THE RISK OF INTESTINAL PARASITIC INFECTIONS
IN KISII MUNICIPALITY, KENYA

BY

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degree of Master of Science (Medical Parasitology) in the School of Pure and
Applied Sciences of Kenyatta University

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The risk intestinal parasitic infections

November, 2008
Declaration

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

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Dedication

To my mother Belidina Nyatanchi and my late Father Hezrom Nyarango, who taught me to keep my eyes on the ultimate price. For their mountain moving faith, everything has simply been possible! and for their sacrifice, struggle and patience, they do not deserve less.

To my wife Mary Nyanchama, understanding that the quest for knowledge has its own price, together with my children Sylvia Kwamboka, Sheila Nyabando and Ezra Omoi alias Robin who never ceased to encourage and support me spiritually, morally and financially. I hope the children will grow to appreciate the literature for they were my constant source of inspiration and energy.

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<table>
<thead>
<tr>
<th>Table of Contents</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Title</td>
<td>i</td>
</tr>
<tr>
<td>Declaration</td>
<td>ii</td>
</tr>
<tr>
<td>Dedication</td>
<td>iii</td>
</tr>
<tr>
<td>Acknowledgements</td>
<td>iv</td>
</tr>
<tr>
<td>Table of Contents</td>
<td>v</td>
</tr>
<tr>
<td>List of Figures</td>
<td>x</td>
</tr>
<tr>
<td>List of Plates</td>
<td>xi</td>
</tr>
<tr>
<td>List of Tables</td>
<td>xii</td>
</tr>
<tr>
<td>List of appendices</td>
<td>viii</td>
</tr>
<tr>
<td>Abstract</td>
<td>xiv</td>
</tr>
</tbody>
</table>

**CHAPTER ONE: INTRODUCTION** ............................................................................. 1

1.1 Background information................................................................................. 1

1.2 Problem statement and justification............................................................. 3

1.3 Research questions......................................................................................... 4

1.4 Hypotheses....................................................................................................... 4

1.5 Objectives of the study................................................................................... 4

1.5.1 General Objective....................................................................................... 4

1.5.2 Specific Objectives..................................................................................... 4

**CHAPTER TWO: LITERATURE REVIEW** ................................................................... 5

2.1 Intestinal parasites........................................................................................ 5

2.2 Distribution of intestinal parasites............................................................. 5
Epidemiology of intestinal parasites .............................................. 6
Modes of transmission of intestinal Parasites .................................. 9
Ingestion ..................................................................................... 9
Skin penetration .......................................................................... 10
Predisposing factors influencing the risk of acquiring intestinal parasites .......................................................... 10
Foodstuffs .................................................................................. 10
Human behaviour and socio-economic status ................................ 11
Environmental factors .................................................................. 12
Genetic risk factors ..................................................................... 13
Life cycle of intestinal parasitic infections .................................... 14
General life cycle of intestinal nematodes ..................................... 15
General life cycle of intestinal protozoa ........................................ 15
Mixed intestinal parasitic infections .............................................. 17
Impact of intestinal parasites on human beings ............................ 17
Human health .............................................................................. 17
Socio-economic status .................................................................. 18
Diagnosis of people with intestinal parasites ................................. 19
Clinical diagnosis ......................................................................... 19
Laboratory diagnosis .................................................................... 19
Parasitological analysis of foodstuffs ............................................ 20
Control of intestinal parasites ...................................................... 20
Sanitation and hygiene .................................................................. 20
Health education .......................................................................... 20
<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.11.3</td>
<td>Processing of foodstuffs before consumption</td>
<td>21</td>
</tr>
<tr>
<td>2.11.3.1</td>
<td>Marinating, pickling, smoking and fermentation</td>
<td>21</td>
</tr>
<tr>
<td>2.11.3.2</td>
<td>Cooking and heat treatment of foodstuffs</td>
<td>22</td>
</tr>
<tr>
<td>2.11.3.3</td>
<td>Freezing of foodstuffs</td>
<td>22</td>
</tr>
<tr>
<td>2.11.3.4</td>
<td>Filtration and disinfections</td>
<td>22</td>
</tr>
<tr>
<td>2.11.3.5</td>
<td>Chemotherapy</td>
<td>23</td>
</tr>
<tr>
<td>2.11.3.6</td>
<td>Intergraded methods of controlling intestinal parasites</td>
<td>23</td>
</tr>
</tbody>
</table>

**CHAPTER THREE: MATERIALS AND METHODS**

<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.1</td>
<td>Study site</td>
<td>25</td>
</tr>
<tr>
<td>3.2</td>
<td>Study design</td>
<td>26</td>
</tr>
<tr>
<td>3.3</td>
<td>Study foodstuff and subjects</td>
<td>26</td>
</tr>
<tr>
<td>3.4</td>
<td>Sampling procedures</td>
<td>28</td>
</tr>
<tr>
<td>3.5</td>
<td>Sample size determination</td>
<td>28</td>
</tr>
<tr>
<td>3.5.1</td>
<td>Butcheries</td>
<td>28</td>
</tr>
<tr>
<td>3.5.2</td>
<td>Foodstuffs</td>
<td>29</td>
</tr>
<tr>
<td>3.5.3</td>
<td>Food handlers</td>
<td>29</td>
</tr>
<tr>
<td>3.6</td>
<td>Laboratory investigations</td>
<td>30</td>
</tr>
<tr>
<td>3.6.1</td>
<td>Foodstuffs</td>
<td>30</td>
</tr>
<tr>
<td>3.6.2</td>
<td>Assessment of food handling practices</td>
<td>30</td>
</tr>
<tr>
<td>3.6.3</td>
<td>Food handlers</td>
<td>30</td>
</tr>
<tr>
<td>3.7</td>
<td>Ethical considerations</td>
<td>31</td>
</tr>
<tr>
<td>3.8</td>
<td>Data analysis</td>
<td>31</td>
</tr>
</tbody>
</table>
CHAPTER FOUR: RESULTS

4.1 Prevalence of intestinal parasites in vegetables sold in Kisii Municipality open air Markets

4.2 Risk factors influencing intestinal parasites at meat selling points

4.2.1 Meat storage methods and prevalence of intestinal parasites

4.2.2 Personnel handling meat, cash and prevalence of intestinal parasites at meat selling points

4.2.3 Prevalence of intestinal parasites and protective attire of meat vendors

4.2.4 Prevalence of intestinal parasites among meat samples obtained from butcheries where houseflies were either present or absent on meat samples

4.3 Occurrence of intestinal parasites among food handlers examined at Kisii level -5 - Hospital

4.3.1 Intestinal parasites among food handlers examined at Kisii level -5 - Hospital

4.3.2 Prevalence of protozoa among food handlers examined at Kisii level -5 - Hospital

4.3.3 Prevalence of intestinal helminthes among food handlers examined at Kisii level -5 - Hospital

CHAPTER FIVE: DISCUSSION

5.1 Discussion
5.1.1 Prevalence of intestinal parasites among vegetable sold in Kisii municipality open air markets

5.2 Influence of meat handling practices on prevalence of intestinal parasites in Kisii municipality

5.3 Occurrence of intestinal parasites among food handlers examined at Kisii level -5 -Hospital

CHAPTER SIX: CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

6.2 Recommendations

6.3 Suggested further research

REFERENCES

APPENDICES

Appendix I: Check list for meat sampling practices in butcheries
<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Figure 1</td>
<td>General life cycle of intestinal nematodes</td>
<td>15</td>
</tr>
<tr>
<td>Figure 2</td>
<td>General life cycle of intestinal protozoa</td>
<td>16</td>
</tr>
<tr>
<td>Figure 3</td>
<td>Diagrammatic representation of integrated methods of interrupting transmission cycle of intestinal parasites</td>
<td>24</td>
</tr>
<tr>
<td>Figure 4</td>
<td>A map of Kisii municipality</td>
<td>25</td>
</tr>
<tr>
<td>Figure 5</td>
<td>Prevalence of intestinal parasites against meat storage methods</td>
<td>35</td>
</tr>
<tr>
<td>Figure 6</td>
<td>Prevalence of intestinal protozoa among examined food handlers</td>
<td>40</td>
</tr>
<tr>
<td>Figure 7</td>
<td>Prevalence of intestinal helminthes among examined food handlers</td>
<td>41</td>
</tr>
</tbody>
</table>
# LIST OF PLATES

<table>
<thead>
<tr>
<th>Plate</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plate 1</td>
<td>Kisii Municipality open air market</td>
<td>26</td>
</tr>
<tr>
<td>Plate 2</td>
<td>Vegetables sold in the open air market of Kisii municipality</td>
<td>27</td>
</tr>
<tr>
<td>Plate 3</td>
<td>Meat selling points</td>
<td>27</td>
</tr>
<tr>
<td>Plate 4</td>
<td>Intestinal parasites isolated from vegetables samples: Cyst of Entamoeba histolytica (A) and fertilized ova of Ascaris lumbricoides (B)</td>
<td>33</td>
</tr>
<tr>
<td>Plate 5</td>
<td>Intestinal parasites isolated from sampled food stuffs: Cyst of Giardia lamblia (A), Hook worm larvae (B) and egg of Trichuris trichiura (C)</td>
<td>34</td>
</tr>
<tr>
<td>Plate 6</td>
<td>Trophozoite of Entamoeba histolytica (A) and unfertilized ova of Ascaris lumbricoides (B) isolated from stool samples</td>
<td>39</td>
</tr>
<tr>
<td>Plate 7</td>
<td>Trophozoite of Balantidium coli (A) and ova of hook worms (B) isolated from stool samples</td>
<td>39</td>
</tr>
</tbody>
</table>
LIST OF TABLES

Table 1  Infestation rates of intestinal parasites in various types of vegetable samples

Table 2  The risk factors influencing intestinal parasites at meat selling points

Table 3  Relationship of intestinal parasites and handling of samples obtained from butcheries where there were vendors and cashier or vendor served dual as cashier

Table 4  Relationship of intestinal parasites and meat samples obtained from butcheries where there were vendors wearing or not wearing white dust coats

Table 5  Relationship of intestinal parasites among meat samples obtained from butcheries where houseflies were either present or absent on meat samples

Table 6  Infestation rates of intestinal parasites in meat samples

Table 7  Categories of intestinal parasites among food handlers examined at Kisii level -5 -Hospital

Table 8  Risk Sources for acquiring intestinal parasitic infections in Kisii Municipality

Page

33
34
36
37
37
38
40
42
# List of appendices

<table>
<thead>
<tr>
<th>Appendix</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appendix I</td>
<td>Check list for meat sampling practices in butcheries</td>
<td>64</td>
</tr>
</tbody>
</table>

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Abstract

Risk is a probability of an adverse outcome or a factor that raises the probability of outcome. Intestinal parasites usually inhabit the gastro-intestinal tract during part or the whole of their life cycle. In human beings, intestinal parasites are often associated with poor personal hygiene and environmental conditions such as contamination of soil and water sources with human faeces resulting from poor sewage disposal hence a major source of intestinal parasite transmission. The study was carried out between December 2006 and June 2007 in Kisii Municipality. The main objective of this study was to establish the risk of infections by intestinal parasites in Kisii Municipality. Random sampling using lottery method was used to select specimens for the study. Parasitological analysis of foodstuffs and stool samples was done at Kisii level -5 Hospital. The Parasitological profile of stool samples was done by direct saline smear and formalin-ethyl acetate sedimentation while for food stuffs concentration of the suspension was used. A light microscope was used for the examination of trophozoites, ova and cysts of intestinal parasites. Food handling practices were observed using a check list and recorded during each sampling day. A computer program (SPSS 11.5 for Windows) was used for data analysis. Multiple logistic regression analysis was used to establish the relationship of various variables with intestinal parasites. The differences were considered to be statistically significant when the p-value obtained was less than 0.05. In all vegetables sampled, spider flower tested highly positive 17 (81.0%) for intestinal parasites while Kales tested least positive 11(52.4%). Out of 84 vegetables sampled 55(65.5%) were infested with intestinal parasites. There was a statistically significant difference observed between infestation rates of intestinal parasites and types of vegetables ($\chi^2$=179.12, df = 3, p =0.000). The prevalence of intestinal parasites was significantly high in the meat samples stored in the open surface compared to those stored in the refrigerator ($\chi^2$ = 37.628, df = 2, p=0.000). Additionally, high prevalence of intestinal parasites was observed in meat samples obtained from butcheries where the vendors served dual roles as cashier compared to the butcheries where there were vendors handling meat and cashier handling cash ($\chi^2$=65.737, df = 2, p=0.000). There was a significantly high prevalence of intestinal parasites on meat samples whose surfaces had houseflies ($\chi^2$=65.737, df = 2, P=0.000). Prevalence of intestinal parasites was high among food handlers of Kisii Municipality where out of 168 food handlers, 69 (41.1%) were infected with one or more intestinal parasites. Of the positive food handlers, 27 (13.1%) were infected with one species of protozoa while 37 (22.0%) were infected with one species of helminth and 5 (3.0%) had mixed infections. This study has shown that there were risks of acquiring intestinal parasitic infections from various sources with meat posing the highest risk of intestinal parasite transmission (75.9 %), followed by vegetables (65.5 %) and food handlers (41.1%). Out of 692 samples of various specimens examined 458 (66.2%) were infested with intestinal parasite, indicating a high overall risk of infections from various sources. The risk of infections by intestinal parasites from various sources indicated a statistically significant difference between various sources ($\chi^2$ =214.966, df = 2, p<0.00). The findings can be used to sensitize the public on the risk of acquiring intestinal parasites as a result of unhygienic food handling practices and can be adopted by municipal authorities to step up control measures for risk factors favouring intestinal parasitic infections.
CHAPTER ONE: INTRODUCTION

1.1 Background information

Risk is the probability of an adverse outcome or a factor that raises the probability of an outcome (WHO, 2002). Parasites are organisms, which derive benefit from living in or on another organism (host) at a cost ranging from using small amounts of the host's food to causing a fatal illness, with highest costs paid in the tropics and sub-tropics where parasites present a continual unacceptable threat to the well being of millions of people (Northrop-Clewes & Shaw, 2000). Intestinal parasites usually inhabit the gastro-intestinal tract during part or the whole of their life cycle.

It is estimated that intestinal parasites are among the most common infections worldwide affecting 3.5 billion people (WHO, 1998). They are the most prevalent among the poorest countries of the developing world, where they are regarded as a serious public health problem (WHO, 1998). In human beings, intestinal parasites are often common in poor environmental sanitation and personal hygiene resulting from contamination of soil and water sources with human faeces (Okyay et al., 2004; Gamboa et al., 2003). The eggs in contaminated soil are transferred onto vegetables by use of hands and ingested directly into the mouth (Koyabashi, 1999), through eating raw vegetables (Mustafa et al., 2001) or undercooked vegetables eaten to retain the natural taste and preserve heat-labile nutrients (Slifko et al., 2000). The risk of intestinal parasites is even higher among the inhabitants of towns of the developing countries especially in the shanties and slums where there is poor disposal of garbage, poor health systems and overcrowding (Crompton & Savioli, 1993). Intestinal parasites eggs, larvae and cysts have been found to adhere to vegetables, fruits, money, fingers, utensils and door handles (Kagei, 1993). Additionally, intestinal
parasites can be transmitted through flies (Monzón et al., 1991) and contaminated fingernails (Ismid & Rukmono, 1983). Strong winds may blow eggs of intestinal parasites in dust to the exposed meat in butcheries (Kunii, 1992) and cysts of intestinal parasites have been found to adhere on meat carcasses (Rajinish et al., 2004) hence increasing the risk of transmission to humans.

In man, intestinal parasites are significantly associated with diarrhoea (Utzinger et al., 1999), loss of appetite, malabsorption, vomiting, abdominal pains, impaired body development, nausea, irritations of intestinal lining, loss of body weight, urticaria rash, parlour, wastage and pot-belly among others (Kim et al., 2002; Sakakibara et al., 2002). They cause significant morbidity and mortality throughout the world, particularly in developing countries especially in persons with comorbidities. This accounts for 2.95-39.0 million Disability Adjusted Life years (DALY) lost and costs 12,000-135,000 lives yearly world wide, the resulting diseases have socio-economic impact in terms of both the cost of treatment per disability adjusted life-year (DALY) as well as the cost per hospitalization (WHO, 2004; Utzinger & Keiser, 2004). One DALY is defined as the loss of one year of healthy life to disease (Muennig et al., 1999). World wide, millions of people suffer from parasitic infections such as *Ascaris lumbricoides* (1.2 billion), *Trichuris trichiura* (795 million), hookworms (*Ancylostoma duodenale* and *Necator americanus*) (740 million) (de Silva et al., 2003) *Entamoeba histolytica* (50 million) (Samuel et al., 2001) and *Giardia lamblia* (2.8 million) (Ali & Hill, 2003). The Kisii Municipal markets are characterized by a lack of bathrooms and washing facilities, poor sanitary conditions of latrines which lack water supplies and a frequent presence of piles of garbage that provide a fertile environment for transmission of intestinal parasites (Nyarango et al., 2008).
1.2 Problem statement and justification

Out of an estimated 3.5 billion people infected with intestinal parasites world wide, 450 million are ill and the populations of infected people is on the upsurge (WHO, 1998). It is projected that by the year 2025, about 57% of the population in developing countries will live in urban areas (Celiksoz et al., 2005) where intestinal parasitic infections persist and flourish due to inadequate sanitation and insufficient health care (Auer, 1990). Epidemiological surveys done in Kenya’s poor peri urban and urban communities revealed a high prevalence of intestinal parasitic infections with *Ascaris lumbricoides* (82%), *Trichuris trichiura* (60%), *Entamoeba histolytica* (41%) and *Giardia lamblia* (30%) (Rijsptra, 1975). Additionally, recent studies done at various locations in Kisii highlands equally showed a high prevalence of intestinal parasites with *A. lumbricoides* (10%), hookworm (4%) and *T. trichiura* (0.1%) (Akhwale et al., 2004). Intestinal parasitic infections results in diseases which have socio-economic impact in terms of losing income, manpower, incurring high medical costs, reduced performance in jobs and agriculture.

Previous studies that have been done in Kenya only show prevalence of intestinal parasites in populations (Rijsptra, 1975; Akhwale et al., 2004). However, the environmental risk factors predisposing individuals to the above infections have not been clearly elucidated (Nyarango et al., 2008). Therefore, this study was designed to establish the risk factors enhancing transmission of intestinal parasites and assess the predisposing sanitary conditions in major markets in Kisii Municipality.
1.3 Research questions

a) What are the intestinal parasites found in vegetables sold in Kisii Municipality?

b) What are the influences of meat handling practices on the prevalence of intestinal parasites in Kisii Municipality?

c) What is the occurrence of intestinal parasites among food handlers examined at Kisii level -5 -Hospital?

1.4 Hypotheses

a) There are no intestinal parasites found in vegetables sold in Kisii Municipality open air Markets.

b) Meat handling practices do not influence the prevalence of intestinal parasites in Kisii Municipality.

c) There are no intestinal parasites among food handlers at Kisii level -5 –Hospital.

1.5 Objectives of the study

1.5.1 General objective

To establish the risk of intestinal parasitic infections in Kisii Municipality, Kenya.

1.5.2 Specific Objectives

a) To establish the prevalence of intestinal parasites in vegetables sold in Kisii Municipality open air Markets?

b) To establish the influences of meat handling practices on the prevalence of intestinal parasites in Kisii Municipality?

c) To determine the occurrence of intestinal parasites among food handlers examined at Kisii level -5 –Hospital?
CHAPTER TWO: LITERATURE REVIEW

2.1 Intestinal parasites

Intestinal parasites inhabit the gastro-intestinal tract of human beings with major
groups of such parasites include parasitic worms (helminths) and protozoa. Intestinal
helminths are classified into three major groups that include: Nematodes (round
worms) like *Ascaris lumbricoides*, hookworms (*Ancylostoma duodenale* and *Necator
americanus*), whipworm (*Trichuris trichiura*) and pinworm (*Enterobius
vermicularis*), trematodes (flukes) such as *Schistosoma mansoni* and cestodes
(tapeworms) that include *Taenia saginata* (beef tapeworm), *Taenia solium* (pork
tapeworm) and *Hymenolepis nana* (dwarf tapeworm). Intestinal protozoa are mainly
categorized into: Amoeba such as *Entamoeba histolytica*, flagellates which include
*Giardia lamblia*, ciliates like *Balantidium coli* and coccidian that encompasses
*Cryptosporidia* *spp* and *Cyclospora* *spp* (de Silva *et al.*, 2003; Brooker *et al.*, 2004).

2.2 Distribution of intestinal parasites

Intestinal nematodes inhabit the human gastro-intestinal tract of more than 25% of the
world’s population (de Silva *et al.*, 2003). This account for 2.95-39.0 million
Disability Adjusted Life Years (DALY) lost and costs 12,000-135,000 lives each year
globally (WHO, 2002, 2004; Utzinger & Keiser, 2004). It is currently estimated that
1,200 million people are infected with *A. lumbricoides* worldwide, 795 million
people are infected with *T. trichiura* and 740 million people are infected with
severe infections are often asymptomatic, while heavy infection can lead to severe
anemia, adverse effects on pregnancy, and impairment of children’s growth and
development, as well as reduced worker productivity. Additionally, the global
prevalence of *Entamoeba histolytica* is estimated to be 500 million people (Crompton & Savioli, 1993), killing 40 000–100 000 people annually (Stanley, 2003) whereas *Giardia lamblia* infects 200 million people globally (Raso, 2004).

Intestinal parasitic infections are more prevalent in the developing world, particularly among the poorest segments of rural communities (Chiodini, 2001). They are widespread across diverse ecosystems in the tropics and subtropics. Recent cross-sectional surveys carried out in sub-Saharan Africa consistently confirmed these observations (Brooker et al., 2000). Lack of access to clean water and improved sanitation facilities and inadequate personal hygiene are important underlying risk factors (Asaolu & Ofoezie, 2003). It has been noted that the number of good quality studies pertaining to parasite communities in entire populations is small compared to the magnitude of this phenomenon and its public health significance and studies carried out focus on children (Raso, 2004).

### 2.3 Epidemiology of intestinal parasites

Common to all human intestinal helminths is that transmission occurs in areas of humid contaminated soils coupled with poor sanitation. Moist and warm soils are required to complete the life-cycle of hookworms, hence transmission can occur year round in tropical and subtropical countries, while in cooler or drier climates, transmission takes place only in the warmer or wet seasons. The eggs of *A. lumbricoides* develop best in shady, damp soils and are resistant to cold and to disinfectants. Direct sunlight and temperatures above 45°C can kill the eggs. The embryo develops at 21-30°C, within a period of 2-4 months; at an optimum temperature of 25°C, developmental period is reduced to 3 weeks. Similarly,
*T. trichiura* primarily infects human beings and is common in areas of high rainfall, high humidity and dense shade (Gilles, 2003).

The distribution among individuals infected with intestinal helminths is highly aggregated. Most individuals harbor few parasites, while only a few harbor a high parasitic load. Expressed in percentages, 10% of the infected population carries approximately 70% of the worms (Anderson & Schad, 1995; Bundy, 1995). Interestingly, the worm fecundity is decreased when the worm load in an individual is high (Anderson & Schad, 1995; Bradley et al., 1992). *Ascaris* and *Trichuris* infection intensities vary among age groups, with an increase in childhood and a decline in adulthood. The heaviest burden with *T. trichiura* is found in school-age children, who may pollute the soil around their house, thus the disease can be transmitted when playing (Gilles, 2003). In contrast, hookworm infection intensities increase steadily with age (Bradley et al., 1992). Behavioral, social, nutritional and genetic factors influence the predisposition of heavily infected individual within a community (Chan et al., 1992; Brooker et al., 2004). For example, cultural or agricultural practices, such as the use of faeces for fertilizer are risk factors for infection.

In areas where *Ascaris* infections are common, three distinct trends have been described. First, high prevalence of over 60% in the whole population over 2 years, with lower infection in adults, where the population is constantly exposed to *Ascaris* eggs by contaminated hands or food. Second, moderate prevalence below 50% with a peak at young school-age children and low prevalence in adults, where family or household transmission is dominant. Third, the overall prevalence is below 10%,
which is related to a focal distribution due to inadequate housing and sanitary conditions or agricultural and behavioral practices (Crompton & Pawlowski, 1985).

*Taenia* spp infection cause taeniasis and previous studies show that it is a major public health problem associated with consumption of pork, beef and lack of knowledge regarding the associated risk factors (Kumar & Gaur, 1994). *Enterobius vermiculais* is prevalent in temperature regions. The male worm dies after copulation in the intestines, while he female is attracted to lower temperatures and an aerobic environment, migrates down the large intestine laying numerous eggs around the anal area (Markell et al., 1999). *Strongloides stercoralis* share their geographic distribution with hookworms (Bogitsh & Cheng, 1998). Trematodes such as *S. mansoni* and *S. japonicum* cause schistosomiasis and remains a significant public health and economic problem, especially in sub-Saharan Africa, where millions of people suffer from morbidity and 200,000 people die every year as a consequence of the chronic nature of infection (van der werf et al., 2003). The global burden of Schistosomiasis may be as high as 4.5 million DALYs lost (WHO, 2002). Recent estimates for sub-Saharan Africa suggest 54 million people are infected with *S. mansoni* (van der werf et al., 2003).

It has been estimated that 12% of the world’s population is infected with *E. histolytica* (Farthing et al., 2003). Today, high prevalence of *E. histolytica* is reported mainly in countries of low socio-economic status, while low prevalence is found in industrialized countries. High prevalence of infection with *E. histolytica* has been reported from the Sub-Saharan Africa (Li & Stanley, 1996; Heckendorn et al., 2002). Cyst carriers are the main reservoir of *E. histolytica* infection. Infection occurs via the
faecal-oral route by ingesting faecal contaminated water or food. Food-borne outbreaks are caused by unsanitary handling of food, and during the preparation of food by infected persons. Agricultural practices such as the use of raw domestic sewage for vegetable cultivation can increase the risk of amoebiasis. It has recently been shown that farming people are significantly more infected with pathogenic intestinal protozoa due to the intake of raw vegetables grown on raw sewage (Srikanth & Naik, 2004). Epidemics due to *E. histolytica* can also occur when raw sewage comes into contact with water supplies and contaminates the drinking water (Farthing *et al.*, 2003). The major reservoirs of *Giardia* cysts are humans and contaminated surface water. *Giardia* cysts are able to survive for long periods outside the host and they are often found in surface water. Studies have indicated that controlling the survival of *Giardia lamblia* cysts in municipal water supplies is difficult since such cysts cannot be inactivated by treatment (Craun, 1984; Jephcott *et al.*, 1986). Contaminated food is also probable route of transmission, although it is thought to be relatively uncommon. Additionally, person to person spread by faecal-oral transmission is described in residential institutions, schools, and day care centres (Mineno & Avery, 2003).

2.4 Modes of transmission of intestinal parasites

2.4.1 Ingestion

Infecive eggs and cysts of faecal orally transmissible intestinal parasites can be acquired from contaminated environmental and poor personal hygiene such as contamination of food handlers’ fingernails with human faeces (Ismid & Rukmono, 1983), contamination with faeces residue has shown a potential transmission risk of intestinal parasites by food handlers (Lourencio *et al.*, 2004). The possibility of
contamination of food or water with eggs and cysts by infected food vendors has been found to be a major route of transmission of intestinal parasites to human beings (Idowu & Rowland, 2006). Recent studies have established that strong winds may blow eggs of intestinal parasites in contaminated dust to the exposed foodstuffs such as meat in butcheries (Kunii, 1992). Additionally, individuals purchasing vegetables and meat at the urban markets have been found to have higher risk of acquiring intestinal parasites (Cifuentes et al., 2000), especially when vegetables are consumed as salads and meat as raw or undercooked, consequently facilitating transmission of intestinal parasites in large numbers (McPherson et al., 2000). Parasites acquired through such a mode include, protozoans *E. histolytica*, *G. lamblia*, *B. coli* and helminthes, *A. lumbricoides*, and *T. trichiura*. However, studies have shown that *A. duodenale* can also be transmitted through ingestion of larvae in contaminated foods (Hotez et al., 2003).

2.4.2 Skin penetration

Infective filariform larvae of hookworms (*A. duodenale* and *N. americanus*) enter the human hosts through pores, hair follicles, even intact skin especially when handling contaminated foods (CDC, 1992). Additionally *strongyloides stercoralis* is transmitted through skin penetration (Lee, 1965).

2.5 Predisposing factors influencing the risk of acquiring intestinal parasites

2.5.1 Foodstuffs

It has been reported that in all tropical, sub-tropical and temperate regions where standards of hygiene are low, infection of intestinal parasites follow the ingestion of salad vegetables contaminated with embryonated eggs which are sometimes 'sticky'
and may be carried onto the mouth by hands, inanimate objects or foods, transmission may also be caused by contamination of a wide variety of foods by infected food handlers (Northrop-Clewes & Shaw, 2000). Additionally, *Ascaris lumbricoides* eggs and hookworm larvae adhere to vegetables and, hence they are then readily distributed in foodstuffs sold in markets. Studies show that *Ancylostoma duodenale* can be acquired by oral ingestion of larvae (Hotez et al., 2003). A survey from Japan found that at one time, *Ascaris lumbricoides* eggs were present on 1,178 of 2,750 items of vegetables sold in 40 Tokyo shops (Kobayashi, 1980). Children living in an area of Marrakesh, Morocco where raw sewage is used for agricultural irrigation were shown to have significantly higher prevalence of *Ascaris lumbricoides and Trichuris trichiura* infections when compared to a group of children where this was not a common practice (Bouhoulm & Schwartzbrod, 1997).

2.5.2 Human behavior and socio-economic status

Specific occupations and behaviors influence the prevalence and intensity of intestinal parasites infections. Engagement in agricultural pursuits remains a common denominator for human hookworm infection. Recent studies established the highest prevalence of intestinal parasites among vegetable growers and farmers (Hotez et al., 1991). Infection with the with intestinal parasites has been found to be endemic among this remote tea-growing community in Assam showing a strong association between low socioeconomic status, the prevalence and intensity of intestinal parasites. Subfactors that significantly correlated with socioeconomic status include: household crowding, literacy, use of footwear, defecation practices, food handling practices and sources of drinking water, have been identified as being important determinants for prevalence and intensity of infections of intestinal parasites in a locality (Anderson,
Studies show that environment of damp alluvial soil, shaded by tea trees, provide a perfect environment for the development of geohelminth larvae and would constitute a significant source of infection and re-infection (Olsen et al., 2001). The association between walking barefoot while outdoors and higher intensity of hookworm infections is a result of the cutaneous penetration of larvae as an infection source.

2.5.3 Environmental factors

Intestinal parasites like *Ascaris lumbricoides* have been found to show high infection rates in urban environments than rural environments (Phiri et al., 2000). In contrast, high rates of hookworm infection are typically restricted to areas where rural poverty predominates (Albonico et al., 1998). The urban-rural dichotomy between *Ascaris-Trichuris* versus hookworm can be partly understood by fundamental differences in the life cycles of these intestinal helminths. The infective stages of *Ascaris-Trichuris* are embryonated eggs having enormous capacity for withstanding the environmental extremes of urban environments. Viable *Ascaris lumbricoides* eggs have been recovered from soil samples for more than 10 years after having been first deposited (Crompton, 1989). In addition to ascaroside, *Ascaris lumbricoides* eggs are coated with a mucopolysaccharide that renders them adhesive to a wide variety of environmental surfaces; this feature accounts for their adhesiveness to everything from door handles, dust, fruits and vegetables, paper money and coins (Kagei, 1983; Crompton, 1989). The “five f’s” of parasitology, fingers, feces, fomites, flies and food might have originated with *Ascaris lumbricoides* in mind. Transmission through the ingestion of *Ascaris lumbricoides* eggs adhering to vegetables is a major route of transmission (Raisanen, 1985). The social and environmental conditions in the
unplanned slums of developing countries are ideal for the persistence of *A. lumbricoides* and *T. trichiura*. Many surveys have shown a high prevalence of these infections in children of slums, shanty towns and squatter settlements (Crompton & Savioli, 1993). However, the population density in urban slums should facilitate drug delivery and opportunities for health education. Individuals should also have easier access to purchasing anthelmintic drugs for treatment of their families (Crompton, 2001).

Climatic factors like warmth, moisture and total rainfall affect transmission of intestinal parasites (Brooker & Michael, 2000). Studies on the prevalence of helminth infections have shown a correlation with amount of rainfall and temperature implying seasonality affects distribution of intestinal parasites such as hookworm whose transmission rates were higher during high rainfall seasons (Mark, 1975; Udonsi *et al.*, 1980). In Saudi Arabia, a seasonal pneumonitis resulting from *Ascaris lumbricoides* migrations has been found to occur annually from March to May (Gelphi & Mustafa, 1967). In Japan, seasonal fluctuations in Ascaris infection were attributed to annual application of night soil to crops (Crompton, 1989).

### 2.5.4 Genetic Risk Factors

Over dispersion is a common feature of population distribution patterns for intestinal parasites infections in humans (Williams-Blangero *et al.*, 1997) leading some investigators to postulate that certain human populations may have increased genetic susceptibility. Epidemiological studies have identified a population of individuals who are predisposed to acquiring heavy hookworm infections despite multiple exposures to the parasite and even anthelmintic chemotherapy (Anderson & Schad,
Predisposition has also been described for *Trichuris trichiura* infections (Bundy, 1986) and *Ascaris lumbricoides* infections (Thein Hlaing et al., 1987; Haswell-Elkins, 1987). Predisposition to all three intestinal parasites may have either an immunologic, genetic or even a combined immunogenetic basis. For instance, some populations with low worm burdens have been noted to be relatively resistant to reinfection. Such individuals were noted to mount parasite specific IgE and eosinophilic responses (Quinnell et al., 1995; Pritchard et al., 1995). In one case, an association was noted between hookworm specific IgM responses and diminished prevalence and intensity (Xue et al., 2000).

2.6 Life cycle of intestinal parasitic infections

2.6.1 General life cycle of intestinal helminths

Intestinal helminthes are mainly nematodes whose developmental process involves ingestion of an egg by human beings in food or water contaminated with feaces which hatches into larval and adult stages, each of the four larval stages are followed by a molt in which the cuticle is shed and the larvae are called second-stage larvae after the first molt and the nematode formed at the fifth stage is called the adult (Fig. 1).
2.6.2 General life cycle of intestinal protozoa

Intestinal protozoa are transmitted by the fecal oral route and tend to exhibit similar life cycles consisting of a cyst stage and a trophozoite stage. Fecal-oral transmission involves the ingestion of food or water contaminated with cysts, after ingestion by an
appropriate host, the cysts transform into trophozoites that exhibit an active metabolism and are usually motile (Haque et al., 2003, Fig.2). The parasite takes up nutrients and undergoes a sexual replication during the trophic phase, however some of the trophozoites develop into cysts characterized by a resistant wall and are instead excreted with the feces. The cyst wall functions to protect the organism from desiccation in the external environment as the parasite undergoes a relatively dormant period waiting to be ingested by the next host. Factors that increase the likely hood of ingesting material contaminated with fecal material play a role in the transmission of these intestinal protozoa. In general, situations involving close human-human contact and unhygienic conditions promote transmission (Haque et al., 2003).

Figure 2. General life cycle of intestinal protozoa. Source (Haque et al., 2003)
2.7 Mixed intestinal parasitic infections

Recent cross-sectional surveys conducted in sub-Saharan Africa, Southeast Asia and South America confirmed that mixed infections are very common in developing countries (Utzinger et al., 1999; Guignard et al., 2000; Keiser et al., 2002; Waikagul et al., 2002 and Tchuem Tchuente et al., 2003). Interestingly, among the few existing studies that have investigated the issue of polyparasitism, most of them focused on a narrow age range, such as school-age children. The few studies performed in entire communities found that polyparasitism increases with age, reaching a plateau in adolescent and young adults and decreases in older age groups (Keiser et al., 2002).

The epidemiology of mixed intestinal parasitic infections is complex and most research groups have, traditionally, concentrated on single parasite-single host interactions (Cox, 2001). A myriad of factors contribute to polyparasitism, including lack of access to clean water and improved sanitary facilities, as well as low hygiene conditions (Asaolu & Ofoezie, 2003).

2.8 Impact of intestinal parasites on human beings

2.8.1 Human health

a) Exanguinivorous (sucking of blood by intestinal parasites from the human host) results in blood loss and this is a result of intestinal parasites such as hookworms that consumes the host blood hence causing microcytic hypochromic anemia (Gilgen et al., 2001). Compensatory volume of blood expands which contributes to hypoproteinemia, oedema, pica, eosinophilia and wasting. It has been noted that prevalence of iron deficiency anemia increased steadily proportionally as intestinal parasitic infection intensity and intestinal blood loss increases (Gilgen et al., 2001).
b) Nutritional effects that cause diseases accompanying intestinal parasitic infections are manifested mainly as nutritional disturbance, reduced food intake, impaired digestion and malabsorption resulting from *Ascaris lumbricoides* and *Trichuris trichiura* infections and the severity of disease caused by soil-transmitted nematodes has consistently been found to depend on the number of worms present per person (Crompton & Nesheim, 2002).

c) Cognition effects are where intestinal parasitic infections affect cognitive function especially when combined with nutritional deficits. Recent studies have shown a correlation between low educational achievement in examinations and intestinal parasitic infections. Further evidence shows that intestinal parasitic infections hamper attention processes (Kvalsvig *et al.*, 1991), especially when intensity of intestinal parasitic infection is high they adversely affects cognition and educational achievement (Kvalsvig *et al.*, 1992, Watkin and Pollitt, 1997). Mechanisms through which mental processes are affected is uncertain, but studies show that the mechanisms are indirect, this can be attributed to iron deficiency anaemia and under nutrition (Pollitt *et al.*, 1989).

d) Gastrointestinal obstruction in which some intestinal parasites are large like *Ascaris lumbricoides* being the largest nematode measuring 15-35 cm in length affects human beings by intestinal obstruction. Likewise *E.histolytica* can cause intestinal ulcerations and gastrointestinal obstruction (Corry *et al.*, 2004).

**2.8.2 Social economic status**

About 20% of Disability Adjusted life Years are usually lost due to a direct impact of intestinal parasitic infections (Murray & Lopez, 1996). Additionally, it is estimated that these infections represent more than 40% of the disease burden in tropical
countries (WHO, 1996). Reports indicate that up to 4.5 million DALYs lost are due to intestinal parasitic infection worldwide (WHO, 2002) and for sub-Saharan Africa, it is estimated that intestinal parasitic infections are responsible for 42.5% of the total DALYs lost in the region (Murray & Lopez, 1996). People living in poor sanitation areas are particularly at high risks for infections, hence associated morbidity and mortality, through a multiplicity of factors, including polluted water, lack of improved sanitation and foods contaminated with eggs and cysts of intestinal parasites. Costs associated with secondary transmission and lost productivity show a positive correlation to parasitic intestinal infections. Additionally high costs are incurred due to outpatient treatment, hospitalization, medical claims and man hours and such infections can result into death (Muennig et al., 1999).

2.9 Diagnosis of people with intestinal parasites

2.9.1 Clinical diagnosis

The symptoms used in clinical diagnosis of parasitic infections though not differential include: loss of appetite, diarrhea, malabsorption and vomiting, abdominal pains, impaired body development, nausea, irritations of intestinal lining, gastrointestinal infections and loss of body weight, urticaria rash, parlour, wastage and pot-belly (Kim et al., 2002).

2.9.2 Laboratory diagnosis

The diagnosis of intestinal parasitic infections is done by detection of eggs, trophozoites or cysts in faeces by using direct smears, Kato-Katz thick smears or concentration methods, and subsequent microscopic examination (Katz et al., 1972; Marti & Escher, 1990).
2.10 Parasitological analysis of foodstuffs

Fresh foodstuffs are washed with distilled water, the suspension is then strained through a sieve of 4mm² pore sizes to remove undesirable materials then the filtrate is centrifuged and examined using a light microscope (Kagei, 1983).

2.11 Control of intestinal parasites

2.11.1 Sanitation and hygiene

Proper disposal of human and animal wastes prevents contamination of foods and drinking water sources, it is an excellent strategy for preventing human intestinal parasitic infections that are transmitted by fecal–oral route (Asaolu et al., 2002). In developing countries, sometimes these wastes however serve as fertilizer for crops. Composting such waste materials has been found to kill eggs of intestinal parasites (Asaolu et al., 2002). Control of flies, and other insects in food selling points prevents dispersal of infective stages of intestinal parasites to foods (Asaolu et al., 2002 & McPherson et al., 2000). Studies indicate that washing of meat, raw vegetables, fruits, utensils and hands prevent cross-contamination of foods with eggs and cysts of intestinal parasites (McPherson et al., 2000).

2.11.2 Health education

People should be educated on proper sanitation, which involves promotion of the use of latrines which do not accommodate the use of human excreta as fertilizer in agriculture (Government of Vietnam, 1997) and such latrines should include the pour flush and septic tanks, which are superior from a hygienic point of view to the traditional ones of composting latrine in which people may store human excreta and have access when needed for use in agricultural production and Sometimes small-
scale farmers use the open or broken sewage system as a source of fertilizer (Gilen et al., 2001). However, for such sanitation and hygienic promotion programmes to be successful, legislation must acknowledge the practice of using excreta as fertilizer.

Intestinal parasitic infections can be prevented or greatly reduced through cost-effective interventions as avoiding ingestion and direct contact with contaminated foodstuffs. Food safety measures help prevent intestinal parasitic infections which are transmitted by meat or vegetables. Health education involves the following: drug treatment for those already infected because they can act as reservoirs of intestinal parasitic transmissions, sanitary and personal hygiene improvements to prevent reinfection and break the life cycle of transmission of parasites from person to person through safe, efficient and hygienic food preparation methods, proper food storage and hand washing especially when one comes into contact with stool (WFP/UNESCO/WHO, 1999).

Health educators should encourage individuals to adopt behaviors that will prevent self reinfections or reservoirs of other people’s infection and must be multidisciplinary where various stakeholders will be involved to educate the public on sanitation and personal hygiene in controlling intestinal parasitic infections (WFP/UNESCO/WHO, 1999).

2.11.3 Processing of foodstuffs before consumption

2.11.3.1 Marinating, pickling, smoking and fermentation

Marinating involves keeping meat in a marinate (mixture of oil, wine, vinegar and spices) to destroy parasites. Pickling is the preserving foods in a pickle (a liquid especially vinegar, salt and water), traditional Mexican methods of salt pickling of
pork kills larvae of parasites (Zanini and Graeff, 2001). Fermentation of meat to produce dry sausages and ham inactivates both protozoa and larvae of parasite worms. Low pH and low water activity kill parasites (Foster et al., 2003; Lund et al., 2000; Zanini & Graeff, 2001).

2.11.3.2 Cooking and heat treatment of food stuffs
Adequate cooking of foods and boiling of water destroy all infective stages of intestinal parasites, however, microwave cooking does not reliably kill all intestinal parasites in foodstuffs because heating is uneven and cooler spots may permit survival of such parasites (Audicana et al., 2002; Wharton & Aalders, 2002).

2.11.3.3 Freezing of foodstuffs
Freezing of raw foodstuffs can inactivate or kill intestinal parasites, however some other foodstuffs require longer or shorter freezing to kill intestinal parasites (CDC, 2003). Therefore, frozen foods should be well cooked and water boiled to destroy intestinal parasites infective stages.

2.11.3.4 Filtration and disinfections
Filtration eliminates some protozoan cysts and oocysts from water. However, Cryptosporidium spp has been found in filtered water. Chlorination eliminates some parasites from water but cysts and oocysts are resistant. (Rabold et al., 1994; Vencz et al., 1997; Von, 2003). Soaking of vegetables in 1.5% bleach solution, vinegar, potassium permanganate solution (24 mg/l) or saturated sodium chloride solution (Zanini and Graeff, 2001) destroy, infective larvae of some nematodes (Greenbloom et al., 1997), A 10% solution of ammonium hydroxide kills 94% of Ascaris lumbricoides eggs after 3 hours (Ondrasovic et al., 2003).
2.11.3.5 Chemotherapy

Individuals identified positive for an infection with intestinal parasites should be treated, as they are the main reservoirs of such parasite transmissions (Farthing et al., 2003). This can be done by administration of antihelminthic drugs such as Mebendazole, Levamisole and Albendazole while Iodoquinol, Dehydroemetine and quinacrine are used for treatment of intestinal protozoa (Morales et al., 2002). Drugs for deworming are potent tools for reducing or controlling intestinal parasitic infection.

2.11.3.6 Integrated methods of controlling intestinal parasites

This involves using combined methods, which interrupts the transmission cycle of intestinal helminthes (Fig.3). Such methods include chemotherapy that decreases the burden and transmission cycle. Studies have demonstration that combined treatment of pathogenic intestinal parasites with single oral doses of praziquantel and albendazole is safe and efficacious (Savioli et al., 1992). Improved sanitation aimed at reducing soil, water or food contamination and health education, which aims at encouraging healthy behaviour is essential in controlling the spread and transmission of intestinal parasites (Savioli et al., 1992).
Figure 3. Diagrammatic representations of integrated methods of interrupting transmission cycle of intestinal parasites. Source (Savioli et al., 1992).
CHAPTER THREE: MATERIALS AND METHODS

3.1 Study site

The study was carried out between December 2006 and June 2007 in Kisii Municipality, which is located at the southern end of the western Kenya highlands within geographical coordinates of 0°41'S 34°46'E and an altitude of 1660m above sea level. The area receives average rainfall of over 1500mm per annum distributed almost throughout the year although there are two rainy seasons (March to May and October to November). Temperatures range from 10°C to 30°C with relative humidity of 88%. The area is densely populated with a population of 70,000 people and a density of 1295 people/km² (CBS, 2001). There are five major open air markets in Kisii Municipality however, foodstuffs were sampled from the two indicated markets (Fig. 4). Majority of the population depends on open air markets as a source of both meat and vegetable foodstuffs although there is poor drainage and sanitation characterized by presence of refuse dump sites nearby (Plate 1).

Figure 4. A map of Kisii Municipality (inset map of Kenya). Source (CBS, 2006).
3.2 Study design

A correlational descriptive study design was used. It was chosen because it answers research questions on what is happening, how it is happening and why it is happening and finally describes the statistical association between two or more variables under study. This is unlike simple descriptive research design that only describes the characteristics of variables while comparative descriptive design only compares variables.

3.3 Study food stuffs and subjects

Two open air markets were selected out of the five markets of Kisii Municipality. A total of 21 samples weighing 250g for species of vegetable: spider flower (Gynandropsis gynandra), black nightshade (Solanum nigrum), cabbage (Brassica oleracea capitata) and kales (Brassica oleracea var. acephala) (Plate 2) were
collected each day from the vendors in the open air markets. A total of 20 samples for various types of meat: beef, mutton and bacon each weighing 250g were collected from 22 selected butcheries within Kisii Municipality that were selected (Plate 3). The 168 food handlers and food stuffs were analysed at Kisii level -5 -Hospital intestinal parasitological profile.

Plate 2. Vegetables sold at the open air markets of Kisii Municipality: (A (spider flower (Gynandropsis gynandra), B (black nightshade (Solanum nigrum), C (cabbage (Brassica oleracea capitata) and D (kales (Brassica oleracea var. acephala).

Plate 3. Meat selling points (E (Vendor serving dual as cashier) F (Open sewer system around meat selling points)
3.4 Sampling procedures

Two open air markets were randomly using lottery method selected out of the five markets of Kisii Municipality. Vegetable samples were collected weekly by randomly using lottery method from vendors in the open air market between 9.00 a.m. and 12.00 mid days. The asymptomatic adult male and female food handlers were randomly selected by lottery method from a list of attendance at Kisii level -5- Hospital for routine examination of stool parasitological profile according to the Kenyan Ministry of Health Regulations (1972). Each subject selected was given a plastic stool container and asked to bring bean-sized stool sample within 24 hours. However, this study did not examine parasitological profile of slaughter houses, dust coats the butchers wear, hand washes of meat vendors, infestation rates of various types of meat and the food handlers examined were not matched with meat and vegetable selling points sampled.

3.5 Sample size determination

3.5.1 Butcheries

This was done according to Mulusa (1988) who suggests that one third of the target subjects are representative enough to make estimate of characteristics being investigated. Hence out of the sixty butcheries in Kisii Municipality a third was twenty two butcheries.
3.5.2 Foodstuffs

The sample size for foodstuffs was calculated on a prevalence of 10%, \( d = 0.05 \) at a confidence level of 95% (Daniel, 1999).

\[
n = \frac{Z^2 \cdot p(1-p)}{d^2}
\]

Where \( n \) = sample size,

\( Z \) = \( Z \) statistic for a level of confidence

\( P \) = expected prevalence or proportion (in proportion of one; if 10%, \( P = 0.1 \))

\( d \) = precision (in proportion of one; if 5%, \( d = 0.05 \)).

\[
n = \frac{1.96^2 \times 0.1(1-0.9)}{(0.05)^2} = 138.3 = \frac{138}{7} = 19.7 \times 21.
\]

Therefore 21 samples of each type of vegetable and 20 meat samples from each butchery were used.

3.5.3 Food handlers

The sample size for food handlers was calculated based on the primary outcome variable (presence or absence) of intestinal parasites, 'best guess' of expected percentage (proportion) based on previous studies = 12.5% (0.125) and desired width of 95% confidence interval = 10% (i.e. +/- 5%) (Thomas et al. 2001).

\[
n = \frac{15.4 \times p \times (1-p)}{w^2}
\]

Where

\( n \) = the required sample size

\( p \) = the expected proportion (proportion) - here 0.125

\( W \) = width of confidence interval - here 0.10

15.4 = a constant
\[
\frac{n = \frac{15.4 \times 0.125 \times (0.875)}{(0.10)^2}}{} = 168
\]

3.6 Laboratory investigations

The parasitological analysis of the foodstuffs and food handlers was carried out at the Kisii Provincial Hospital.

3.6.1 Foodstuffs

Vegetable and meat parasitological analysis was done as described by Kagei (1983). The 250g samples of each foodstuff were washed in distilled water. The suspension was strained through a sieve of 4mm² pore size to remove undesirable materials. The filtrate was centrifuged at 3000 rpm for 2 minutes. The supernatant was discarded and the deposit suspended in magnesium sulphate floatation fluid of specific gravity 1.3 and the centrifuged again at 3000 rpm for another 2 minutes. The floatation fluid was filled to the brim and a cover slip was superimposed on it to stand for 5 minutes. The cover slip was lifted, placed on a glass slide and examined under a light microscope. The cysts and eggs present were identified as described by Suzuki (1981).

3.6.2 Assessment of food handling practices

The meat handling practices of the butcheries including the meat storage method(s), the handlers’ hygienic standards and the presence of houseflies on meat samples were observed on every sampling occasion using a checklist (Appendix I).

3.6.3 Food handlers

Food handlers attending Kisii level -5 -Hospital selected for stool parasitological profile were each given a plastic stool container and asked to bring stool sample
within 24 hours. A direct saline smear of stool sample specimen obtained from the food handlers was prepared and examined using a light microscope for trophozoites, ova and cysts of intestinal parasites. The stool samples were examined for intestinal parasites in direct smear and formalin-ethyl acetate sedimentation method (Truant et al., 1981) where 10 mls of formalized stool sample was added to a 15 ml centrifuge tube and 3 ml of formalin-ethyl acetate solvent was added. The tube was stoppered, shaken vigorously for 30 s, and the mixture was centrifuged at 2000 rpm for 2 min. After loosening the debris plug, the top three layers were decanted, the pellet was suspended in residual water and homogenized with gentle stirring, and slides were prepared for examination using a light microscope. The cysts, trophozoites and eggs present were identified (Suzuki, 1981).

3.7 Ethical considerations

Ethical clearance was obtained from Kenyatta University and Ministry of Science and Technology. Consent of the food handlers was obtained before taking the samples for stool examination.

3.8 Data analysis

A computer program (SPSS 11.5 for Windows) was used for data analysis. The categorical (present or absent) dependent and independent variables were coded in Excel before importing to SPSS, multiple logistic regression analysis was used. $\chi^2$ was used to establish the difference in distribution of dependent variable (outcome) among independent variables (risk factors). The differences were considered to be statistically significant when the p-value obtained was less than 0.05.
CHAPTER FOUR: RESULTS

4.1 Prevalence of intestinal parasites in vegetables sold in Kisii Municipality open air Markets

The 84 vegetable samples collected were infested with one or more intestinal parasites. Of the protozoa, *Entamoeba histolytica* was the most prevalent parasite detected among vegetables sampled 33 (39.3%). The least protozoa isolated from vegetable samples was *Balantidium coli* 20 (23.8%). Additionally, among the helminthes *Ascaris lumbricoides* 39 (46.4%) highly infested vegetables while *Trichuris trichiura* 20 (23.8%) was the least parasite isolated from vegetables. Sixteen (19.0%) of the samples were highly infested with mixed infestations comprising of *Entamoeba histolytica* and *Ascaris lumbricoides* with 3 (1.8%) having *Entamoeba histolytica* and *Ascaris lumbricoides* however, a few of the vegetables were infested *Entamoeba histolytica* and *Trichuris trichiura* 10 (12.0%). In all, spider flower had the highest prevalence 68 (81.0%) of intestinal parasites while Kales were least infested 43 (51.1%) (Table 1). There was a statistically significant difference between prevalence rates of intestinal parasites and types of vegetables ($\chi^2 = 179.12$, $df = 3$, $p = 0.000$). The cysts of *Entamoeba histolytica* were the major protozoa isolated from vegetable samples while helminthes included fertilized eggs of *Ascaris lumbricoides* (Plate 4). The other parasites isolated from food stuffs were protozoa cysts of *Giardia lamblia*, helminth larvae of hook worms and *Trichuris trichiura* eggs (Plate 5).
Table 1: Infestation rates of intestinal parasites in various types of vegetable samples

<table>
<thead>
<tr>
<th>Parasite class/ species</th>
<th>Kales (n=21)</th>
<th>Cabbage (n=21)</th>
<th>Black night shade(n=21)</th>
<th>Spider flower (n=21)</th>
<th>% infestation of total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Protozoa</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Entamoeba histolytica</em></td>
<td>7(8.3)</td>
<td>7(8.3)</td>
<td>9(10.7)</td>
<td>10(12.0)</td>
<td>33(39.3)</td>
</tr>
<tr>
<td><em>Giardia lamblia</em></td>
<td>6(7.1)</td>
<td>10(12.0)</td>
<td>5(6.0)</td>
<td>10(12.0)</td>
<td>31(36.9)</td>
</tr>
<tr>
<td><em>Balantidium coli</em></td>
<td>4(4.8)</td>
<td>6(7.1)</td>
<td>6(7.1)</td>
<td>4(4.8)</td>
<td>20(23.8)</td>
</tr>
<tr>
<td><strong>Sub Total protozoa</strong></td>
<td>17(13.9)</td>
<td>23(27.4)</td>
<td>20(23.8)</td>
<td>24(28.6)</td>
<td></td>
</tr>
<tr>
<td><strong>Helminthes</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Ascaris lumbricoides</em></td>
<td>9(10.7)</td>
<td>9(10.7)</td>
<td>10(12.0)</td>
<td>11(13.1)</td>
<td>39(46.4)</td>
</tr>
<tr>
<td><em>Hookworms</em></td>
<td>4(4.8)</td>
<td>7(8.3)</td>
<td>9(10.7)</td>
<td>5(6.0)</td>
<td>25(29.8)</td>
</tr>
<tr>
<td><em>Trichuris trichiura</em></td>
<td>3(3.6)</td>
<td>2(2.4)</td>
<td>8(9.5)</td>
<td>7(8.3)</td>
<td>20(23.8)</td>
</tr>
<tr>
<td><strong>Sub Total Helminthes</strong></td>
<td>16(19.4)</td>
<td>18(21.4)</td>
<td>27(32.1)</td>
<td>23(27.4)</td>
<td></td>
</tr>
<tr>
<td><strong>Mixed infections</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>E.histolytica+A.lumbricoides</em></td>
<td>3(3.6)</td>
<td>2(2.4)</td>
<td>4(4.8)</td>
<td>7(8.3)</td>
<td>16(19.0)</td>
</tr>
<tr>
<td><em>E.histolytica+G.lambia</em></td>
<td>2(2.4)</td>
<td>3(3.6)</td>
<td>2(2.4)</td>
<td>5(6.0)</td>
<td>12(14.3)</td>
</tr>
<tr>
<td><em>E.histolytica</em> + Hookworms</td>
<td>3(3.6)</td>
<td>1(1.2)</td>
<td>4(4.8)</td>
<td>6(7.1)</td>
<td>14(16.7)</td>
</tr>
<tr>
<td><em>E.histolytica + T. trichiura</em></td>
<td>2(2.4)</td>
<td>2(2.4)</td>
<td>3(3.6)</td>
<td>3(3.6)</td>
<td>10(12.0)</td>
</tr>
<tr>
<td><strong>Sub -total mixed infestations</strong></td>
<td>10(10.7)</td>
<td>8(9.5)</td>
<td>13(15.5)</td>
<td>21(25.0)</td>
<td></td>
</tr>
<tr>
<td><strong>Overall total number of Vegetables</strong></td>
<td>43(51.1)</td>
<td>49(58.3)</td>
<td>60(71.4)</td>
<td>68(81.0)</td>
<td></td>
</tr>
</tbody>
</table>

Plate 4. Intestinal parasites isolated from vegetables samples: Cyst of *Entamoeba histolytica* (A) and fertilized ova of *Ascaris lumbricoides* (B)
Plate 5. Intestinal parasites isolated from sampled food stuffs: Cyst of *Giardia lamblia* (A), Hook worm larvae (B) and egg of *Trichuris trichiura* (C)

### 4.2 Risk factors influencing intestinal parasites at meat selling points

The risk factors influencing infection with intestinal parasites associated with food handling practices were investigated in 22 butcheries. These factors included the meat storage methods, cashier serving meat and handling cash, the wearing or not wearing white dustcoats and presence or absence of houseflies on meat samples (Table 2).

<table>
<thead>
<tr>
<th>Risk factor</th>
<th>No of samples (n)</th>
<th>(%)Frequency of intestinal parasites</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Storage Method</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Refrigerator</td>
<td>80</td>
<td>31 (7.0)</td>
</tr>
<tr>
<td>Open surface</td>
<td>200</td>
<td>165 (37.5)</td>
</tr>
<tr>
<td>Wire mesh</td>
<td>160</td>
<td>138 (31.4)</td>
</tr>
<tr>
<td><strong>Cashier</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Absent</td>
<td>300</td>
<td>263 (59.8)</td>
</tr>
<tr>
<td>Present</td>
<td>140</td>
<td>71 (16.1)</td>
</tr>
<tr>
<td><strong>Protective clothing</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Present</td>
<td>200</td>
<td>134 (30.5)</td>
</tr>
<tr>
<td>Absent</td>
<td>240</td>
<td>200 (45.5)</td>
</tr>
<tr>
<td><strong>Houseflies</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Present</td>
<td>300</td>
<td>263 (60.0)</td>
</tr>
<tr>
<td>Absent</td>
<td>140</td>
<td>71 (16.1)</td>
</tr>
</tbody>
</table>
4.2.1 Meat storage methods and prevalence of intestinal parasites

Out of the 22 butcheries where meat was sampled, the most preferred storage method used was placing the meat on the surface of a table (open surface) 10 (45.5%) while the least was placing the meat in refrigerator 4 (18.2%). Meat placed in an open surface was highly infested 165 (37.5%) with intestinal parasites compared with meat stored in a refrigerator which had least infestation rates 31 (7.0%) of intestinal parasites (Fig. 5). There was a significant difference of prevalence of intestinal parasites depending on the storage method used ($\chi^2 = 37.628$, df = 2, p=0.000).

![Figure 5. Prevalence of intestinal parasites against meat storage methods](image)

4.2.2 Personnel handling meat, cash and prevalence of intestinal parasites at meat selling points

The number of butcheries where vendors played dual roles as cashier were 15 (68.2%) while those that had different meat vendors and cash were 7 (31.8%). In the meat samples obtained from areas where vendors served dual roles of handling meat and cash, 263 (87.7%) meat samples were infested with intestinal parasites whereas those obtained from butcheries where there were vendors and cashiers 71 (50.7%) meat
samples were infested with intestinal parasites. There was a significant difference in prevalence of intestinal parasites in meat samples where the vendors served dual roles as cashier compared to the butcheries where there were vendors handling meat only and cashier handling cash ($\chi^2=65.737$, df=1, p=0.000) (Table 3).

**Table 3: Relationship of intestinal parasites and handling of samples obtained from butcheries where there were vendors and cashier or vendor served dual as cashier**

<table>
<thead>
<tr>
<th>Risk factor</th>
<th>n</th>
<th>Frequency of intestinal parasites (%)</th>
<th>$\chi^2$</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vendor</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dual as cashier</td>
<td>300</td>
<td>263 (87.7%)</td>
<td>65.737</td>
<td>0.000</td>
</tr>
<tr>
<td>Vendor and cashier</td>
<td>140</td>
<td>71 (50.7%)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**4.2.3 Prevalence of intestinal parasites and protective attire of meat vendors**

The meat samples obtained from butcheries where vendors were white dustcoats had a low prevalence of intestinal parasites 134 (67.0%) whereas those meat samples obtained from butcheries where vendors were not wearing white dustcoats a high prevalence of intestinal parasites 200 (83.3 %). The wearing of white dustcoats did not significantly determine the number of intestinal parasites ($\chi^2 =7.500$, df =1 p=0.060) among meat samples (Table 4).
Table 4: Relationship of intestinal parasites and meat samples obtained from butcheries where there were vendors wearing or not wearing white dust coats

<table>
<thead>
<tr>
<th>Risk factor</th>
<th>n</th>
<th>Frequency of intestinal parasites (%)</th>
<th>$\chi^2$</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protective clothing</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vendor wearing white</td>
<td>200</td>
<td>134 (67.0%)</td>
<td>7.5</td>
<td>0.060</td>
</tr>
<tr>
<td>dustcoats</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vendor not white</td>
<td>240</td>
<td>200 (83.0%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>dustcoats</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

4.2.4 Prevalence of intestinal parasites among meat samples obtained from butcheries where houseflies were either present or absent on meat samples

The number of butcheries where houseflies were found on meat samples collected were 13 (59.1%) while those that did not have houseflies was 9 (40.9%). Meat samples that were frequently in contact with houseflies had a high prevalence of intestinal parasites 263 (87.7%) compared with meat samples that were not in contact with houseflies 140 (50.7%). There was a significant difference in prevalence of intestinal parasites on meat samples exposed to houseflies ($\chi^2=65.737, df=1$  $P=0.000$) (Table 5).

Table 5: Relationship of intestinal parasites among meat samples obtained from butcheries where houseflies were either present or absent on meat samples

<table>
<thead>
<tr>
<th>Risk factor</th>
<th>n</th>
<th>Frequency of intestinal parasites (%)</th>
<th>$\chi^2$</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>House flies</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Presence on meat</td>
<td>300</td>
<td>263 (87.7%)</td>
<td>65.737</td>
<td>0.000</td>
</tr>
<tr>
<td>Absent on meat</td>
<td>140</td>
<td>71 (50.7%)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Four hundred and forty meat samples collected were infested with one or more intestinal parasites. Of the protozoa *Entamoeba histolytica* 91 (20.7%) highly infested meat samples while *Balantidium coli* 12 (2.7%) was the least intestinal parasite infesting vegetables. Additionally, among the helminthes *Ascaris lumbricoides* 108 (24.5%) highly infested with *Trichuris trichiura* 6 (1.4%) being the least. Four (0.9%) of the samples were infested with mixed infestations comprising of *Entamoeba histolytica* and *Ascaris lumbricoides* with 3 (0.7%) having *Entamoeba histolytica* and *Trichuris trichiura*. In all meat sampled, a high proportion 334 (75.9) were highly infested with intestinal parasites (Table 6). There was no statistically significant difference between infestation rates of intestinal parasites types ($\chi^2=119$, df=3, p >0.050).

Table 6: Infestation rates of intestinal parasites in meat samples

<table>
<thead>
<tr>
<th>Parasite class/ species</th>
<th>(%) Infestation rates of meat examined (N= 440)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Single infestations</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Protozoa</strong></td>
<td></td>
</tr>
<tr>
<td><em>Entamoeba histolytica</em></td>
<td>91 (20.7)</td>
</tr>
<tr>
<td><em>Giardia lamblia</em></td>
<td>57 (13)</td>
</tr>
<tr>
<td><em>Balantidium coli</em></td>
<td>12 (2.7)</td>
</tr>
<tr>
<td><strong>Sub Total protozoa</strong></td>
<td>160 (36.4)</td>
</tr>
<tr>
<td><strong>Helminthes</strong></td>
<td></td>
</tr>
<tr>
<td><em>Ascaris lumbricoides</em></td>
<td>108 (24.5)</td>
</tr>
<tr>
<td>Hookworms</td>
<td>53 (12.0)</td>
</tr>
<tr>
<td><em>Trichuris trichiura</em></td>
<td>6 (1.4)</td>
</tr>
<tr>
<td><strong>Sub Total Helminthes</strong></td>
<td>167 (38.0)</td>
</tr>
<tr>
<td><strong>Mixed infections</strong></td>
<td></td>
</tr>
<tr>
<td><em>E.histolytica</em>+<em>A.lumbricoides</em></td>
<td>4 (0.9)</td>
</tr>
<tr>
<td><em>E.histolytica</em> + <em>T. trichiura</em></td>
<td>3 (0.7)</td>
</tr>
<tr>
<td><strong>Sub -total mixed infestations</strong></td>
<td>7 (1.6)</td>
</tr>
<tr>
<td><strong>Overall total number of meat sampled</strong></td>
<td>334 (75.9)</td>
</tr>
</tbody>
</table>
4.3 Occurrence of intestinal parasites among food handlers examined Kisii level -5 -Hospital

4.3.1 Intestinal parasites among food handlers examined at Kisii level -5 -Hospital

Stool specimens were collected from the food handlers attending the Kisii Provincial Hospital. Out of 168 food handlers, 69 (41.1%) were infected with one or more intestinal parasites. Out of 69 infected food handlers 27 (13.1%) were infected with one species of protozoan, 37 (22.0%) were infected with one species of helminth and 5 (3.0%) had mixed infections, with 3 (1.8%) having *Entamoeba histolytica* and *Ascaris lumbricoides* (Plate 5) and 2 (1.2%) had *E. histolytica* and *Giardia lamblia* (Table 7). The trophozoites of *Entamoeba histolytica* were the major protozoa isolated from stool samples whereas unfertilized eggs of *Ascaris lumbricoides* were the main helminthes (Plate 6). The other parasites isolated from stool samples included protozoa trophozoites of *Balantidium coli* and eggs of hook worms (Plate 7).
Table 7: Categories of intestinal parasites among food handlers examined at Kisii level -5 -Hospital

<table>
<thead>
<tr>
<th>Parasite class/ species</th>
<th>Number of infected cases (n)</th>
<th>(%)Infection per class of Parasite</th>
<th>(%) Infection of those examined. (N=168)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Single infections</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Protozoa</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Entamoeba histolytica</td>
<td>20</td>
<td>74.1</td>
<td>11.9</td>
</tr>
<tr>
<td>Giardia lamblia</td>
<td>6</td>
<td>22.2</td>
<td>3.6</td>
</tr>
<tr>
<td>Balantidium coli</td>
<td>1</td>
<td>3.70</td>
<td>0.6</td>
</tr>
<tr>
<td><strong>Sub Total protozoa</strong></td>
<td>27</td>
<td>100</td>
<td>16.1</td>
</tr>
<tr>
<td><strong>Helminthes</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ascaris lumbricoides</td>
<td>22</td>
<td>59.5</td>
<td>13.1</td>
</tr>
<tr>
<td>Hookworms</td>
<td>13</td>
<td>35.1</td>
<td>7.7</td>
</tr>
<tr>
<td>Trichuris trichiura</td>
<td>2</td>
<td>5.4</td>
<td>1.2</td>
</tr>
<tr>
<td><strong>Sub Total Helminthes</strong></td>
<td>37</td>
<td>100</td>
<td>22.0</td>
</tr>
<tr>
<td><strong>Mixed infections</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E.histolytica + A.lumbricoides</td>
<td>3</td>
<td>60.0</td>
<td>1.8</td>
</tr>
<tr>
<td>E.histolytica + G.lambia</td>
<td>2</td>
<td>40.0</td>
<td>1.2</td>
</tr>
<tr>
<td><strong>Sub -total mixed infections</strong></td>
<td>5</td>
<td>100</td>
<td>3.0</td>
</tr>
<tr>
<td>Overall total number of</td>
<td>69</td>
<td></td>
<td>41.1</td>
</tr>
</tbody>
</table>

4.3.2 Prevalence of intestinal protozoa among food handlers examined at Kisii level -5 -Hospital

The most prevalent intestinal protozoa parasite species was *Entamoeba histolytica*, 20 (11.9 %) and least prevalent was *Balantidium coli* 1(0.6 %), in their decreasing order of prevalence (Fig.6).

![Figure 6. Prevalence of intestinal protozoa among examined food handlers](image)

Species of protozoa infecting food handlers
4.3.3 Prevalence of intestinal helminthes among food handlers examined Kisii level -5 - Hospital

The most prevalent intestinal helminth parasite species was *Ascaris lumbricoides*, 22 (13.1 %) and least prevalent was *Trichuris trichiura* 2 (1.2%) in their decreasing order of prevalence (Fig. 7).

![Graph showing prevalence of intestinal helminthes among examined food handlers]

**Figure 7. Prevalence of intestinal helminthes among examined food handlers**

The risk of acquiring intestinal parasitic infections from various sources was high with meat posing the highest risk of intestinal parasite transmission (75.9 %) and food handlers (41.1%) were the least. Out of 692 samples of various specimens examined 458(66.2%) were infested with intestinal parasites hence indicating a high overall risk of infections from various sources. There was a significant difference of acquiring intestinal parasitic infections from various sources ($\chi^2 = 214.966$, df = 2 $p=0.000$)(Table 8).
Table 8: Risk Sources for acquiring intestinal parasitic infections in Kisii Municipality

<table>
<thead>
<tr>
<th>Risk Source</th>
<th>Sample (n)</th>
<th>Frequency of intestinal parasites</th>
</tr>
</thead>
<tbody>
<tr>
<td>Meat</td>
<td>440</td>
<td>334 (75.9)</td>
</tr>
<tr>
<td>Vegetables</td>
<td>84</td>
<td>55 (65.5)</td>
</tr>
<tr>
<td>Stool</td>
<td>168</td>
<td>69 (41.1)</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>692</strong></td>
<td><strong>458 (66.2)</strong></td>
</tr>
</tbody>
</table>
CHAPTER FIVE: DISCUSSION

5.1 Discussion

5.1.1 Prevalence of intestinal parasites among vegetables sold in Kisii Municipality open air markets

The study has shown that there is a high degree of vegetable contamination with pathogenic human intestinal parasites in Kisii Municipality. The most common intestinal parasites that were found on the vegetable samples were *Entamoeba histolytica*, and *Ascaris lumbricoides* while the least were *Balantidium coli* and *Trichurus turchiura*. Eggs of *Trichurus trichiura* were rare on vegetable samples due to the fact that they are less resistant to environmental stress such as drying or direct exposure to sunlight (Klaas 1987). The protozoan cysts and helminth eggs recovered from vegetables were essentially those that were shed in human faeces dispersed onto the environment indiscriminately. The isolated intestinal parasites from vegetables pose a risk of water or food borne diseases like amoebiasis through ingestion of vegetables contaminated with intestinal parasite eggs and cysts (Okoronkwo & Onwuliri, 1998) which are eaten as salads or raw without cleaning.

The vegetable samples collected are among the most common vegetables consumed in Kisii Municipality. In all vegetables sampled, spider flower highly infested with intestinal parasites while Kales were least infested and this may cause a high risk of infection since traditionally spider flower vegetables may be poorly cooked without washing. However there was a high prevalence of intestinal parasites among the vegetables sampled and this may be attributed to the use of untreated sewage wastes as fertilizer and poor sanitation during harvesting and handling of the vegetables (Mustafa et al., 2001).
The garden soils from where vegetables are sold within Kisii Municipality open air markets could be obtained from areas contaminated with helminth eggs or cysts of protozoa. These eggs and cysts can be transmitted to farmers or vendors’ hands and finally onto the vegetables, hence starting the intestinal parasites transmission process to the population through soiled hands. Children could contaminate the vegetable gardens with their excreta thus seed the soil with intestinal parasites eggs and cysts that develop and upon maturation pose a risk of infection to people who consume such foods. A heap of refuse dumps in the study area are located near the market center where arrays of food items were displayed. Studies done at Ibadan Nigeria have indicated that filthy houseflies carry intestinal parasites mechanically onto vegetables (Adeyeba & Okpala, 2000), hence increasing the risk of transmission of intestinal parasites to the vegetable samples.

Studies done in Bangladesh have indicated that 90% of human excreta find its way into garden soil, water sources and refuse damps and this serve as a source of intestinal parasites infection (Muttalib et al., 1983; Adeyeba & Okpala, 2002). Besides, studies done in rural areas of Japan revealed that nearly half of the vegetables sold in markets are contaminated with *Ascaris lumbricoides* eggs because raw sewage wastes was used as a fertilizer (Slifko et al., 2000). The sewer pipes in the Municipality are often broken and the night soil passed into small gardens surrounding Kisii Municipality.

The risk of infection with intestinal parasites to the population is increased because these contaminated vegetables are sometimes eaten raw, undercooked to retain the natural taste and preserve heat-labile nutrients, or unclean (Slifko et al., 2000).
Additionally, studies done in Mexico city have shown that vegetables purchased at urban markets have been found to have higher rates of infestation with intestinal parasites (Cifuentes et al., 2004). A relatively new problem is the development of resistance to the small number of drugs available to treat intestinal parasitic infections, particularly such a resistance is a result of consumption of vegetables and fruits containing cysteine proteinases (Gillian et al., 2006).

The prevalence of intestinal parasites was higher in meat compared to vegetables. This is an indication that dust from refuse dumps is blown by wind through the meat surface hence contaminating it with eggs and cysts of intestinal parasites. Such eggs or cysts transferred by dust and wind could originate from human faeces in places where people defaecate on the ground because they lack access to functional toilets or use of sewer products as fertilizer and this is shown in Kisii municipality where mainly street children defaecate on the dumping sites of the open air market hence this increases the risk of intestinal parasites transmission. Earlier studies done in villages in Bangladesh had revealed that environmental dust can be a source of pathogenic intestinal parasitic transmission (Muttaib, 1993). In addition, studies done in Tokyo have shown that strong winds may blow eggs and cysts of intestinal parasites in dust to the exposed meat (Kunii, 1992) and such a feature of climate is occasionally experienced in Kisii Municipality.

5.2 Influence of meat handling practices on prevalence of intestinal parasites in Kisii Municipality

Out of the 22 butcheries from where meat was sampled, the least frequent storage method used were placing the meat in refrigerator whereas placing the meat on an open surface was the most frequent storage method used. This exposes meat samples
to dust particles and houseflies hence increasing the risk of contamination with pathogenic intestinal parasites. Additionally it implies laxity of public officers who should advice the meat vendors on proper meat storage methods.

The prevalence of intestinal parasites were significantly higher in the meat samples stored in the wire mesh compared to those stored in the refrigerator which were significantly less. There was a significantly high prevalence of intestinal parasites in meat samples where the vendors served dual roles as cashier compared to the butcheries where there were vendors serving meat while handling cash. The findings indicates that such meats have high prevalence of intestinal parasites compared to butcheries where there are different personnel serving meat and handling money. This can be attributed to meat vendors coming into contact with intestinal parasites eggs or ova through touching of items like utensils, furniture, door handles. Also fingernails can be a source of intestinal parasite infections. Previous studies done in Yokogagwa, Tokyo indicates that serving meat and handling money enhances the risk of acquiring intestinal parasites (Kagei, 1983 and Singh et al., 2004). The cysts of intestinal parasites have been found to adhere on meat carcasses (Rajnish et al., 2004) hence increasing the risk of intestinal parasitic infections especially where meat is undercooked or eaten raw.

The wearing of white dustcoats did not significantly determine the frequency of intestinal parasites among meat samples compared to those where meat samples were handled by vendors who were not wearing white dustcoats. This implies that though intestinal parasitic frequency was high in meat samples obtained from butcheries where meat handling personnel were not wearing white dust coats, the prevalence of
intestinal parasites was not statistically significant. A study done in Ontario reveals that where barrier techniques like gloves and protective clothing are used, prevalence of pathogens contaminating meat at selling points is reduced (Public Health and Epidemiology Report, 2001).

There was a significantly high prevalence of intestinal parasites on meat samples whose surfaces had houseflies this may be attributed to poor environmental sanitation in Kisii Municipality that is characterized by dumping of garbage near meat selling points, poor state of municipal toilets that lack piped water. Broken sewer pipes increases chances of exposing meat to intestinal parasites, as houseflies are a major pathway for eggs and cysts from such sources onto meat surfaces hence increasing prevalence of intestinal parasites on meat samples. Recent studies done in a typical slum area of Metropolitan Manila have shown that mechanical vectors like houseflies transfer eggs and cysts of intestinal parasites onto improperly stored meat. (Monzón et al., 1991).

5.3 Occurrence of intestinal parasites among food handlers examined Kisii level - 5 - Hospital

This study indicated that prevalence of intestinal parasites was high among food handlers of Kisii Municipality where 41.1% were infected with one or more intestinal parasites. Majority of the food handlers were infected with one species of protozoan while some were infected with one species of helminth and a few had mixed infections. This finding agrees with earlier studies done at different locations in Kisii highlands that showed a high prevalence of intestinal parasites among patients (Akhwale et al., 2004). This high prevalence is a risk to patrons since they do not sanitize their hands, use food-handling tools (tongs, spoons, utensils or bakery/serving
papers) and handle money while serving food (Michaels, 2002). Foods sold in markets may be contaminated from hands that have not been washed after defecation hence increasing risks of transmission of intestinal parasites to consumers (Nichols, 1999). Recent studies done in La Plata, Argentina reveals that high prevalence of intestinal parasites in any population is a result of contaminated soil and water sources in addition to deficient sanitary conditions and socio-cultural conditions (Gamboa et al., 2003).

Poor personal hygiene can greatly contribute to the high prevalence of intestinal parasites among food handlers especially where toilet paper usage is not common possibly due to low income, cleaning the anal area by washing with the hand, toilets are poorly sanitized, lack of soaps in the toilets or such people do not use soaps after defecation. Studies done in Northern Ireland have shown that this increases the risk of transmission of intestinal parasites to the inhabitants as this food handlers act as reservoirs of such parasites (Northrop-Clewes & Shaw, 2000). The intestinal parasites infecting food handlers in Kisii Municipality were similar with those infesting food samples implying that such foods could be a risk to the public consuming such food stuffs.

This study has shown that there were higher risks of acquiring intestinal parasitic infections from various sources however meat posed the highest risk of intestinal parasite transmission while food handlers posed the least. This can be attributed to favorable climatic conditions in this area which is essential for thriving of cysts and eggs of intestinal parasites as air temperatures range from 10°C to 30°C with relative humidity of 88%, this findings agrees with studies done in markets at Ibadan, Nigeria.
which showed high occurrence rates of intestinal parasites (53.4%) in refuse dumps which had favorable air temperatures (26.1 ± 0.6°C) and high relative humidity (82 ± 3.0%) additionally this accords well with other reports that survival of intestinal parasites is dependent on favorable degree of temperatures, moisture, humidity, desiccation and biological activities (Adeyeba and Akinbo, 2002), and this climatic conditions and biological activities are similar to those of Kisii Municipality. The risk of infections by intestinal parasites from various sources indicated a statistically significant difference between various sources and this meant that the risk of contracting intestinal parasites is higher from meat consumption and lower from food handlers.

This is an indication of poor personal hygiene habits and environmental sanitation due to limited faeces control from household wastewater as a result of broken sewage system that may contaminate vegetables at in the gardens or at market selling points. Meat was highly contaminated with intestinal parasites since the Kisii Municipal meat selling points are near garbage dumping sites and poorly maintained toilets that mostly lack piped water hence increasing chances of mechanical transmission of cysts and eggs of intestinal parasite onto meat surfaces by houseflies, cockroaches, and rats and occasionally by dust. Lack of hand washing after visiting toilets or washing anal area with water increases the risk of contamination of intestinal parasites with foodstuff when food handlers are selling to consumers. Meat may be eaten raw, poorly cooked or vegetables are eaten as salads especially cabbages which are popular in making salads at 'chips' (roasted *Ipomea batatus* tubers) selling points in Kisii Municipality hence increasing transmission risks of intestinal parasites to consumers of such foods.
A higher proportion of inhabitants of Kisii Municipality may be unaware of sanitation, good hygienic practices knowledge of public health regulations and how to avoid environmental pollution that increases the risk of transmission of intestinal parasites. This confirms similar studies done in Sanliurfa, Turkey which revealed that among risk factors contributing to infections by intestinal parasites to human beings were stool which ranked highest (88.5%), soil 84.4 %), water (60.8%) and vegetables (14.0%) and all the samples examined contributed to high overall risk (59.5%) of transmission of pathogenic intestinal parasites to the inhabitants (Mustafa et al., 2001). Generally the risk of transmission is bound to be higher in the study area since there is lack of adequate toilets nor waste disposal facilities hence residents make use of the market as dumping ground for wastes and Street children use it as disposal ground for their excrement.
CHAPTER SIX: CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

The following conclusions were made from this study:

1. Spider flower (*Gynandropsis gynandra*) was highly infested whereas Kales (*Brassica oleracea var. acephala*) were least vegetables infested with intestinal parasites.

2. *Entamoeba histolytica* and *Ascaris lumbricoides* were the most prevalent protozoa and helminth among foodstuffs and food handlers.

3. The risk factors associated with food handling practices were storage and display methods of food stuff and personnel handling money while serving foods to consumers.

4. The prevalence of intestinal parasites among the food handlers was 41%, this poses a high risk to patrons since the handlers do not clean their hands.

6.2 Recommendations

1. There is need for Kisii Municipal council and other relevant stake holders to sensitize the public on food safety and Good Manufacturing Practice (GMP).

2. Kisii Municipal council and other relevant stake holders should improve sanitation conditions in and around the market through waste collection as this will reduce the risk of acquisition of intestinal parasites by the public.

3. Public health officers should ensure that a regular parasitological examination of food handlers is conducted according to the Public Health Act.
6.3 Suggested areas for further research

This study suggests the following areas for further research:

1. Assessment of soils from gardens where vegetables are grown or sold for intestinal parasites.

2. Evaluation of risks of acquiring intestinal parasites from abattoirs and water used to wash implements in meat selling points.

3. Establishment of the frequency of examination of food handlers for intestinal parasites.

4. Determination of the density of intestinal parasites among various risk factors.

5. Investigation of the factors associated with high prevalence of intestinal parasites in Spider flower (*Gynandropsis gynandra*).
REFERENCES


Appendix I

Check list for meat sampling practices in butcheries

<table>
<thead>
<tr>
<th>Vendors</th>
<th>Meat Storage</th>
<th>Protective clothing</th>
<th>House flies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dual as cashier</td>
<td>Refrigerated</td>
<td>Present</td>
<td>Present</td>
</tr>
<tr>
<td>Vendor and cashier present</td>
<td>Wire mesh</td>
<td>Absent</td>
<td>Absent</td>
</tr>
<tr>
<td></td>
<td>Open surface</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Name of parasites identified