestinal schistosomiasis causes blood loss in stool which can lead to anaemia (Stephenson, 1987).

Thus, deleterious effects of intestinal helminthiasis on the welfare of an individual or a community depends on the parasite species, the intensity and duration of infection, the nature of the interactions of the parasite species with other concurrent conditions and socioeconomic factors (WHO, 1987). The contribution of each of these components vary in magnitude from place to place. This variation coupled with the fact that these components constitute confounders whose complete elimination is difficult, may be the reason why studies on the interaction of helminthiasis and malnutrition continue to yield conflicting results.

Ascaris-infected Indian children have been found to be significantly lighter and thinner than their non-infected equals (Gupta, 1990). In 1983, a statistically significant negative correlation was reported between nutritional status and heavy *Trichuris* infection amongst children by Gilman and co-workers (Gilman et al., 1983).

In the same study, the rate of concomitant bacterial and protozoal infection was also found to be significantly higher amongst children having heavy trichuris infection. A significant negative correlation between subcutaneous fat and *Ascaris* infection has also been reported amongst Kenyan preschool children (Latham and Latham, 1977). Stephenson and others recently reported significant improvement in growth following deworming of Kenyan school children with hookworm, Trichuris trichuria and Ascaris lumbricoides (Stephenson et al., 1990).

A number of authors have however reported findings which suggest no unfavourable nutritional effect of intestinal helminthiasis. Michaelsen found no association between hookworm infection and nutritional status amongst school children in Botswana (Michaelsen, 1985). Barnish and Baker found no relationship between nutritional status and strongyloidiasis amongst children in Papua New Guinea (Barnish and Baker, 1987). Kandiah and co-workers found no relationship between intestinal helminthiasis and various anthropometric and biochemical indices of nutritional status (Kandiah et al., 1984).

These conflicting findings could very well be reflecting the real picture as the pathogenicity of the intestinal helminths may vary in different places. The consequences are also a function of a multiplicity of variables which vary from place to place.

It is also generally accepted that light infections are of little nutritional consequence and one should not expect to find measurable nutritional effect of parasitic infections in situations where the wormloads are low, however high the prevalence may be. The detection of this relationship is also dependent on the prevalence of the nutritional disorder of interest.

2.3 VITAMIN A AND INTESTINAL HELMINTHIASIS

Retinol is a fat soluble vitamin essential for growth, normal functioning of the retina and development of epithelial surfaces. It is chiefly found in milk, butter, cheese, egg yolk, liver and some fatty fish. The liver oils of fish are the richest natural sources of vitamin A. Beta carotene, a precursor of vitamin A found in association with chlorophyll in dark green vegetables forms the main source of vitamin A in areas where animal foods are seldom eaten (Davidson and Passmore, 1986).

Vitamin A deficiency relates to any state in which the vitamin A status is subnormal. The assessment of vitamin A nutritive status can be done clinically through observation for a number of ocular and extra-ocular signs which have some correlation with the serum vitamin A levels. These features include various degrees of corneal xerosis, night blindness, xerophthalmia and follicular keratosis. This assessment can also be done biochemically by measurement of serum retinol.

The most commonly used methods for serum retinol determination are spectrophotometry, fluorometry, and high performance liquid chromatography (HPLC) (Turley and Brewster, 1990). Plasma retinol values in excess of 20ug/dl (0.7umol/l) are not associated with the deficiency state, but the further down the value is below 20ug/dl the more severe the deficiency. Plasma levels in excess of 50ug/dl (1.75umol/l) have frequently been reported in healthy adults. There is no clear evidence as to what plasma values are indicative of hypervitaminosis A, but they are probably in excess of 100ug/dl (3.5umol/l) (WHO, 1982). Determination of vitamin A concentration in autopsy liver samples, though yielding considerable variation in results from different sites, has received attention recently as a method of assessing the vitamin A status of a population (WHO, 1982).

Numerous studies have suggested that intestinal helminthic infections impair the absorption of vitamin A (Mahalanabis et al., 1976; Sivakumar and Reddy, 1975; Sheehy et al., 1962). Although inadequate intake is of primary importance in the development of vitamin A deficiency, malabsorption is probably a major contributory factor (WHO, 1982). Studies in Panama have reported significantly lower plasma vitamin A concentration in Ascaris-infected compared with uninfected children (30+-1.0 versus 34.0+-0.9 ug/dl, $p < 0.01$) (Taren et al, 1986; Taren et al.,1987a)" (Stephenson, 1987).

It has been shown that *Ascaris* infected individuals exhibit vitamin A malabsorption which improves after deworming (Crompton et al.,1984; Mahalanabis et al.,1976). Since vitamin A is known to influence the integrity of the body's immune system, by impairing its absorption, ascaris infection increases susceptibility to infection indirectly.

It has been shown that vitamin A deficiency is associated with high child mortality and correction of the deficiency results into a reduction in mortality (Sommer et al., 1983). In this study the relationship between ascaris infection and serum vitamin A is examined by comparing the serum vitamin A level of ascaris infected children with those of non-infected controls.

The practical implications of the association between ascariasis and serum vitamin A, if ascertained, would be that one should expect programmes designed for controlling *ascaris* infection to influence the prevalence of xerophthalmia in areas where both conditions are endemic.

CHAPTER III

RESEARCH METHODOLOGY

3.0 STUDY DESIGN:

A cross sectional survey of descriptive nature with an analytical component was undertaken amongst primary school-children in Asego Division of Homa bay District in the month of November, 1992. The prevalence of intestinal helminthiasis, malnutrition and serum vitamin A levels were determined.

3.1 STUDY SITE:

The study was conducted in Asego Division of Homa bay District in south western Kenya on the south eastern shores of lake victoria. The District borders Siaya and Kisumu Districts to the north, Nyamira and Kisii Districts to the east, Migori to the south and the republic of Uganda to the west. Administratively it is divided into five Divisions of which Asego is the most centrally located. The five Divisions are further subdivided into 34 locations two of which are within Asego. There are five constituencies which represent the political subunits and whose boundaries correspond to the divisional borders.

The climate is basically equatorial, modified by the effects of altitude, relief and the lake. The temperature in the lower parts range from a mean minimum of 17° to a mean maximum of 30°.

In the higher eastern parts, the mean minimum and maximum temperatures range 14° and 23°. Rainfall occurs almost throughout the year with a maximum during April and May.

The features of the area relevant to high prevalence of helminthiasis are climatic conditions favourable for transmission of geohelminths, poor environmental sanitation, low public health awareness and inadequate health facilities. The inhabitants of the two division are Luos, most of whom are small scale farmers deriving their income from the sale of food crops and scarce livestock products. The area is fairly homogenous with respect to socioeconomic status of its inhabitants, which is generally low.

In 1987, South Nyanza District, whose eastern divisions now constitute Homa bay District was reported as having an infant mortality rate of 216/1000 which was the highest for Kenya with a national rate of 87/1000 (GOK, Ministry of Planning and National Development, 1987). Prevalence of severe malnutrition was reported as 15% whereas mild malnutrition rate was 35% amongst pre-school children in 1987 (GOK,1989). Immunization coverage was a mere 35% and helminthiasis was the 3rd commonest disease condition, after malaria and respiratory infections in the same year (GOK, 1989).

3.2 STUDY POPULATION

Study population consisted of primary school children in Asego Division of Homa bay District aged 6-10 years. The entire Division has a total of 17,500 primary school pupils registered in 62 schools. A representative sample of 659 pupils selected from 8 primary schools participated in the study.

3.3 SAMPLE SIZE DETERMINATION

For the purpose of sample size determination, the prevalence of intestinal helminthiasis was taken as 25% (GOK, Director of Medical services, 1990)

$$N = \frac{z^2 p.q}{d^2}$$

Where N = desired sample size.

z = standard normal deviate corresponding to 95% confidence interval.

p = proportion of children with helminthiasis in the population (0.25).

q = (1-p) (proportion of children in the population without helminthiasis) 0.75.

d = degree of accuracy desired. (0.05).

$$\text{So} \quad N = \frac{1.96^2 \times 0.25 \times 0.75}{0.05 \times 0.05}$$

$$= 288 + 10\% \text{ attrition rate.}$$

$$= 317.$$

The attrition represents a safety precaution against the possibility of ending up with an inadequate sample size in case some members of the study population have to be excluded from the final statistical analysis.

3.4 SAMPLING PROCEDURE:

Multistage sampling was used. The unfavourable financial implications of strict probability sampling at all stages necessitated the employment of non-probability sampling in the initial stages. Asego division in South Nyanza District was selected purposively for this study. Schools in this division have good communication links to the Division of Vector Borne Diseases Laboratory (DVBD), where examination of specimens was to be done. The selection of these schools was further dictated by time constraints as each stool specimen had to be fixed and prepared for microscopic examination within three hours of collection. Rural schools in Asego lying within ten kilometres of the Homa bay municipal boundary were identified. Eight of these were selected by simple random method. All pupils below class four from these schools.were comprehensively selected for helminthic screening and assessment of nutritional status. All the pupils in class 1-3 were screened because the population of interest (i.e those aged 10 years and below) are virtually all within this bracket. Stratification by the outcome of stool examination, nutritional status, age and sex was done before selection of matched subsamples for serum vitamin A screening. The details of the sampling used are presented diagrammatically in figure 1.

SAMPLING FLOW CHART:

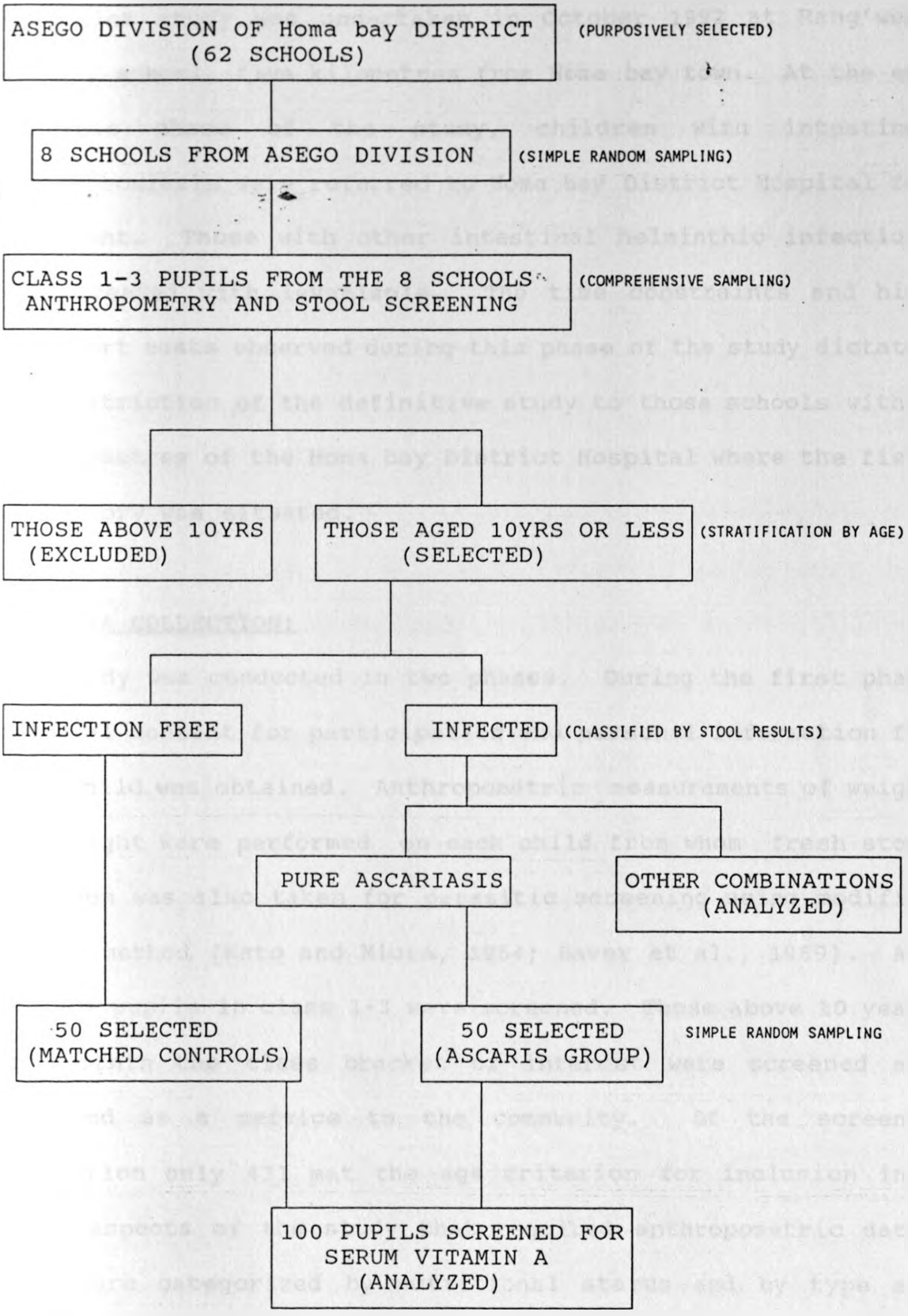

Figure 1.1 **Sampling flow chart**

3.5 PILOT STUDY:

The pilot study was undertaken in October 1992 at Rang'wena primary school, five kilometres from Homa bay town. At the end of this phase of the study, children with intestinal schistosomiasis were referred to Homa bay District Hospital for treatment. Those with other intestinal helminthic infections were treated with levamisole. The time constraints and high transport costs observed during this phase of the study dictated the restriction of the definitive study to those schools within 10 kilometres of the Homa bay District Hospital where the field laboratory was situated.

3.6 DATA COLLECTION:

The study was conducted in two phases. During the first phase parental consent for participation and personal information for each child was obtained. Anthropometric measurements of weight and height were performed on each child from whom fresh stool specimen was also taken for parasitic screening using modified Kato's method (Kato and Miura, 1954; Baver et al., 1969). All the 659 pupils in class 1-3 were screened. Those above 10 years but within the class bracket of interest were screened and dewormed as a service to the community. Of the screened population only 431 met the age criterion for inclusion into those aspects of the study that required anthropometric data. They were categorized by nutritional status and by type and intensity of helminthic infection.

During the second phase, 50 children who met the age criterion for inclusion into the study and had *Ascaris lumbricoides* as the only intestinal helminthic infection were randomly selected and screened for serum vitamin A levels. They were matched by age, sex and nutritional status with a similar number of infection-free controls who were also screened for serum vitamin A levels.

3.7 ANTHROPOMETRY

3.7.1 HEIGHT:

Height measurement was done using a locally made vertical board with a detachable sliding headpiece. Fixed to the vertical board was a tape measure calibrated in millimetres and centimetres. The vertical board was in turn fixed to a flat wooden platform. During height measurement each child would stand barefoot on the wooden platform with his back against the vertical board. The child's height would be determined by the position of the headpiece on the tape measure when the feet are together at the centre of the board with the back of the heels, calves, buttocks and the occiput just touching the vertical board. All height measurements were taken by the investigator and each was recorded to the nearest 0.5 centimetres.

3.7.1.1 WEIGHT:

Weights were measured using a digital scale calibrated in units of 0.1 kgs. Each pupil was weighed barefoot in school uniform.

Any extra clothing like jackets and pullovers were removed prior to the weighing exercise. Adjustment factor based on the type of clothing and sex was developed by weighing clothes from a subsample of 20 pupils of each sex from each school.

3.7.2 STOOL SPECIMEN COLLECTION AND EXAMINATION.

All stool specimens were collected between 8.30 a.m and 11.00 a.m. After being briefed on how to collect stool samples, each pupil was served with a half metre square sheet of paper, a wooden spatula, a labelled plastic screw-top stool container and toilet tissue papers then released for the exercise of stool collection in the latrines. Each would defaecate on the half metre square sheet of paper then transfer a small portion of stool into the plastic stool container using the wooden spatula. The used spatula and the remaining stool portion were wrapped in the square sheet of paper then discarded into the pit. The stool container with its contents would then be submitted for urgent transfer to the laboratory, where they were prepared for examination by Kato technique within three hours of collection.

3.7.2.1 "THE KATO THICK SMEAR TECHNIQUE"

Stool examination for evidence of intestinal helminthiasis based on presence of eggs was done by the Kato's thick smear technique. This technique involves examination of 50 micrograms of fresh stool specimen by clearing the direct faecal smear pressed out thinly under a glycerine impregnated cellophane coverslip.

A sample of fresh stool was pressed through a fine wire gauze sieve (#25) to remove fibrous tissues. Using a plastic applicator stick, a portion of the sieved stool was transferred to a microscope slide by carefully filling a template hole of 50 microgram capacity resting on the slide. A strip of cellophane impregnated with glycerine and a tincture of malachite green was pressed over the faeces on the slide until it was evenly spread. The specimen was left to stand until the faecal background cleared. In this study, there was no problem in identification of schistosome eggs even within 30 minutes of slide preparation. The entire preparation was examined under low power objective. Helminth eggs were identified, counted using a digital telecounter and then recorded.

Despite its slightly lower sensitivity compared to the concentration method of stool examination, the Kato technique was preferred in this study because it is quantitative, cheap, simple and rapid. Its quantitative nature was of particular interest because it formed a good basis for comparison, which was vital in this study.

3.7.3 SERUM VITAMIN A.

To examine the relationship between ascaris infection and vitamin A status, a subsample of 100 children was selected from amongst those who had undergone nutritional assessment and screening for intestinal helminthiasis.

Out of this sample two groups, ascaris-infected and control, were defined. The ascaris group consisted of children who had Ascaris lumbricoides as the only the only infection, as determined by stool examination for ova. The control group consisted of children who had no evidence of any helminthic infection. The two groups were comparable with respect to all other important parameters, e.g., age, sex composition, nutritional status and social class.

Principle

Determination of serum vitamin A was done spectrophotometrically using a modification of the Carr-Price method (Pearson and Neeld, 1963) which employs trifluoroacetic acid (TFA) as the chromogen. Retinol and its esters react with TFA yielding transiently blue complexes (retinylic and anhydroretinylic cations) which absorbs at 620nm. The optical density of the resulting solution is proportional to the concentration of retinol in the original solution. This forms the basis of this test. Beta-carotene (a vitamin A precursor present in blood) also gives colour reactions similar to retinol, resulting in falsely high retinol levels. The concentration of beta-carotene can be estimated by measuring its absorbance at 450nm. Its contribution to the apparent concentration of retinol is corrected by subtracting its absorbance at 450nm from the absorbance of the test solution at 620nm.

Amongst the many methods available for vitamin A determination, the Carr-Price method and its modifications are widely used because they are cheap. A modification of the Carr-Price method in which Triflouroacetic acid (TFA) is used as the chromogen is employed here. The fluorometric approaches offer two to threefold greater sensitivity than the spectrophotometric methods (Turley and Brewster, 1990). Low cost however justifies the use of spectrophotometric method here. High Performance Liquid Chromatography (HPLC) methods offer the greatest sensitivity and specificity for retinol and they even allow for simultaneous determination of serum tocopherol, but they require large investment in equipment.

Materials and reagents

Absolute ethanol; Petroleum ether; Chloroform; Acetic anhydride; Trifluoroacetic acid; Beta carotene standard; Vitamin A standard Vitatron spectrophotometer equipped with 10*75 mm cuvettes, centrifuge, test tubes, aluminium foils.

Procedure

3.5 mls human blood was obtained through venepuncture in conditions of subdued illumination then put in an acid washed glass bottle covered with aluminium foil. Each specimen was centrifuged at 3000 revolutions per minute for 5 minutes and 1.5 mls serum separated then stored in acid washed plastic tubes at -10°C for 6 weeks before being analyzed.

All haemolysed samples (detected by observation of reddish discoloration of the serum) were discarded. To 0.5 ml of serum an equal volume of ethanol was added to release retinol from its binding protein. Extraction of retinol was done by adding 3.0 mls of petroleum ether then vortex mixing for 10 mins. Further extraction was achieved by roller mixing for 2 more minutes. This treatment ensures separation of carotene and vitamin A. The mixture was then centrifuged slowly at 1000 revolutions per minute then 2.0 mls of the resulting supernatant pipetted off into a cuvette. Its absorbance measured at 450nm against a petroleum ether blank was used to determine the beta carotene level. The cuvette was then retrieved and the 2.0 mls of petroleum ether evaporated to dryness under nitrogen in a water bath at 35 - 40°C. The resulting residue was dissolved in 0.1 ml of chloroform to which 0.1 ml of acetic anhydride was added. The spectrophotometer was set to zero at 620nm with a blank consisting of chloroform and TFA. The test cuvette was inserted in the spectrophotometer and 1.0 ml of TFA added to its contents then its absorbance read exactly 30 seconds later. The observed optical density is contributed by vitamin A as well as beta-carotene.

Quantification of serum beta-carotene and vitamin A.

This quantification was done using standard curves. Beta-carotene standard solution was diluted with petroleum ether to give solutions containing 0.5, 1.0, 1.5, and 2.0 microgrammes of beta-carotene per ml. The optical densities of these solutions were read at 450 nm against a petroleum ether blank and a standard curve plotted. F was found to be 3.9, derived as shown below.

$$F = \frac{\text{ug of Beta Carotene/ml}}{\text{optical density at 450nm}}$$

Amount of beta carotene in the sample was calculated as :

Serum beta carotene in ug per 100 ml

$$= \frac{\text{O.D450nm} \times 3 \times 3.9 \times 100}{0.5}$$

$$= \text{O.D450nm} \times 2430$$

Where 3.0 = volume of petroleum ether used for extraction.

3.9 = factor derived from standard curve as shown above.

0.5 = volume of standard solution (serum) used.

A TFA -Beta carotene was run to determine a correction factor since beta carotene also reacts with TFA to give a blue colour which contributes to the optical density at 620 nm.

The optical densities of varying concentration of standard beta carotene solutions were read at 450nm and then at 620 nm following TFA reactions. The correction factor was found to be 0.028, derived as follows:

$O.D_{620nm} = O.D_{450nm} \times C.F$

$$C.F = \frac{O.D_{620nm}}{O.D_{450nm}}$$

Vitamin A standard curve was prepared by carrying out TFA reactions on standard solutions containing varying concentrations of retinol per ml and reading their optical densities at 620 nm. F was found to be 5.3.

$$\text{Vit. A (ug/100ml)} = [\ OD_{620} - (OD_{450} \times CF)\ ] \times 1.2 \times 100 \times 2 \times 5.3$$

$$= [\ OD_{620} - (OD_{450} \times 0.028)\ ] \times 1272$$

5.8 DATA ANALYSIS.

All stages of data analysis were performed using computers at the Unit of Applied Human Nutrition of the University of Nairobi. Data entry was done using DbaseIII+. Analysis of obtained anthropometric measurements was carried out using the CDC/WHO software Anthro, which utilizes NCHS/WHO reference populations. The cut-off point for all anthropometric indices was -2 (i.e a z-score below -2 was considered significant). Further analysis was done using EPI5 and SPSS version 2.0. Statistical tests used included student t for differences between means, chi-square test for associations, Pearson correlation and regression analysis. A value of $p < 0.05$ was considered significant. All the p-values in the text are Yate's corrected. Graphic presentations were developed using Havard graphics version 2.0.

CHAPTER IV

RESULTS

4.0 INTRODUCTION:

A total of 659 children in primary classes 1, 2 and 3 underwent anthropometric assessment of nutritional status and stool screening for intestinal helminthiasis. Only 441 of them met the age criterion for inclusion into those aspects of the study that required nutritional status data (i.e aged 5- 10years). For reasons that included improper recording of date of birth, failure to determine the date of birth and loss of specimens, only 431 of these were included in the final analysis. Data on intestinal helminthiasis is presented on the entire population of 659 children. The serum vitamin A status of 30 children with ascariasis was compared with those of a similar number of children without any infection. The two groups were comparable with respect to age, sex and socioeconomic background.

The demographic characteristics of the study population is summarised in table 4.1 below. The mean age for the entire study population was 9.3 years (sd = 1.9). Females constituted 48.1% of the study population and they tended to be younger with a mean age of 9.2 years as opposed to a mean of 9.4 years for their male counterparts. This difference was however not statistically significant.

Table 4.1 Distribution of study population by age, sex and class.

	n	Males %	Females %
TOTAL SUBJECTS	659	51.9	48.1
AGE GROUP(years)			
5 - 6	15	20.0	80.0
6 - 7	58	41.4	58.6
7 - 8	104	51.0	49.0
8 - 9	131	50.0	50.0
9 -10	124	58.1	41.9
>10	227	50.1	49.3
CLASS			
I	357	49.0	51.0
II	174	60.3	39.7
III	128	48.4	51.6

4.1 NUTRITIONAL STATUS DATA.

Anthropometric data is presented on a subsample of 431 children aged 5-10 years, where the cut-off point used was -2 sd for all the anthropometric indices considered.

Table 4.2 Prevalence of Malnutrition (n=431).

STUNTED	WASTED		
	YES	NO	TOTAL #
YES	0	56	56(13.0%)
NO	5	370	375(87.0%)
TOTAL #	5(1.2%)	426(98.8%)	431

Table 4.3 Prevalence of malnutrition by sex.

PARAMETER	PERCENTAGE PREVALENCE		
	Males	Females	Both sexes
Stunting	18.1%	7.0%	13.0%
Wasting	0.9%	1.5%	1.2%
Underweight	12.9%	4.0%	8.8%
n	232	199	431

Stunting was the commonest form of malnutrition with a prevalence of 13.0%. The rate of wasting was 1.2%. The prevalence of stunting was significantly higher among males than females (p = 0.001). The prevalence of wasting was not sex related. The prevalence of undernutrition, based on weight for age deficit, was also significantly higher among males (p=0.002) but it was merely a reflection of the sex difference in stunting rate. Based on weight for age deficit at a cut-off point of -2 sd, only 8.8% of the entire study population could be classified as malnourished.

Figure 4.1 Prevalence of malnutrition by sex

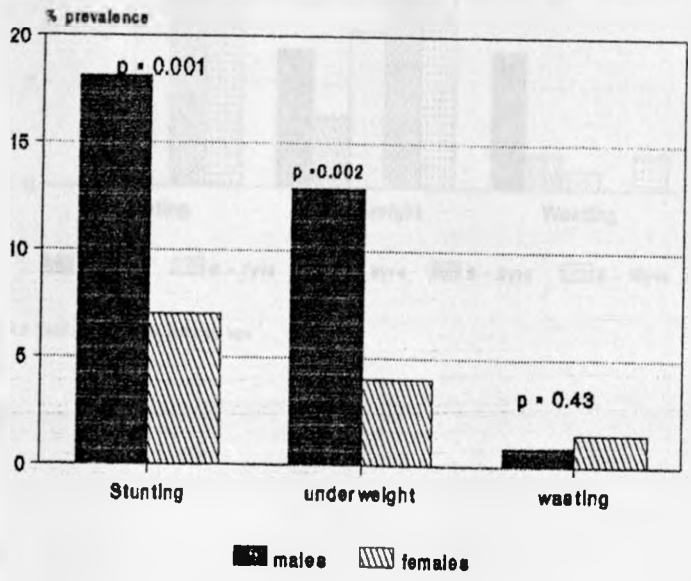

fig 4.1 prevalence of manutrition by sex

Table 4.4 Prevalence of malnutrition(<-2 Sd) by age.

AGE GROUP (months)	STUNTING %	WASTING %	UNDERWEIGHT %
60 - 72	0.0	6.7	6.7
72 - 84	5.0	1.7	3.4
84 - 96	10.4	0.9	7.6
96 - 108	15.7	0.0	10.5
108 - 120	18.0	1.7	11.1

The prevalence and severity of stunting showed a consistent increase with advancing age. The prevalence of wasting tended to decrease with rising age.

Figure 4.2 Prevalence of malnutrition by age.

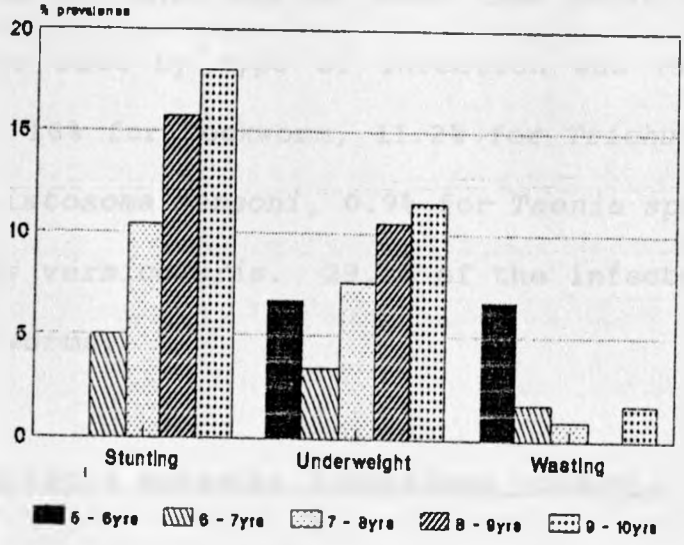

Fig 4.2 Malnutrition prevalence by age

4.2 PREVALENCE OF INTESTINAL HELMINTHIASIS:

All the 659 pupils who participated in this study were screened for intestinal helminthiasis. The prevalence of intestinal parasites encountered in this study is illustrated in table 4.5.

Table 4.5 Distribution of the study population by type of parasite isolated (n= 659).

SEX	Male	Female	Total (%)
Number examined	342	317	659 (100)
Number positive	149	139	288 (43.7)
Parasites			
A. lumbricoides	66	59	125 (19.0)
Hookworm	56	50	106 (16.1)
T. trichuria	32	42	74 (11.2)
S. mansoni	46	27	73 (11.1)
E. vermicularis	3	2	5 (0.8)
Taenia ssp.	3	3	6 (0.9)

31.0% of those screened had at least one intestinal helminth. The prevalence rate by type of infection was 19% for *Ascaris lumbricoides*, 16% for hookworm, 11.2% for *Trichuris trichuria*, 11.1% for *Schistosoma mansoni*, 0.9% for *Taenia species* and 0.8% for *Enterobius vermicularis*. 29.2% of the infected individuals had multiple worms.

Table 4.6 Multiple parasite infections (n=659).

Number of helminthic infections (multiple parasites)	No of children affected	%
o	371	56.3
1	204	31.0
2	68	10.3
3	15	2.3
4	1	0.1
Total	659	100

4.3.1 Intensity of the parasitic infections

The criteria used in the classification of the intensity of infection for each parasite is indicated in table 4.7. The details of these criteria are in the appendix. Only the four most commonly encountered parasites are considered here.
Only 4 out the 288 infected children had heavy infection. Majority of the children had light infections.

Table 4.7 Wormloads.

INTENSITY OF INFECTION	LIGHT NO (%)	MODERATE NO (%)	HEAVY NO(%)	CRITERIA USED (Ref)
Ascaris	101 (80.8)	22(17.6)	2 (1.6)	WHO, 1981
Hookworm	106 (100)	0.0	0.0	Beaver, 1984
T. trichuria	74 (100)	0.0	0.0	Beaver, 1984
S. mansoni	55 (76.4)	15(20.8)	2 (2.8)	Sleigh, 1985

4.3.2 Prevalence of intestinal helminthiasis by age and sex.

The prevalence of helminthiasis was examined by age and sex. No statistically significant relationship was demonstrable between infection rate and age. The results also indicated that both girls and boys have similar infection prevalence although males are more prone to intestinal schistosomiasis (p=0.058). Table 4.5

Table 4.8 **Prevalence of helminthic infection by age.**

	ascaris %	hookw %	trichur %	mansoni %	enterob %	all %
Age group (yrs)						
5 - 6	33.3	20.0	13.3	6.7	0.0	53.3
6 - 7	15.5	6.9	17.2	3.4	0.0	39.7
7 - 8	15.4	14.4	6.7	9.6	0.0	38.5
8 - 9	16.0	16.8	15.3	12.2	0.8	44.3
9 -10	18.5	15.3	11.3	14.5	1.6	45.2
10-12	25.3	16.3	9.0	10.2	1.2	45.2
>12	14.8	26.2	9.8	14.8	0.0	45.9
p value	0.11	0.10	0.83	0.38	0.74	0.87

4.3.3 Relationship between helminthiasis and malnutrition.

No statistically significant association was demonstrable between the indices of nutritional status used in this study and helminthic infections, taken together or individually.

Table 4.9 Correlation of PEM and helminthiasis.

	ASCAR	HOOKW	TRICH	S.MANS	ALL WORMS
STUNTING	0.70	0.86	0.58	0.92	0.94
WASTING	0.61	0.46	0.52	0.42	0.67
UNDERWT	0.63	0.95	0.50	0.56	0.98

Key:

Ascar = *ascaris lumbricoides*
Hoohw = hookworm
Trich = *trichuris trichuria*
S.Mans = *schistosoma mansoni*

4.3 SERUM VITAMIN A RESULTS.

The relationship between ascaris infection and vitamin A status was examined by comparing the serum vitamin A values of 30 ascaris infected children with those of a similar number of children matched for age and sex and free of any infection. Because of haemolysis, breakages, loss of labels and recovery of inadequate quantities of serum, only 60 instead of the 100 collected as 50 matched samples, were analyzed for serum vitamin A. The final groups could not satisfactorily be paired for a strict matched analysis. The groups were however comparable with respect to important parameters like anthropometric measurements, age and sex composition, making this analysis possible. Student t-test for difference between means was therefore performed. The results are presented in table 4.9.1 where it is seen that the overall serum vitamin A status for each group was good. All controls had serum vitamin A above 24ug/dl.

Only one ascaris infected child had serum vitamin A below 20ug/dl. The mean serum vitamin A for ascaris infected children was 41.2mg/dl whereas the mean for controls was 57.7mg/dl. The difference is statistically significant with a p-value less than 0.01.

Table 4.9.1 Comparison between ascaris and control group .

parameter	ascaris group-30 X (s.d)	control group-30 X (s.d)	p-value
mean age yrs.	7.80 (1.4)	7.8 (1.5)	0.77
mean ht/age(Z)	-0.58 (1.38)	-0.79 (1.19)	0.59
mean wt/ht(Z)	-0.63 (0.77)	0.61 (0.75)	0.65
mean serum vit.A	41.20 (14.6)	57.9 (9.9)	<0.001
mean serum B-Carot.	75.90 (26.9)	99.83 (29.6)	0.006
vit. A/B-Carotene	1.84	1.71	

Serum vitamin A levels decreased with rising wormload. This negative correlation however not statistically significant (r = -0.26). Correlation analysis of serum vitamin A sex, age and nutritional status revealed no significant association. For the control group, males had a higher mean serum vitamin A than their female counterparts. In the ascaris infected group this relationship is reversed with males having a lower mean serum vitamin A level than females. This could possibly explained by the fact that males had higher wormlaods than females.

Figure 4.3 Serum vitamin A and wormload.

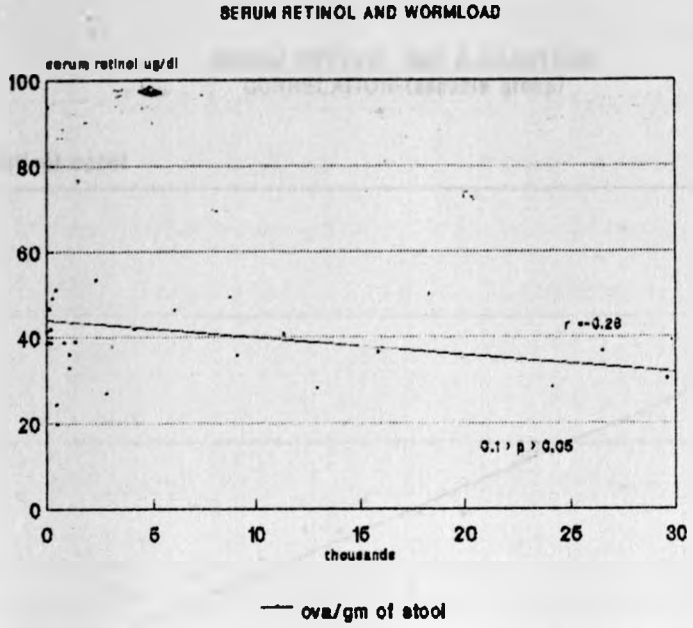

figure 4.3

4.5 SERUM BETA CAROTENE:

The serum beta carotene levels were averagely high for both groups, with a mean of 75.9ug/dl for the ascaris group and 99.8ug/dl for the controls, but the value for the ascaris group was significantly lower ($p = 0.006$). As expected, a statistically significant positive correlation was demonstrated between serum retinol and beta carotene ($r = 0.74$, $p < 0.001$). This positive correlation was demonstrable amongst *Ascaris* infected ($r=0.77$, $r^2=0.59$) and non-infected children ($r = 0.6$, $r^2=0.36$). A negative correlation was also demonstrated between serum beta-carotene and ascariasis.

Figure 4.4 Correlation between serum retinol and beta carotene.

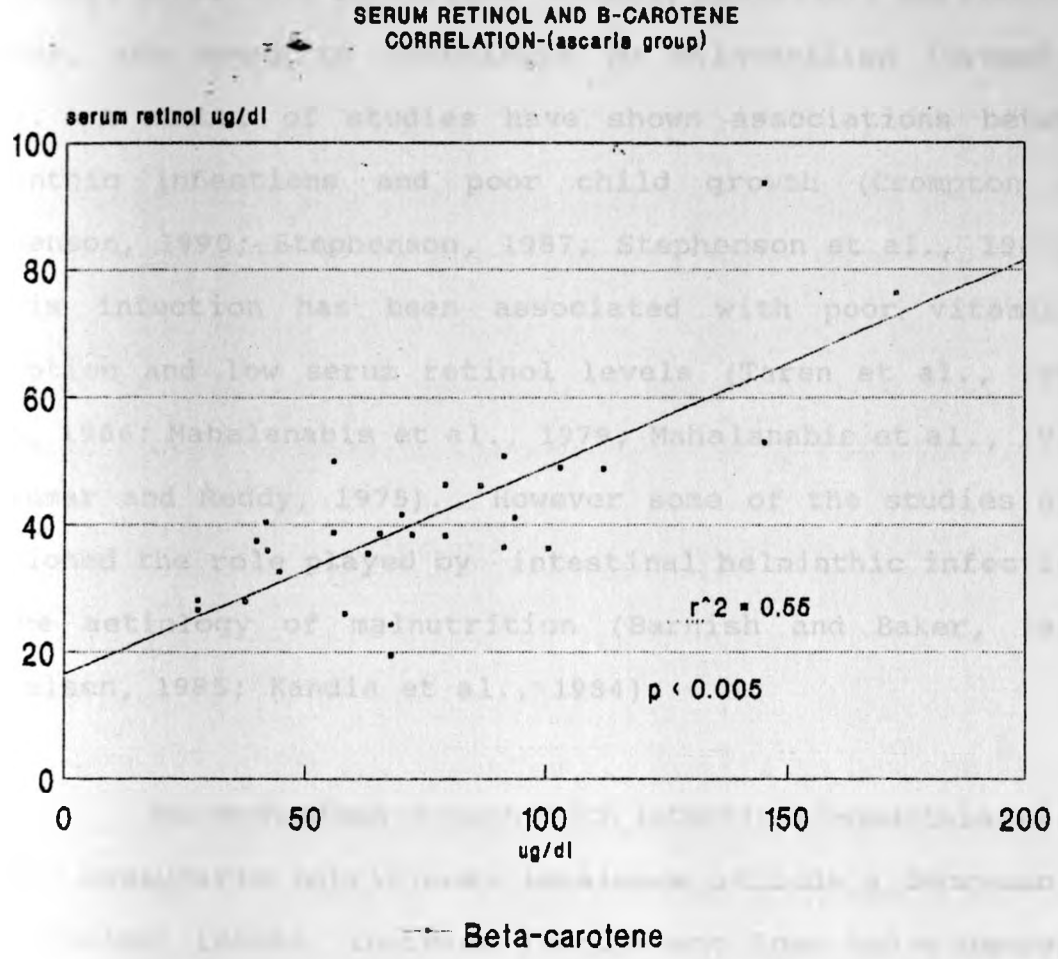

Figure 4.4

CHAPTER V

DISCUSSION

5.0 INTRODUCTION

Under certain circumstances and in a variety of places, some intestinal helminthic infections, notably ascariasis and hookworm disease, are known to contribute to malnutrition (Crompton, 1986). A number of studies have shown associations between helminthic infections and poor child growth (Crompton and Stephenson, 1990; Stephenson, 1987; Stephenson et al., 1987). Ascaris infection has been associated with poor vitamin A absorption and low serum retinol levels (Taren et al., 1987; Taren, 1986; Mahalanabis et al., 1979; Mahalanabis et al., 1976; Sivakumar and Reddy, 1975). However some of the studies have questioned the role played by intestinal helminthic infections in the aetiology of malnutrition (Barnish and Baker, 1987; Michaelsen, 1985; Kandia et al., 1984).

The mechanisms through which intestinal helminthiasis can lead to measurable nutritional imbalance include a decrease in host nutrient intake, increase in nutrient loss and a decrease in nutrient utilization within the body (Stephenson, 1987). It has also been suggested that depressed growth may be mediated by cachectin/tumour necrosis factor alpha and other cytokines produced in response to infections (Stephenson et al.,1993). Despite the improved understanding of the mechanisms through which helminthic infections can lead to malnutrition, considerable controversy still surrounds the subject.

5.1 HELMINTHIC INFECTIONS:

The overall prevalence of intestinal helminthiasis in the current study was estimated to be 43.7%, demonstrating how widespread the problem of worms is in the study area. This figure is however bound to be an underestimate because the design of this study did not account for the detection of non ova-producing helminthic infections and false negative stool results. The figures are however higher than previous reports which quoted the prevalence of helminthiasis in South Nyanza as 30% (GOK, MPND, 1989) and that for the whole country as 25% (GOK-DMS, 1990). This disparity in prevalence suggests that the study area could be a pocket of higher endemicity than most parts of the country.

For schistosomiasis, the estimated prevalence of 11.1% is lower than what has been reported for a number of areas within the lake region in close proximity to this study area. An infection rate of 50% was reported for pupils in Rusinga island (Pamba, 1974) while a prevalence rate of 46% was reported for school children in Mfangano island (Wijers and Munanga, 1971). For Port Victoria, a fishing village in the shores of lake victoria intestinal schistosomiasis prevalence rate of 30% was reported for the entire population in 1983 (Masaba, 1983).

The three most commonly encountered helminths in this study were *Ascaris lumbricoides*, hookworm and *Trichuris trichuria*, in order of decreasing frequency. A similar hierarchy of prevalences was reported for children in Kano plains within Kisumu District (Kinoti, 1971).

Intensity of infection of all worms encountered in this study were generally light.

Correlation of helminthic infection and age revealed no significant association between these two parameters. Analysis of these prevalences by sex however revealed that males had a marginally significant higher prevalence of intestinal schistosomiasis than females ($p=0.58$). This difference in sex specific prevalence of infections was however not detected with respect to the other helminthes. The higher prevalence of schistosomiasis in males is probably due to the fact that male activities like fishing and watering animals involve longer durations of contact with water, increasing the risk of infection. Predominant involvement in outdoor activities and their inherently adventurous nature also predispose them to contracting schistosomiasis from contaminated water.

5.2 INTESTINAL HELMINTHIASIS AND MALNUTRITION

The results of this survey showed a substantial prevalence of stunting (13%) but a rather low prevalence of wasting (1.2%). According to the fourth nutrition survey, 19.5% of Kenyan pre-school children were stunted whereas 3% were wasted. Stunting was shown to increase with age in terms of severity and overall prevalence. This demonstrates the cumulative negative effects over time of the nutritional stresses that lead to stunting.

The relationship between intestinal helminthiasis and nutritional status was examined by comparing the prevalence of malnutrition amongst infected children with those of non-infected ones. No statistically significant association was demonstrable between any of the anthropometric indices of nutritional status used in this study and intestinal helminthiasis. This means that the light and moderate intensities of helminthic infections observed in this study had no detectable influence on nutritional status. Similar relationship between intestinal helminthiasis and nutritional status has been reported for children in Bengoka peninsula in Saba (Kandia et al., 1984), Zimbabwe (Loeweson et al., 1986), Papua New Guinea (Barnish and Baker, 1987), Botswana (Michaelsen, 1985) and Ethiopia (Freij et al., 1979). These observations are in direct contrast to reports by a number of authors that a significant negative correlation exists between intestinal helminthiasis and nutritional status (Gupta, 1990,; Gilman et al., 1983, Latham and Latham, 1977 and Stephenson et al., 1993). This contrast in observations by different workers is attributable, in part to the variability in intensity of infections as well as the diversity in the severity of the nutritional disorders considered in each study. In general, light infections are only likely to cause slight morbidity and so are unlikely to produce any anthropometrically detectable effects on the nutritional status. The duration of infection also has to be taken into account as it has to be sufficiently long to influence anthropometric measurements.

The apparent lack of association between helminthic infection and nutritional status implied by the results of this survey is inconclusive because it is based on a study population with light infections, low prevalence of malnutrition of only mild and moderate severity and in whom the duration of infection may have been a confounder.

5.3 SERUM VITAMIN A AND ASCARIS INFECTION:

Regarding serum vitamin A status and Ascaris infection, serum vitamin A levels of 30 Ascaris infected children was compared with those 30 non-infected controls. It was found that the mean serum vitamin A level for the Ascaris group (41.2 ug/dl) was significantly ($p<0.01$) lower than the 57.9ug/dl for the controls. This finding substantiates previous reports from India and Panama that Ascaris infection impairs serum vitamin A (Taren et al., 1987; Mahalanabis et al., 1979). Correlation analysis revealed a weak negative correlation between Ascaris infection (wormload) and serum retinol. The mean serum retinol level for each group was within the normal range (the lower limit of the normal range=20ug/dl). Clearly, the study population was not vitamin A deficient and the intensity of ascaris infection was generally light (based on WHO definition of 1987 as quoted by Stephenson in 1987).

This relationship between serum vitamin A and Ascaris infection is of important public health implications for areas with low dietary intake of vitamin A and high prevalence and intensity of ascariasis because these two factors would at least contribute towards xerophthalmia in an additive fashion. For areas with adequate dietary intake of vitamin A, the implication of this relationship is that the presence of heavy ascaris infection would lower the threshold for precipitation of epidemic xerophthalmia by social and environmental factors.

As for this study population, the implication of this relationship is that a situation exists in which ascariasis is insidiously undermining the vitamin A status of children but there is still no overt vitamin A deficiency. Such situation is potentially dangerous because relatively minor climatologic or socioeconomic changes can easily precipitate xerophthalmia of epidemic proportions in this population. Moreover, knowing the seasonal nature of vitamin A deficiency, it would not be surprising to find a vitamin A situation which is the direct opposite of what is reported here if this survey were repeated during a different season. As observed earlier, this survey was done in the post-harvest period and it also coincided with season of abundant popular wild fruits especially Pawpaws and Mangoes.

Kenya is a country where vitamin A deficiency shows considerable seasonal and regional variation. There are however some segments of the population whose consistent low intake of vitamin A constitutes a special problem requiring special attention. The findings of this study suggest that Homa bay was seasonally favoured with respect to vitamin A intake at the time of the survey. A vitamin A consumption study amongst preschoolers in South Nyanza District during a period of normal agricultural production showed that 25% of these children had a consistently low vitamin A intake, meaning that in periods of poor agricultural cycles, vitamin A deficiency can be a serious problem (Kennedy and Oniang'o, 1992).

CHAPTER VI

CONCLUSIONS AND RECOMMENDATIONS

6.0 CONCLUSIONS

-Ascaris infection can impair micronutrient nutritional status even when there is no anthropometrically detectable nutritional effect. A strong negative association was revealed between ascariasis and serum vitamin A in the absence of any association between this infection and any anthropometric index of nutritional status.

-Vitamin A deficiency was not a problem in South Nyanza at the time of this survey despite its being adversely affected by ascariasis, whose prevalence was high. This situation is however considered precarious because it can only be maintained by sustained high dietary intake of retinol and its precursors. Minor fluctuations in dietary supply of these nutrients can easily lead widespread xerophthalmia of in such a community.

-The absence of association between intestinal helminthiasis and PEM (measured anthropometrically) contrasts with the findings of a number of earlier studies. Strict comparison of research findings is however confounded by the problem of use of varied cut-off points in defining wormloads. The absence of association observed here is considered inconclusive for several reasons.

The prevalence of malnutrition particularly those of severe forms was low, the infections were generally of light intensity and the duration of infection could have been a confounder. Light infections are unlikely to cause marked nutritional effects. The duration of infection has to be sufficiently long in order for any anthropometric changes to be detectable.

-Male children in Homa bay District are at a significantly higher risk of stunting than females. There could be social practices that put males at a risk of consistent lower dietary intake of some or all foods, compared to their female counterpart.

That intestinal helminthiasis contributes significantly towards the aetiology of malnutrition is a hypothesis that is only accepted in part because it is shown here that:-

there is no relationship between PEM (measured anthropometrically) and intestinal helminthiasis.

Ascariasis contributes significantly towards the aetiology of avitaminosis A.

6.1 RECOMMENDATIONS.

-Because of their widespread prevalence, any negative effect of intestinal helminthic infections is affecting a large number of children. Immediate deworming campaign should be started in South Nyanza in view of the high prevalence observed. In this campaign, treatment of children with the more serious forms of these infections (e.g *Schistosoma mansoni*) should be accorded higher priority. This should be followed by intermittent mass deworming to break the transmission cycles and keep prevalence low.

-Ascaris control should form an integral part of any vitamin deficiency control programme in areas where avitaminosis A coexists with ascariasis.

-An internationally acceptable standard for reporting the intensity of infections should be developed for all commonly encountered helminths. This would facilitate comparison of research findings.

-More studies should be carried out in different communities amongst preschool and school children in order to settle the current uncertainties regarding the association between helminthic infections and nutritional status. These future studies should preferably be longitudinal in nature and incorporate the recording of the duration of infection.

-Future studies on this subject should be carried out amongst populations with high intensity and prevalence of both malnutrition and helminthiasis.

-More indepth studies should be carried out in the same area to determine the factors that put male children at a higher risk of stunting.

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APPENDIX I

Quantification of serum beta-carotene and Vitamin A.

Three standard curves were prepared in order to achieve this: The estimation of beta-carotene was done by measuring the absorbance of the test solution at 450nm and interpolating the levels from a standard curve, which was prepared by plotting optical density (y-axis) against the concentration of each standard (x-axis). Optical densities of varying concentrations of beta carotene were determined at 450nm. Petroleum ether was used as the blank and 0.5 mls of the standard solution dissolved in 3.0 mls of petroleum ether in each case.

Beta carotene in petroleum ether standard:

Beta carotene standard solution was diluted with petroleum ether to give solutions containing 0.5, 1.0, 1.5 and 2.0 microgrammes of beta-carotene/ml. Petroleum ether was used as a blank and the optical densities read at 450 nm (see table AI).

Table AI Beta-carotene standard.

B-carotene (ug/ml)	O.D at 450nm	F= $\frac{\text{ug B-carotene/ml}}{\text{O.D at 450nm}}$
0.5	0.127	3.9
1.0	0.256	3.9
1.5	0.380	3.9
2.0	0.508	3.9

The observed optical density is proportional to the concentration of beta-carotene in the standard (test) solution.

i.e B-carotene (ug/ml) = F * O.D at 450nm.

where F is the constant of proportionality.

Serum b-carotene in microgrammes/100mls.

$$= O.D_{450nm} \times \frac{3}{0.5} \times 3.9 \times 100$$

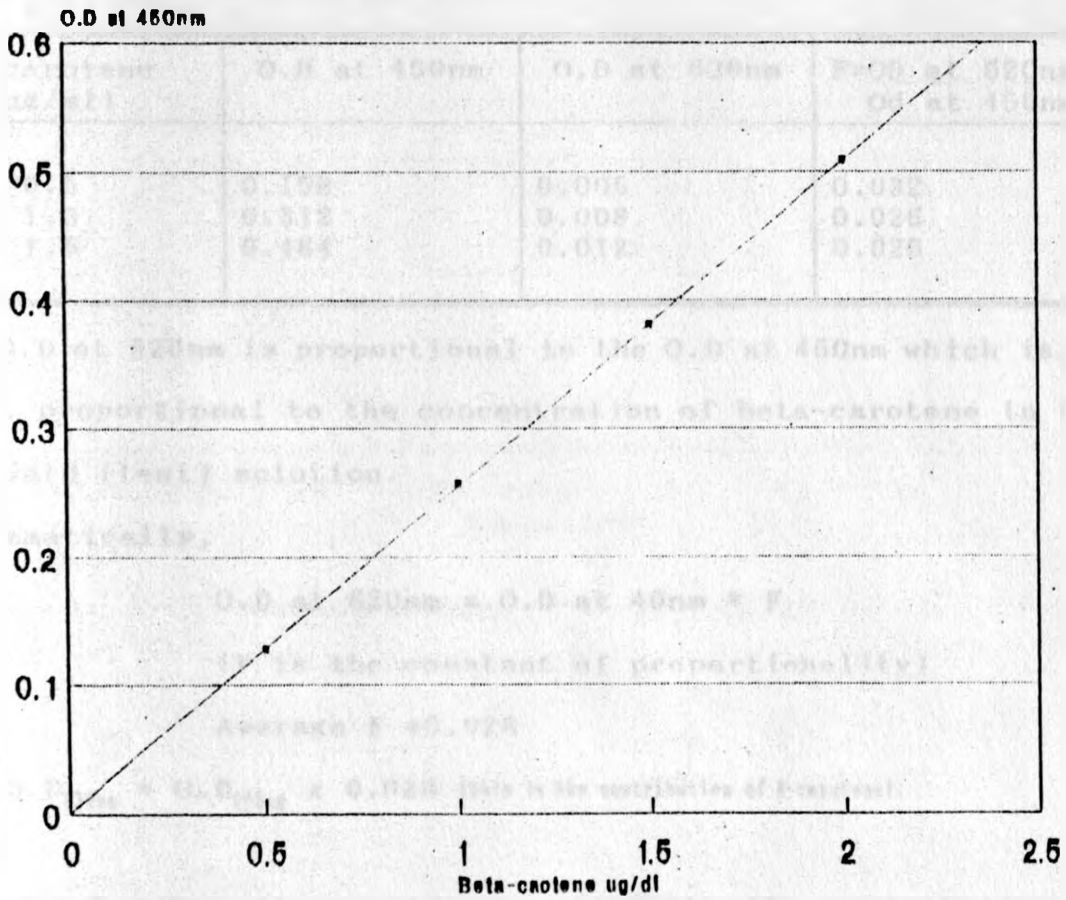
$$= O.D_{450nm} \times 2430$$

3.0 = volume of petroleum ether used (extraction).

3.9 = F (derived as shown above)

0.5 = volume of the standard (serum) used.

Beta-caretene standard curve



Trifluoroacetic acid beta-carotene standard.

This standard curve makes it possible to predict the absorbance contributed by beta carotene at 620nm given its absorbance at 450nm. It therefore makes it possible to eliminate the contribution of beta-carotene to the O.D observed at 620nm.

For this determination, carotene standards of varying concentrations were made up in chloroform. TFA reactions were carried out on 0.1 ml of each standard solution.

Table A2 TFA Beta carotene standard

B-carotene (ug/ml)	O.D at 450nm	O.D at 620nm	F=OD at 620nm Od at 450nm
0.5	0.158	0.005	0.032
1.0	0.312	0.008	0.026
1.5	0.464	0.012	0.026

The O.D at 620nm is proportional to the O.D at 450nm which is, in turn, proportional to the concentration of beta-carotene in the standard (test) solution.

Mathematically,

O.D at 620nm = O.D at 40nm * F

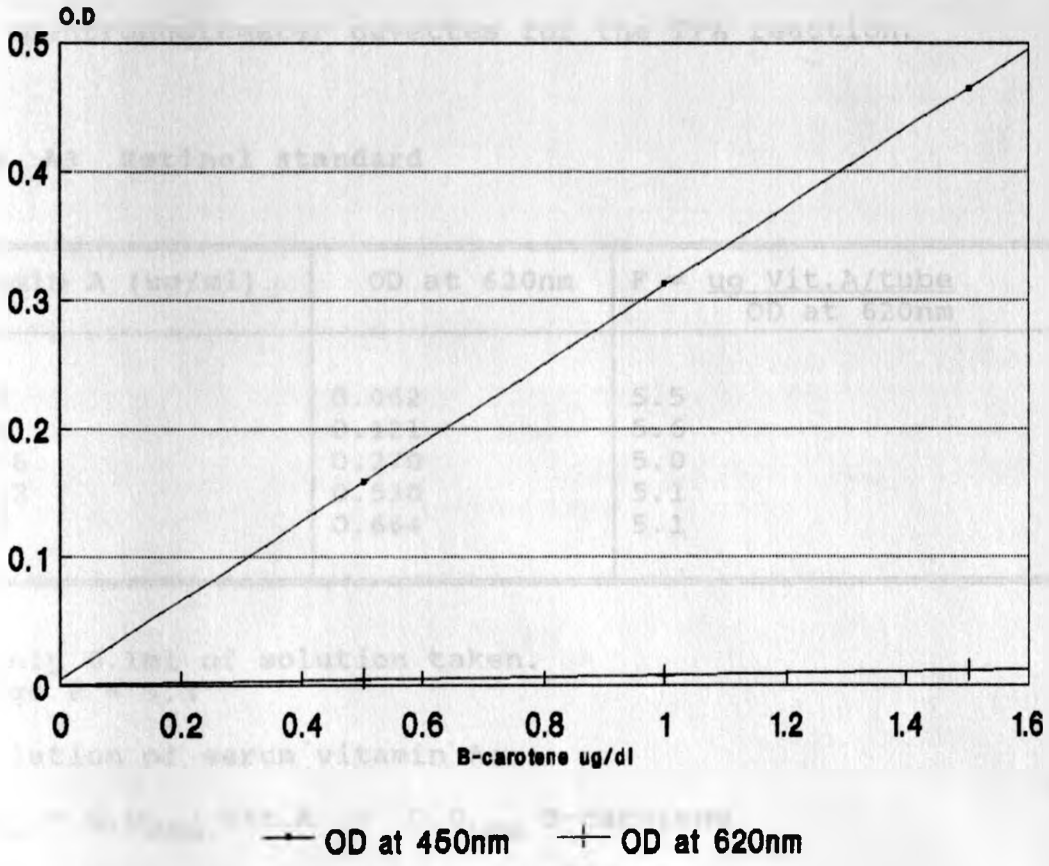
(F is the constant of proportionality)

Average F =0.028

SO $O.D_{620nm} = O.D_{450nm} \times 0.028$ (this is the contribution of B-carotene).

Knowing F makes it possible to eliminate the contribution of beta-carotene towards the apparent serum retinol.

TFA-Beta Carotene Standard curve



Vitamin A standard:

The absorbance of the test solution at 620nm is contributed both by vitamin A and beta carotene. The contribution of beta-carotene to the observed optical density has to be subtracted before deducing the vitamin A concentration from the standard curve. Vitamin A standards were prepared from stock standard solution to give solutions containing 3.39, 6.78, 13.56, 27.12 and 33.9 ug/ml. 0.1 ml aliquots of these standards were pipetted into spectrophotometer cuvettes for the TFA reaction.

Table A3 Retinol standard

Vitamin A (ug/ml)	OD at 620nm	F = ug Vit.A/tube / OD at 620nm
3.39	0.062	5.5
6.78	0.121	5.6
13.56	0.270	5.0
27.12	0.530	5.1
33.9	0.664	5.1

N/B only 0.1ml of solution taken.
Average F = 5.3

Calculation of serum vitamin A:

$O.D_{620nm} = O.D_{620nm}$ Vit.A + $O.D_{620nm}$ B-carotene

$O.D_{620nm}$ Vit.A = $O.D_{620nm} - O.D_{620nm}$ B-carotene

But $O.D_{620nm}$ B-carotene = $O.D_{450nm} \times 0.028$ (where 0.028 is the correction factor).

So Vit. A (ug/100ml) = $[\ OD_{620} - (OD_{450} \times CF)\ ] \times 2 \times 100 \times 1.2 * 5.3$

$= [\ OD_{620} - (OD_{450} \times 0.028)\ ] \times 1590(1272)$

Retinol standard curve

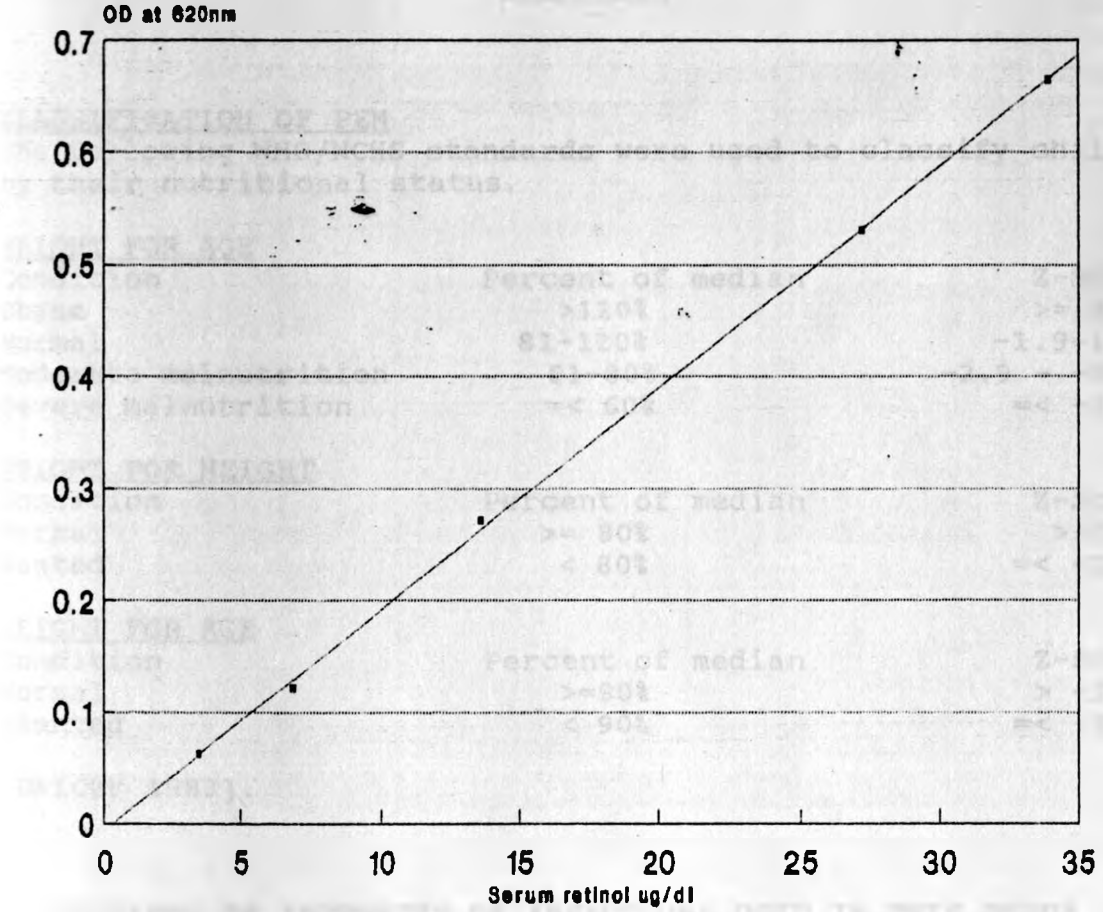


Fig. 3.4

APPENDIX II

RESULTS

CLASSIFICATION OF PEM

The following WHO/NCHS standards were used to classify children by their nutritional status.

WEIGHT FOR AGE

Condition	Percent of median	Z-Scores
Obese	>120%	>= 2.0sd
Normal	81-120%	-1.9-1.9sd
Moderate malnutrition	61-80%	-2.9 - -2.0sd
Severe malnutrition	=< 60%	=< -3.0sd

WEIGHT FOR HEIGHT

Condition	Percent of median	Z-Scores
Normal	>= 80%	>-2.0sd
Wasted	< 80%	=< -2.0sd

HEIGHT FOR AGE

Condition	Percent of median	Z-Scores
Normal	>=90%	> -2.0sd
Stunted	< 90%	=< -2.0sd

[UNICEF 1983].

DEFINITIONS OF INTENSITY OF INFECTIONS USED IN THIS STUDY

Parasite	Intensity of infection	Egg count	Reference
A. lumbricoides	light	under 7000 epg	WHO, 1981
	moderate	7000 - 35000	
	heavy	over 35000	
hookworm	light	under 5000 epg	Beaver et al.,'84
	moderate	5000 - 20000	
	heavy	over 20000	
T. trichuria	light	under 5000 epg	Beaver et al.,'84
	moderate	5000 - 20000	
	heavy	over 20000	
S. mansoni	light	1 - 100 epg	Sleigh et al.,'85
	moderate	101 - 400	
	heavy	over 400	

Modified from "The impact of helminth infection on human nutrition" by Stephenson, L.S. and Holland, C.

Table A4 MEAN Z-SCORES BY AGEGROUP AND SEX

	MALES MEAN SCORE (SD)	N	FEMALES MEAN SCORE (SD)	N
STUNTING:				
4-6yrs	0.64(2.34)	3	2.26(1.78)	12
6-8yrs	-0.71(1.09)	78	-0.29(1.02)	87
8-10yrs	-1.20(1.10)	151	-0.91(0.84)	100
All ages	-1.01(1.15)	232	-0.45(1.24)	199
WASTING:				
4-6yrs	-1.53(1.13)	3	-0.67(0.56)	12
6-8yrs	-0.41(0.79)	78	-0.42(0.81)	87
8-10yrs	-0.46(0.64)	151	-0.47(0.70)	100
All ages	-0.46(0.71)	232	-0.46(0.74)	199
UNDERWEIGHT:				
4-6yrs	-0.77(1.08)	3	0.87(0.93)	12
6-8yrs	-0.78(0.89)	78	-0.44(0.77)	87
8-10yrs	-1.14(0.80)	151	-1.01(0.68)	100
All ages	-1.10(0.85)	232	-0.65(0.87)	199

Table A5 Distribution of the study children by weight for age.

WEIGHT/AGE	No.	%
Obese	3	0.7
Normal	391	90.7
Moderately malnourished	37	8.6
Severely malnourished	0	0.0
Total	431	100.0

Table A6 Relationship between intestinal helminthiasis, nutritional status, age and sex (correlation matrix). The p-values given are Yate's corrected.

	ASCAR	HOOKW	TRICH	S.MANS	ALL WORMS	AGE	SEX
STUNTING	0.70	0.86	0.58	0.92	0.94	0.05	0.01
WASTING	0.61	0.46	0.52	0.42	0.67	0.26	0.58
SEX	0.82	0.83	0.11	0.05	0.99	-	1.00
AGE	0.11	0.10	0.83	0.38	0.87	1.00	-

Table 4.9 Sex specific prevalence of helminthic infections.

Sex	Ascar	Hookw	Trichu	Mansoni	Entero	All worms
Female	18.6	15.8	13.2	8.5	0.6	43.8
Male	19.3	16.4	9.4	13.5	0.9	43.6
p value	0.82	0.83	0.11	0.058*	0.54	0.99

APPENDIX III

DATA COLLECTION SHEETS

APPLIED HUMAN NUTRITION UNIT - UNIVERSITY OF NAIROBI.

INTESTINAL HELMINTHIASIS AND PEM SURVEY OCT. - DEC. 1992.

DATA COLLECTION SHEET. DATE.....

SCHOOL . . . . . .

CLASS . . . . . .

NAME	ID #	SPC	SEX	BDATE	PARENT	WT	HT

NO OF MALES.....

NO OF FEMALES.....

FILLED BY.....

APPLIED HUMAN NUTRITION UNIT - UNIVERSITY OF NAIROBI.
INTESTINAL HELMINTHIASIS AND PEM SURVEY OCT. - DEC. 1992.

STOOL SCREENING RESULTS. DATE.....

SCHOOL . . . . . .

NO	ASCAR	HOOKW	TRICH	SMANS	EVERM	TAENI	STERC	OTHER

ASCAR = *Ascaris lumbricoides.*

HOOKW = Hookworm.

TRICH = *Trichuris trichuria.*

SMANS = *Schistosoma mansoni.*

EVERM = *Enterobius vermicularis.*

TAENI = *Taenia ssp.*