ABSTRACT

A Study of Hunger, BMI, and the Occurrence of Infectious Disease in Rural Western Kenya

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The purpose of this study was to determine the state of food insecurity in a poverty-stricken community in western Kenya using a hunger scale questionnaire (HSQ) to investigate the three-fold relationship between food insecurity, body mass index (BMI), and infectious disease. This cross-sectional study analyzed data from a clinical sample of 480 patients of the Luo ethnicity who completed the HSQ in May 2011. The results showed that 94.37% of patients were designated as food-insecure, while merely 5.63% were food-secure. Out of the 187 cases of infectious disease, 180 cases were found in food-insecure patients (92.26%). Of the 6.88% of patients who had worms, none were food-secure. The most striking finding was the association between food insecurity, age, and BMI: 51.20% of food-insecure youths had BMIs within the severely thin range, compared to only 3.73% of food-insecure adults. The majority of adults, regardless of food insecurity, had BMIs concentrated in the normal range ($p = <.0001$). In addition to determining the severity of the hunger crisis in this community, these findings demonstrate the susceptibility of youth to food insecurity's threatening consequences: low BMI. This study adds support for the use of the HSQ as an effective predictor for BMI and for continued research investigating the potential role of the HSQ as a determinant of the occurrence of infectious disease.

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A STUDY OF HUNGER, BMI, AND THE OCCURRENCE OF INFECTIOUS DISEASE IN RURAL WESTERN KENYA

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DEDICATION

This study is dedicated to my family, boyfriend, friends living at the Nyakach Plateau, and to everyone suffering from hunger. May people continue "to look after [the] orphans and widows in their distress and to keep [themselves] from being polluted by the world" (James 1:27).

CHAPTER 1

Introduction

One of today's primary health concerns, hunger is a serious condition that results from a shortage of nutrients needed to maintain a healthy and productive lifestyle [49]. Currently, 925 million people worldwide experience hunger, 98% of whom live in developing countries [20, 28]. In sub-Saharan Africa alone, 212 million people suffer from undernourishment [32]. Despite the enormity of this crisis, however, uneven progress has been made to decrease hunger in several areas around the world, especially in Kenya where 31% of the population is undernourished [20].

Due to the combination of drought, poverty, escalating food prices, and lack of relief effort, the hunger crisis in Kenya has greatly increased in severity over the past year, leading to high acute malnutrition rates and threats to food security [36]. As food security begins to decrease with rising hunger and constrained resources, the body mass index (BMI) of many Kenyan households is expected to lessen. By using a hunger scale questionnaire developed from the Community Childhood Hunger Identification Project (CCHIP), this cross-sectional study aims to validate the direct relationship between food security and BMI in rural western Kenya [44].

While previous studies use the hunger scale questionnaire exclusively as an indicator for food security and anthropometric status, this study goes one step further, utilizing the survey as an additional predictor for the occurrence of infectious disease. Similar to the correlation between food security and BMI, a relationship exists between

an individual’s malnutrition and risk of contracting disease [49].With significantly lower caloric intake and substantial deficiencies in one or more micronutrients, undernourished people are more susceptible to infectious diseases, such as malaria, acute respiratory infection, gastroenteritis and pneumonia, in comparison to well-fed people. Undernutrition leads directly to infectious disease by decreasing the efficiency of the immune system, resulting in the accumulation of pathogens inside the body [16, 49]. Thus, this study’s primary objective is to investigate the three-fold relationship of hunger, BMI, and infectious disease, in hopes of verifying the hunger questionnaire’s effectiveness as a screening tool for anthropometric status and disease development.

CHAPTER TWO

Review of Literature

Hunger is a crucial, underlying cause of the world's burden of disease [10]. One of today's greatest health concerns, hunger affects more than 925 million people, 98% of whom live in developing countries. Among the developing countries, 60% of deaths in children less than five are the result of malnutrition and other hunger-related diseases [14]. The world's highest proportion of hunger can be found in sub-Saharan Africa, where one in three people are undernourished [20, 27].

Globally, the prevalence of undernutrition has decreased over the past thirty years, as developing countries move towards the completion of the first Millennium Development Goal (MDG 1), which aims to halve the amount of child undernutrition before 2015. Accordingly, the pattern of child stunting has declined from 47% in 1980 to 33% in 2000 [42]. Much of the progress towards the MDG 1, however, is attributable to only a few countries. In China, for example, childhood stunting decreased by more than half between 1992 and 2000, in keeping with significant economic growth and poverty reductions. Countries in sub-Saharan Africa, on the other hand, have shown very little progress, if any [48]. Contrary to the global trend, the rate of child stunting in Eastern Africa has increased by 0.08% per year, while the per-capita income growth of sub-Saharan Africa remains stagnant and the poverty rate increases [42, 48]. This strong correlation between stunting and poverty suggests the necessity of economic growth to reduce child malnutrition.

The fourth Millennium Development Goal (MDG 4) aspires to reduce child mortality by two-thirds between 1990 and 2015. Several countries have made significant progress towards achieving MDG 4, as the annual mortality rate in children between one to fifty-nine months decreased from 10.6 million per year in 2000-2003 to 8.795 million per year in 2008. Similar to MDG 1, however, many regions are not on target to meet this aim of decreasing under-five mortality, especially sub-Saharan Africa and south Asia [4]. In the early 1970's, sub-Saharan Africa had the largest child mortality rate out of all the world regions; but since then, it has had the smallest decrease in child deaths. Currently, 41% of all child deaths occur in sub-Saharan Africa [5].

Over the last decade, persistent drought, civil conflict, economic problems, and widespread disease have prevented the improvement of nutrition in East Africa countries [15]. After facing more than eighteen months of drought, for instance, Somalia is experiencing its most severe nutrition crisis since the Somalia famine from 1991-1992 [39]. Similarly, Kenya is currently undergoing one of its driest years since 1950, following three failed rainy seasons [36]. A low income food deficit country, Kenya now contains roughly 31% undernourished people [20, 31, 37]. The combination of drought, high food prices, crop failure, and livestock mortality has exacerbated the hunger crisis in Kenya, increasing acute malnutrition rates and food security threats to a new degree [36].

Despite the escalating hunger crisis in East Africa, there has been a sufficient lack of relief effort and international support [36]. For over fifty years, the United States has been the leader for providing food assistance throughout the world. However, U.S. funding for food aid has dropped from 20% of U.S. official development assistance in 1980 to 5% in 2007. Consequently, President Obama has made significant efforts to

improve the international response for food assistance during his presidential term. At the G8 Summit in June 2009, President Obama pledged to give $3.5 billion over a 3-year period to twenty developing countries in sub-Saharan Africa, Asia, Latin America, and the Caribbean, in response to the worldwide hunger and food security crisis. The United States pledge is part of a global commitment comprised of more than $20 billion [27].

In May 2010, the Department of State officially launched the Administration's global hunger and food security initiative, Feed the Future (FtF).The initiative's two main goals are to stimulate the growth of the agriculture sector through improvements in markets, trade, infrastructure, and technologies; and to improve the nutritional status of the twenty developing countries. Funding for FtF largely depends on Congressional appropriations [27].However, with only one year remaining, FtF still needs $1.6 billion to fulfill the original $3.5 billion pledge. Due to the world's current financial crisis, there is a large possibility that the initiative will suffer cuts in Congressional budget debates over foreign aid, as seen in 2011.Though most developing countries will receive less than the initial proposed amounts, a handful of countries – including Kenya – will receive the original amount requested, as a result of government prioritization [40].

Before examining the relationship between food insecurity and its primary outcomes, we must first discuss the definition of hunger and its components, including food security, malnutrition, and undernutrition. During the late twentieth century, the definition of hunger underwent a great transformation [43, 44]. Lack of agreement on the meaning of hunger and how to measure it resulted in delayed public policy concerning the global issue. While the Harvard School of Public Health defined hunger as the "chronic under consumption of food and nutrients," researchers at Cornell University

expanded this definition, describing hunger as "the inability to acquire or consume an adequate quality or sufficient quantity of food in socially acceptable ways, or the uncertainty that one will be able to do so" [44]. In their definition, the researchers at Cornell characterized hunger as having two divisions (household and individual) and four components (quantity, quality, psychological, and social). Using research from Cornell, the Life Science Research Organization (LSRO) developed a new term, food insecurity, to include the wider social context of lack of food and to constrict the word "hunger" to its biological meaning [44]. Widely used in the literature, the LSRO's definitions for food security, food insecurity, and hunger are listed below:

> Food security is defined as access by all people at all times to enough food for an active, healthy life and includes at a minimum: a) the ready availability of nutritionally adequate and safe foods, and b) the assured ability to acquire acceptable food in socially acceptable ways (e.g. without resorting to emergency food supplies, scavenging, stealing, and other coping strategies). Food insecurity exists whenever the availability of nutritionally adequate and safe foods or the ability to acquire acceptable food in socially acceptable ways is limited or uncertain. Hunger … [is] the uneasy or painful sensation caused by lack of food … At the individual and household levels, four dimensions (quantity, quality, psychological acceptability, and social acceptability) need to be measured to identify food insecurity [13, 30, 44].

Similar to the researchers at Cornell, the LSRO described food insecurity as having four components: quantity refers to the amount of food available; quality refers to the types of food available; psychological acceptability refers to an individual's feelings of deprivation about food availability; and social acceptability refers to an individual's evaluation of his or her food situation in relation to society [12]. It is essential to note that food security relies on both quantity and quality. In order to be considered food-secure, people ought to not only acquire the necessary quantities of food, but also consume nutritionally adequate foods that contain sufficient energy and micronutrients

[52]. Thus, there is a great need to promote the importance of food diversity, especially in food-insecure communities, where the incidence of infectious disease is high. Important food components that are indispensable to human health include sources of energy (calories), macronutrients (water, protein, carbohydrates, fiber, fat), and micronutrients (minerals and vitamins) [52].

In addition to food security, two other components of hunger discussed in this study are malnutrition and undernutrition. According to the World Food Programme, malnutrition is a "condition in which people experience either nutritional deficiencies or an excess of certain nutrients," whereas undernutrition is a "manifestation of hunger that results from serious deficiencies in one or a number of macronutrients and micronutrients" [49]. For the purposes of this study, the terms hunger, malnutrition, and undernutrition will be used interchangeably, with malnutrition referring exclusively to a lack of required nutrients.

The two main outcomes of food insecurity are anthropometric status and health. Consequently, the assessment of food insecurity serves as a valid measure of an individual's nutritional state and his or her physical, mental, and social wellbeing [41]. Young children who are exposed to high levels of food insecurity frequently suffer from irreversible consequences, which can be expressed for up to three generations [50]. Examples of deleterious effects induced by food insecurity include stunted growth, learning difficulties in school, impaired mental development, behavioral problems, reduced work capacity, increased susceptibility to infectious disease, and lower economic productivity later in life [2, 9, 41, 42, 53]. Suboptimal feeding and premature weaning are

two of the primary contributors to an infant's steady decline in nutritional status from birth [3].

Despite its high prevalence, there is a lack of simple, cost-effective approaches to accurately measure food insecurity in underdeveloped areas of the world. Traditional methods require a substantial amount of funds, laboratory equipment, trained personnel, and time to analyze results [23]. By using surveys as a screening tool for food insecurity, however, researchers can eliminate many of these obstacles. Available indicators of food insecurity today include Radimer/Cornell's food insecurity index, the Community Childhood Hunger Identification Project's (CCHIP) hunger scale, and questions in the third National Health and Nutrition Examination Survey (NHANES) [12]. In order to be confirmed as a "definitive criterion measure," a questionnaire must be precise, dependable, and accurate for its designated purpose [22]. Accordingly, both the Radimer/Cornell and CCHIP questionnaires have been confirmed in the literature as effective measures of food insecurity in rural communities and households with children [22, 24]. To establish validity, both questionnaires were evaluated against a definitive measure of hunger, comprised of a thorough interview with a household member. Each interview was conducted by a skilled, food security professional who possessed no knowledge of the two questionnaires' contents. When compared to the interviewers' findings, the Radimer/Cornell and CCHIP questionnaires agreed on the classification of food insecurity in over five-sixths (85%) of the households [22].In this study, we will utilize the CCHIP hunger scale to measure the prevalence of food insecurity in a rural community in western Kenya, where the population is almost homogenously Luo.

Following research at Cornell University, the CCHIP created a simple, yet scientifically valid, questionnaire to measure the prevalence of food insecurity within a community [44]. Composed of eight questions, the CCHIP hunger scale measures an individual's degree of food insecurity by the frequency of his or her affirmative responses [35]. If the interviewee answers yes to 5 or more questions, the household is considered "hungry." If he or she answers yes to 1-4 questions, the household is considered at "risk of hunger." A negative response indicates that the household is "food-secure" [34]. For each of the eight main questions, two additional sub-questions are asked to determine the degree of the food insecurity component over a thirty day period. Moreover, the hunger scale can be further divided into three sub-categories, analyzing food security at the household (questions 1 and 2), individual (questions 3 and 4), and childhood (questions 5-8) levels [24].

In 1999, the National Food Consumption Survey (NFCS) set out to determine the food consumption, nutrient intake, and anthropometric status of South African children ages one to nine through the use of five questionnaires. Based on the CCHIP, the NFCS's hunger scale questionnaire (HSQ) determined a household's level of food security by evaluating the interviewee's perception of experiencing hunger [24, 34]. The NFCS in South Africa sampled 3,120 children from varying areas of residence, including urban, rural, tribal, and farming areas, resulting in a clear division of food security levels [34]. The results of the NFCS are as follows.

At the national level, one out of two households experienced hunger and only one out four households was found to be food-secure, demonstrating the high degree of food insecurity in South Africa [34]. Households classified as food-insecure or at risk of

hunger had lower anthropometric measurements, in comparison to food secure households [24]. Additionally, an inverse relationship was found between age and stunting: the older the children, the lower the prevalence of stunting [14]. Similar to anthropometric status, the micronutrient and energy levels were lowest in rural households with the least food security. Out of the South African children surveyed, micronutrient deficiencies included shortages in the Recommended Dietary Allowance (RDA) for energy, folate, calcium, iron, zinc, selenium, riboflavin, and vitamins A, D, C, E, and B_6[34].

When measuring the level of food insecurity, the NFCS also determined a household's food procurement and availability [35]. In accordance with the prevalence of micronutrient deficiencies, the number of food items procured by households in rural and tribal areas was lower than the number procured by households in urban areas, largely due to differences in income. Households with higher incomes were found to have a greater quantity and quality of food items, suggesting a positive relationship between food security and socioeconomic status [34]. Along with food security and socioeconomic status, higher levels of maternal education were likewise associated with greater food security and lower levels of underweight, stunting, and wasting [14]. Overall, the NFCS explored many risk factors (income, maternal education) and consequences (BMI, micronutrient deficiencies) of food insecurity.

Established by the NFCS, food insecurity is not shared equally amongst all people, differing within a range of risk factors, such as economic status, age, gender, education level, and ethnicity [49]. As a result of these elements, food insecurity can exert different effects on the nutritional status of different people. In the Suba district of rural western

Kenya, for example, anthropometric data was collected amongst school students, ages five to seventeen, for a study analyzing the growth patterns and nutritional status of Luo students in grades 1-8. Results of the study showed major differences in the nutritional status among the two sexes and various age groups. While there was a greater percentage of thin, undernourished males than females above the age of thirteen, there was a greater percentage of overnutrition in the younger age groups, particularly among females. Discrepancies in nutritional status between the sexes may be due to boys' involvement in more energy-demanding activities and girls' increased food access due to cooking responsibilities [47]. The emerging pattern of overweight children in younger age groups is the adverse consequence of poor dietary choices and patterns. This study demonstrates that Luo children - especially males - are typically undernourished at early adolescence, putting these children at risk for developmental delays as they approach their teenage years due to poor growth performance resulting from food insecurity [47].

Besides early adolescence, food insecurity also shows a bias towards young children less than two years [3, 50, 54]. After evaluating the nutritional status of children under five years in rural, western Kenya, Kwena et al discovered that the greatest decrease in nutritional status occurred between three and eighteen months, the time of weaning and the peak of malaria mortality [33]. This data not only points to the close interaction between malaria and malnutrition during the first two years of life, but also suggests that few food-insecure children in sub-Saharan Africa will reach their full growth potential. Because of the vulnerability of infants to food insecurity and disease, institutions like the American Academy of Pediatrics strongly recommend that mothers breastfeed their children throughout the first year of an infant's life in order to provide their children with

a strong and healthy foundation [51]. Compared to infants who are exclusively breastfed, infants who are not breastfed are five times more likely to die from infectious diseases [5]. Moreover, Kwena et al also found that the percentage of children with malnutrition in Kenya varied greatly by province, illustrating the influence of environmental and economic factors on nutritional status [33].

In addition to nutritional status, food insecurity is an important predictor of an individual's health, confirmed by the synergistic relationship between undernutrition and acute infectious disease. Together, undernutrition and infectious disease have more adverse effects on a person's health than the sum of their individual effects combined [5, 49]. A bidirectional association, undernutrition increases a person's susceptibility to infection, while infection negatively affects a person's nutritional state [45]. By examining this reciprocal relationship in detail, the second portion of the current study takes the NFCS one step further, evaluating the extent to which the hunger scale is associated with the presence of acute infectious disease.

Out of the 8.795 million child deaths in 2008, 68% were caused by infectious diseases, such as diarrhea (15%), pneumonia (18%), and malaria (8%) [4].In Africa, approximately three-fourths of all deaths are attributable to infectious disease [18]. Rural areas of western Kenya, specifically, are home to a wide range of infectious illnesses, from acute respiratory infections to parasitic worms. Following their establishment of a surveillance system in 2001, the Centers for Disease Control and Prevention (CDC) and Kenya Medical Research Institute (KEMRI) have provided substantial evidence that infectious disease is a major cause of death in western rural Kenya for both adults and children. In children between one month and twelve years of age, major causes of death

included malaria (28.9 %), diarrhea (16.2%), pneumonia (15.9%), and meningitis (5.3%). In adults between the ages of thirteen and thirty-four years, the CDC and KEMRI reported a high prevalence of human immunodeficiency virus (HIV), with 11% in men and 21% in women [1].

While investigating the major causes of global mortality, researchers have simultaneously examined undernutrition's role as an underlying factor of disease-related deaths. In sub-Saharan Africa and Asia, ten cohort studies investigated the two-way relationship between childhood undernutrition and cause-specific mortality, measuring low weight-for-age in children and calculating the relative risk of dying attributable to child weight-for-age. In the childhood deaths examined, 60.7% deaths due to diarrhea, 52.3% deaths due to pneumonia, 44.8% deaths due to measles, and 57.3% deaths due to malaria were accredited to undernutrition. Undernutrition was found to significantly increase a child's mortality risk by enhancing his or her susceptibility to infectious disease [10].

In individuals with high food insecurity, undernutrition increases their vulnerability to infection by decreasing immune function and permitting pathogens to settle in the digestive tract [49]. Impaired immune functioning is caused by deficiencies in protein, vitamins (A, B, C, D, E), and minerals (iron, zinc, copper, magnesium, selenium). These nutrient deficiencies cause impaired immune function through a combination of mechanisms, including impaired antibody formation, decreased thymic function, reduced natural killer cell activity, lower interferon production, impaired phagocytic activity, depressed cell-mediated immunity, and impaired delayed cutaneous hypersensitivity [45]. Acute infectious diseases, on the other hand, aggravate the

nutritional status of an individual by causing a reduction in appetite (anorexia), reduced intestinal absorption (malabsorption), increased energy requirements, fever, or decreased production of vitamins (A, B) and minerals (zinc, iron, copper) [45,49]. Parasitic worms, for instance, exacerbate an individual's malnourished state through malabsorption. By absorbing nutrients in the host's gastrointestinal tract, intestinal helminthes prevent the host from obtaining its required nutrients [25].

Throughout several studies, undernutrition has been proven to interact with an assortment of infectious diseases, including malaria, measles, pneumonia, diarrhea, and HIV. For example, a 2002 study in northern Ghana established low body mass index (BMI) as a fundamental cause of malaria-associated morbidity and mortality. Researchers found that low weight-for-age can increase the risk of malaria infection up to 70% [16]. Specific mechanisms of how undernutrition increases the susceptibility to malaria are not yet fully understood. However, likely mechanisms involve the suppression of immune responses to pathogens and disruption in antibody formation [16, 47]. A study in Tamale, Ghana provided further evidence of the bidirectional relationship between malnutrition and malaria. Over a four month period, a total of 290 children between the ages of six months and nine years who showed symptoms of severe malaria were seen by a pediatrician. Out of the 290 children surveyed, 42% of the children were malnourished. Data collected from this study demonstrated that being underweight increased a child's risk of dying from malaria by three fold [38].

Similar to malaria, the combination of HIV infection and malnutrition accelerates disease progression and mortality. Untreated HIV infection increases the body's energy requirements, while it decreases an individual's appetite and absorption of nutrients,

leading to the development of malnutrition [26, 32]. Until changes in public policy and improvements in funding are made, food-insecure people will continue to make up a large proportion of patients who suffer from infectious disease.

Despite the high prevalence of infectious illnesses, the majority of people in Africa with acute infectious diseases rarely seek aid at health facilities. Reasons for not seeking healthcare at clinics include cost, distance, quality, seriousness of the illness, and unawareness about the benefits of healthcare [18].In a study of the rural Bondo district of western Kenya, researchers found that seeking care at health facilities was independently related to socioeconomic status and the severity of symptoms. Children with higher socioeconomic status or greater severity of disease were more likely to go to a healthcare facility than children with lower socioeconomic status or less severe disease [8]. Due to a deficiency in effective reporting systems coupled with an unequal representation of groups of people, reliable statistics on the causes of death in several developing countries are missing. Accurate information about cause-specific mortality is needed to prioritize interventions in high-risk areas [17].

Food insecurity has the potential to critically alter both the anthropometric status and health of an individual, resulting in irreversible, intergenerational, and often fatal effects. However, “more definite findings on the nutrition and health consequences of hunger and food insecurity” are needed [41]. Therefore, the primary purpose of this study is twofold: to provide information specific to the Luo community on the Nyakach Plateau and information generalizable to the wider scientific community, concerning the relationship between food insecurity, BMI, and acute infectious disease. In doing so, this study aims

to confirm the validity of the hunger scale questionnaire as an indicator for both anthropometric status and disease development.

CHAPTER THREE

Hypothesis

Research Questions

Research Question 1

What is the relationship between patients' food security, age, body-mass-index, and occurrence of infectious disease?

Primary Hypothesis

Patients with less food security will have a lower body-mass-index and a greater occurrence of infectious disease, compared to patients with greater food security.

Null Hypothesis

There is no relationship between patients' food security, body-mass-index, and occurrence of infectious disease.

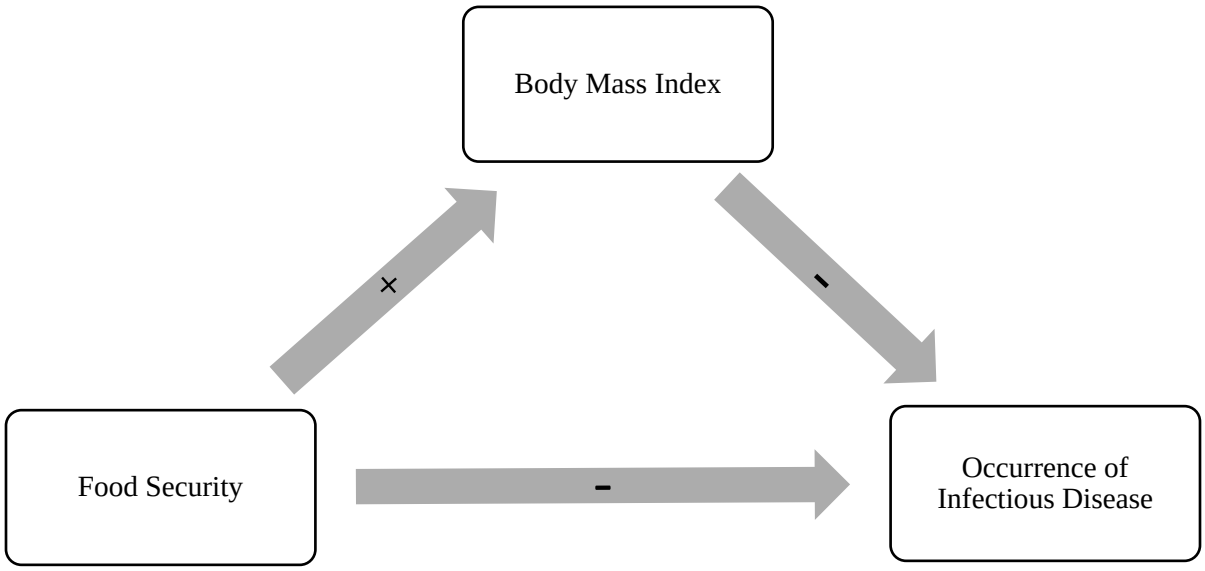
Secondary Hypothesis

Younger patients with less food security will have a greater occurrence of infectious disease than older patients with less food security.

Null Hypothesis

There is no relationship between patients' age, food security, and occurrence of infectious disease.

Figure 1: Primary Hypothesis



CHAPTER FOUR

Methods

Study Site and Population

In the summer of 2011, a group of 31 college students and 8 adults on a medical and public health trip visited and worked on the Nyakach Plateau in rural western Kenya. From May 18 to May 27, 2011, the team saw over 800 patients in a temporary clinic and also participated in a range of public health projects, such as planting fruit tree seedlings, installing rain water harvesting systems, teaching in local schools, and measuring lead levels in the ground water. During this ten day period, data was collected for the current study from participants who were recruited from patients who came to the clinic.

The temporary clinic was established within a 7m x 18m stone church building, located in the Upper Nyakach Division of the Nyando District. This location is roughly 36 km (22. 4 miles) southeast of Kisumu, Kenya and 12 km (7.5 miles) southeast of Lake Victoria. 25 meters southwest of the clinic was the lab, a small building with two main rooms. The majority, if not all, of regular clinic attendees were of the Luo ethnicity, spoke Luo as their primary language, and exhibited similar socioeconomic characteristics, including income, education level, and occupation. Of the people attending the clinic, subsistence farming and pastoral herding were the most common occupations.

Study Type

The study is a cross-sectional assessment of patients' food security, BMI, and infectious disease. Interviews were conducted to determine the state of food insecurity in the community, and the variables were measured during one clinic visit. After receiving instruction from the study's primary investigator, trained interviewers working through translators carried out the interviews, using a copy of a hunger scale questionnaire (HSQ) to direct each interview on which the patient's responses were marked.

In order to ensure the privacy of the individuals, translators conducted one-on-one interviews within a spare room of the lab, located in the back of the building. Before beginning, the interviewer first obtained the individual's informed consent. Each interview lasted approximately ten minutes. If the individual was too young to answer the questionnaire for him or herself, the primary caregiver answered the survey in his or her place. At the conclusion of the day, translators returned the completed questionnaires to the study's primary investigator.

Sample

The study is based on data drawn from a convenience sample of people who came to the clinic during the period of May 18 to May 27. Participants were either patients or family members of patients waiting to be seen by the doctor. Most adults and adolescents were invited to participate in the study, and 480 of 821 patients (58.47%) participated. No particular groups were systematically excluded. Lack of participation in the study was primarily due to time constraints and limited numbers of translators. Of the people asked, less than 10% refused to participate.

Measurement of Variables

Food Security

As discussed in the Review of Literature, the Hunger Scale Questionnaire (HSQ) is a standardized survey, previously published and validated by the Community Childhood Hunger Identification Project (see Appendix A). Composed of eight questions, the HSQ assesses the food insecurity of an individual by taking the sum of his or her affirmative responses. For each of the eight main questions, two sub-questions were asked to measure the frequency of food insecurity throughout a thirty day period. In the literature, previous studies have used a scale to measure the degree of food insecurity: if a patient answers yes to 5 or more questions, he or she is considered food insecure. If a patient answers yes to 1-4 questions, he or she is considered at risk of food insecurity. A negative response to all eight questions indicates that the patient is "food-secure." In this study, the latter scale was used first to analyze the distribution of food insecurity levels on the Nyakach Plateau.

Body Mass Index (BMI)

BMI is defined as the weight in kilograms divided by the height in meters squared [6]. Height was measured in centimeters, using a measuring tape attached to the lab's front wall. Trained volunteers measured patients' heights by having them stand upright against the tape with their backs against the wall. Mass was measured in kilograms, using a locally-purchased spring-scale. BMI can be computed with the formula:

$$\text{BMI} = \frac{Mass\ (kg)}{Height\ (m^2)}$$

Based on the World Health Organization's BMI classifications, this study categorized BMI as either having three or six levels. For the two categories of BMI used in this study, higher levels of BMI represent increasing weight-for-height. The BMI classification for six levels is illustrated below:

Level	Classification	Principal Cut-Off Points	Additional Cut-Off Points
1	Severely thin	< 16.00	< 16.00
2	Very thin	>= 16.00	<= 16.99
3	Mildly thin	>= 17.00	<= 18.49
4	Moderate	>= 18.50	<= 24.99
5	Pre-Obese	>= 25.00	<= 29.99
6	Obese	> 30.00	> 30.00

Acute Infectious Disease

Acute infectious disease was defined as patients who were diagnosed with either one or a combination of the following: lymphadenitis, cellulitis, sinusitis, upper respiratory infection, bronchitis, pneumonia, tonsillitis, toothache or cavities, appendicitis, ear infection, conjunctivitis, urinary tract infection, vaginitis, gonorrhea, syphilis, typhoid, mumps, pharyngitis, worms, amoebas, gingivitis, acute vomiting, acute diarrhea, and/or malaria. The prevalence of HIV was not examined in this study because it is a chronic – not acute – infectious disease. All medical diagnoses were made by two physicians, trained and board certified in the United States.

Age

This study divided age into two main categories, designating children and early adolescents from adults. Adults were defined as anyone older than sixteen years, while children and early adolescents were defined as anyone younger than or equal to sixteen.

Seventeen years was chosen as the minimum age of adulthood in accordance with the marriage practices of the Luo community on the Nyakach Plateau.

Data Analysis

The survey responses and the 2011 clinical data were double-entered into Microsoft Excel in two separate spreadsheets. For the HSQ, the responses were entered into Excel using a codebook created by the primary researcher (see Appendix A). The two databases were then imported into SAS statistical software version 9.2, where they were merged together and checked for discrepancies. Univariate frequencies for all the created variables were calculated, followed by multivariate statistical analyses of the data using SAS (SAS Statistical Software, Cary, North Carolina). Alpha was set at 0.05.

Given that the majority of the variables were categorical, this study used contingency table analysis as the primary method of analysis. Additionally, relative risk (RR) was computed to estimate the relationships between acute infectious disease, low BMI, and food insecurity. Relative risk was calculated using the following formula:

$$\text{RR} = \frac{Proportion\ exposed\ (Food\ Insecure)}{Proportion\ not\ exposed\ (Food\ Secure)}.$$

CHAPTER FIVE

Results

Univariate Statistics

Over a ten day period, a total of 480 interviews were conducted to assess the nature of food insecurity in Luo individuals on the Nyakach Plateau. The overwhelming majority of people surveyed were food-insecure. Determined by peoples' responses to the eight primary questions of the hunger scale questionnaire (HSQ), 5.63% of patients were designated as food-secure, while the remaining 94.37% were found to be food-insecure (Table 1). Most of the data analysis compared food security (no affirmative responses) against food insecurity (any affirmative response) due to the severity of the Nyakach Plateau's hunger crisis and the large proportion of food-insecure people. The present study did not use the scale of insecurity proposed by the literature because of the uneven distribution of patients' affirmative responses.

Of the 480 people surveyed, 187 people were diagnosed with a minimum of one infectious disease. More than one-third (38.96%) of the sample population had at least one case of infectious disease. A total of 17 different types of acute infectious diseases were found in the sample. These diseases, in decreasing order of prevalence, included malaria (8.54%), worms (6.88%), bronchitis (6.25%), upper respiratory infection (4.79%), conjunctivitis (3.96%), sinusitis (2.92%), pneumonia (2.71%), ear infection (2.50%), toothache/cavities or vaginitis (1.88%), cellulitis or urinary tract infection or gonorrhea (1.04%), acute diarrhea or pharyngitis (0.63%), and typhoid or amoebas (0.42%). Within the sample population, malaria had the largest prevalence of an

individual infectious disease at 8.54%, followed closely by worm infection at 6.88%. When considered as a group, however, acute respiratory infections - sinusitis, bronchitis, upper respiratory infection, pneumonia, and tonsillitis - affected the largest proportion of the population at 17.29%. With the exception of the infectious diseases as a whole, malaria and worms were the only types of acute infectious diseases analyzed individually in the current study.

Table 1

Variable	Frequency	Proportion (%)
Food Security		
Secure	27	5.63
Non-Secure	453	94.37
Diagnosis of an Infectious Disease		
Positive Diagnosis	187	38.96
Negative Diagnosis	293	61.04
Diagnosis of Malaria		
Malaria	41	8.54
No Malaria	439	91.46
Diagnosis of Worm Infection		
Worms	33	6.88
No Worms	447	93.13

BMI

Body mass index (BMI) was calculated for each of the 480 patients surveyed and is presented in table 2. BMI measurements were then divided into either three or six levels of classification, following WHO standards. When BMI was categorized into three levels, the first (severely, very, or mildly thin) and second (moderate) levels held the highest percentage of patients' BMIs with a combined 85.06%, leaving only 14.93% in the third (pre-obese or obese) level. When BMI was further divided into six categories, 43.13% of BMIs fell into the fourth level (moderate), followed by 18.48% in the first

level (severely thin). Similar to the three classification levels described above, the smallest percentage (3.79%) of patients' BMIs was found in the sixth level, which is attributable to obesity. For both types of classifications, BMI measurements were most highly concentrated in the moderate level, corresponding to the normal range for BMI. Percentages for the various BMI classifications are presented in Table 2.

Table 2	**BMI WHO Six Categories**							
BMI WHO Three Categories	**Freq** **Row Pct**	Severely Thin	Very Thin	Mildly Thin	Moderate BMI	Pre-Obese	Obese	**Total**
	Severely, Very, or Mildly Thin	78 44.07%	40 22.60%	59 33.33%	0 0.00%	0 0.00%	0 0.00%	**177** **41.94%**
	Moderate BMI	0 0.00%	0 0.00%	0 0.00%	182 100.00%	0 0.00%	0 0.00%	**182** **43.12%**
	Pre-Obese or Obese	0 0.00%	0 0.00%	0 0.00%	0 0.00%	47 74.60%	16 25.40%	**63** **14.93%**
	Total	**78** **18.48%**	**40** **9.48%**	**59** **13.98%**	**182** **43.13%**	**47** **11.14%**	**16** **3.79%**	**422** **100%**

Security and BMI

Food security was compared against the six-level classification of BMI (Table 3). Similar to the sample's overall BMI pattern (Table 2), both tables illustrated that the greatest proportion of food-secure and insecure people were concentrated in level 4, whereas the smallest proportions were in the pre-obese and obese categories. In Table 3, it is important to note that only food-insecure people had ranges of BMIs corresponding to pre-obesity and obesity. Of the 21 secure people, 0% had BMI measurements associated with levels 5 and 6. Contrastingly, 71.43% of secure patients had BMIs within the normal range, compared to the 41.65% of insecure patients. Over 98% of the

severely thin BMI people were food-insecure, while less than 2% of the same BMI group were food-secure. Viewed another way, 19% of the people who were food-insecure were severely thin, while less than 5% of the people who were food-secure were severely thin. That is, patients who were food-insecure were four times as likely to be severely thin as patients who were food-secure (Table 3).

Table 3	**Food Security**			
BMI WHO Six Categories	**Freq** **Row Pct** **Col Pct**	Secure	Insecure	**Total**
	Severely Thin	1 1.28% 4.76%	77 98.72% 19.20%	**78** **18.48%**
	Very Thin	3 7.50% 14.29%	37 92.50% 9.23%	**40** **9.48%**
	Mildly Thin	2 3.39% 9.52%	57 96.61% 14.21%	**59** **13.98%**
	Moderate BMI	15 8.24% 71.43%	167 91.76% 41.65%	**182** **43.13%**
	Pre-Obese	0 0.00% 0.00%	47 100.00% 11.72%	**47** **11.14%**
	Obese	0 0.00% 0.00%	16 100.00% 3.99%	**16** **3.79%**
	Total	**21** **4.98%**	**401** **95.02%**	**422** **100%**
	$\chi^2 = 10.5073$, $p = 0.0621$, $df = 5$			

Worms and BMI

The relationship between BMI and parasitic worm infection is seen in Table 4. Patients without worms followed the same BMI pattern illustrated in earlier tables: the largest percentage of people had BMIs in the moderate range (45.15%). Patients infected with worms demonstrated a significantly different BMI pattern, with 83.33% of their BMIs in category one (severely, very, or mildly thin), 16.67% in category two (moderate), and 0.00% in the pre-obese or obese category. Of those in BMI category 1, the proportion with worms was twice the size of the proportion of those not infected with worms (83.33% vs. 38.78%).

Table 4	**BMI WHO Three Categories**				
Worm Infection	**Freq** **Row Pct**	Severely, Very, or Mildly Thin	Moderate BMI	Pre-Obese or Obese	**Total**
	Worms	25 83.33%	5 16.67%	0 0.00%	**30** **7.11%**
	No Worms	152 38.78%	177 45.15%	63 16.07%	**392** **92.89%**
	Total	**177** **41.94%**	**182** **43.13%**	**63** **14.93%**	**422** **100%**
	$\chi^2 = 23.2559$, p = <.0001, df = 2				

Age and BMI (n = 414)

Tables 5 and 6 confirm the positive association between a patient's age and BMI. When BMI was divided into three levels, there was more than twice the percentage of young survey participants in BMI level 1 than adults: the first BMI level was composed of 68.02% of people younger than or equal to 16 years and only 31.98% of adults. In Table 5, 88.64% of children and early adolescents had BMI's in level 1, 11.36% had

BMIs in level 2, and 0.00% had BMIs in level 3. While the overwhelming majority of young patients had BMIs in level 1, more than half of the adults surveyed had a normal BMI (58.51%). As seen in Table 6, the proportion of youth in the BMI groups was consistently smaller from levels 1 to 6 and was highest in adults at level 4.

Table 5	**BMI WHO Three Categories**				
Age	**Freq** **Row Pct** **Col Pct**	Severely, Very, or Mildly Thin	Moderate BMI	Pre-Obese or Obese	**Total**
	Youth (age ≤16)	117 88.64% 68.02%	15 11.36% 8.33%	0 0.00% 0.00%	**132** **31.88%**
	Adults (age 17+)	55 19.50% 31.98%	165 58.51% 91.67%	62 21.99% 100.00%	**282** **68.12%**
	Total	**172** **41.55%**	**180** **43.48%**	**62** **14.98%**	**414** **100%**
	$\chi^2 = 178.4236$, p = <.0001, df = 2				

Table 6	**BMI WHO Six Categories**							
Age	**Freq** **Row Pct** **Col Pct**	Severely Thin	Very Thin	Mildly Thin	Moderate BMI	Pre-Obese	Obese	**Total**
	Youth (age ≤16)	65 49.24% 86.67%	26 19.70% 66.67%	26 19.70% 44.83%	15 11.36% 8.33%	0 0.00% 0.00%	0 0.00% 0.00%	**132** **31.88%**
	Adults (age 17+)	10 3.55% 13.33%	13 4.61 33.33%	32 11.35% 55.17%	165 58.51% 91.67%	46 11.11% 16.31%	16 5.67% 100.00%	**282** **68.12%**
	Total	**75** **18.12%**	**39** **9.42%**	**58** **14.01%**	**180** **43.48%**	**46** **11.11%**	**16** **3.86%**	**414** **100%**
	$\chi^2 = 204.8284$, p = <.0001, df = 5							

Age and BMI (n = 697)

After establishing an association between age and BMI, the findings of this study were reinforced by analyzing the same relationship in all of the 2011 clinic patients. Of the 274 children and early adolescents, 85.40% had BMIs in level 1, 13.50% had BMIs in level 2, and only 1.09% had BMIs in level 3. Of the 423 adults, 19.62% had BMIs in level 1, 58.87% had BMIs in level 2, and 21.51% had BMIs in level 3.

Table 7	**BMI WHO Three Categories**				
Age	**Freq** **Row Pct** **Col Pct**	Severely, Very, or Mildly Thin	Moderate BMI	Pre-Obese or Obese	**Total**
	Youth (age ≤16)	234 85.40% 73.82%	37 13.50% 12.94%	3 1.09% 3.19%	**274** **39.31%**
	Adults (age 17+)	83 19.62% 26.18%	249 58.87% 87.06%	91 21.51% 96.81%	**423** **60.69%**
	Total	**317** **45.48%**	**286** **41.03%**	**94** **13.49%**	**697** **100%**
	χ^2 = 292.9946, p = <.0001, df = 2				

Age, BMI, and Security

For each of the two age groups, the prevalence of food security was analyzed in relation to the six levels of BMI (Tables 8 and 9). Of the 132 youths surveyed, none were pre-obese or obese. Only 5.30% of the young participants were designated as food-secure. Out of these seven individuals, three had BMIs within the very thin range (42.86%), followed secondly by two children with moderate BMIs (28.57%). Of the insecure patients, over half (51.20%) had BMIs within the severely thin range, and only

10.40% had BMIs within the moderate range. Food-insecure youths were three times as likely to have BMIs in the first level, in comparison to food-secure individuals (Table 8).

Similar to the younger age group, only 4.96% adults were food-secure, while 95.04% were food-insecure. In contrast to the youths, however, there was a distinct patterning of food-secure adults. Thirteen out of the fourteen food-secure adults had normal BMIs, totaling 92.86% of all adults with food security. No food-secure adults were found in BMI levels 1, 2, 5, or 6. Like adults with food security, food-insecure adults were most highly concentrated in BMI level 4 (Table 9).

Youth (age ≤ 16)				
Table 8	**Food Security**			
BMI WHO Six Categories	**Freq** **Row Pct** **Col Pct**	Secure	Insecure	**Total**
	Severely Thin	1 1.54% 14.29%	64 98.46% 51.20%	**65** **49.24%**
	Very Thin	3 11.54% 42.86%	23 88.46% 18.40%	**26** **19.70%**
	Mildly Thin	1 3.85% 14.29%	25 96.15% 20.00%	**26** **19.70%**
	Moderate BMI	2 13.33% 28.57%	13 86.67% 10.40%	**15** **11.36%**
	Pre-Obese	0 0.00% 0.00%	0 0.00% 0.00%	**0** **0.00%**
	Obese	0 0.00% 0.00%	0 0.00% 0.00%	**0** **0.00%**
	Total	**7** **5.30%**	**125** **94.70%**	**132** **100%**
	$\chi^2 = 5.8834$, $p = 0.1174$, $df = 3$			

Adults (age 17+)				
Table 9	**Food Security**			
BMI WHO Six Categories	**Freq** **Row Pct** **Col Pct**	Secure	Insecure	**Total**
	Severely Thin	0 0.00% 0.00%	10 100.00% 3.73%	**10** **3.55%**
	Very Thin	0 0.00% 0.00%	13 100.00% 4.85%	**13** **4.61%**
	Mildly Thin	1 3.13% 7.14%	31 96.88% 11.57%	**32** **11.35%**
	Moderate BMI	13 7.88% 92.86%	152 92.12% 56.72%	**165** **58.51%**
	Pre-Obese	0 0.00% 0.00%	46 100.00% 17.16%	**46** **16.31%**
	Obese	0 0.00% 0.00%	16 100.00% 5.97%	**16** **5.67%**
	Total	**14** **4.96%**	**268** **95.04%**	**282** **100%**
	$\chi^2 = 7.6399$, $p = 0.1772$, $df = 5$			

Security and Infectious Disease

In contrast to the recurrent patterns established between food security, age, and BMI, there was a less clearly defined association between food security and infectious disease, shown in Table 10. Out of the 27 secure people featured in Table 10, 74.07% did not have infectious disease, whereas 25.93% had a least one diagnosis of an acute infectious illness. Among the food-secure, 25.93% had an infectious disease; among the food-insecure, 39.74% had an infectious disease. Thus, the food-insecure people manifested a 53% higher risk of infectious disease, although the difference was not statistically significant.

Table 10	Food Security			
Infectious Disease	**Freq** **Row Pct** **Col Pct**	Secure	Insecure	**Total**
	Infectious Disease	7 3.74% 25.93%	180 92.26% 39.74%	**187** **38.96%**
	No Infectious Disease	20 6.83% 74.07%	273 93.17% 60.26%	**293** **61.04%**
	Total	**27** **5.63%**	**453** **94.37%**	**480** **100%**
	$\chi^2 = 2.0433$, $p = 0.1529$, $df = 1$			

Malaria and Security

Table 11 exhibits a lack of association between malaria and food security ($p = 0.3545$). Of the 41 malaria cases in this sample, all cases with the exception of 1 (97.56%) were found in food-insecure patients; however, most non-malaria cases (94.08%) were also found in people with food insecurity.

Table 11	Food Security			
Malaria	**Freq** **Row Pct** **Col Pct**	Secure	Insecure	**Total**
	Malaria	1 2.44% 3.70%	40 97.56% 8.83%	**41** **8.54%**
	No Malaria	26 5.92% 96.30%	413 94.08% 91.17%	**439** **91.46%**
	Total	**27** **5.63%**	**453** **94.37%**	**480** **100%**
	$\chi^2 = 0.8572$, $p = 0.3545$, $df = 1$			

Worms and Security

A diagnosis of worm infection was the second type of infectious disease analyzed in relation to food security. All 33 cases of worm infection in Table 12 were found in patients with food insecurity. Of the 27 secure people, 100.00% were free of worm infection (Table 12). This observed difference was not statistically significant.

Table 12	**Food Security**			
Worm Infection	**Freq** **Row Pct** **Col Pct**	Secure	Insecure	**Total**
	Worms	0 0.00% 0.00%	33 100.00% 7.28%	**33** **6.88%**
	No Worms	27 6.04% 100.00%	420 93.96% 92.72%	**447** **93.13%**
	Total	**27** **5.63%**	**453** **94.37%**	**480** **100%**
	$\chi^2 = 2.1121$, p = 0.1461, df = 1			

CHAPTER SIX

Discussion

Globally, there is a widening food security gap between developed countries and developing areas of the world. In 2010, 85.5% of households in the United States were designated as food-secure, whereas the remaining 14.5% of households experienced food insecurity at least once throughout the year [21]. Contrary to the food stability seen in America, sub-Saharan Africa is prone to recurring undernutrition. In Kenya alone, the number of nutritional deficiencies from undernutrition is significantly higher than the World Health Organization's recommended dietary standards [19, 47].Through this study's evaluation of food security on the Nyakach Plateau in rural western Kenya, an overwhelming 94.37% of the surveyed population was found to be food-insecure with only 5.63% of food-secure individuals, while more than a third of the sample suffered from at least one case of acute infectious illness (Table 1). Consequently, the main objective of this study was to define the association between food insecurity, anthropometric status, and acute infectious disease within this sample, while determining the usefulness of the hunger scale questionnaire (HSQ) as a predictor for nutritional status and disease development.

The results of this study showed that the largest percentage of people had BMIs within the mildly thin or moderate range, whereas the smallest percentage had BMIs within the pre-obese or obese range (Table 2). A similar pattern was established when BMI was considered in relation to food security: the majority of patients' BMIs were localized within the moderate BMI category, regardless of the state of food security

(Table 3). In contrast to the food-insecure people, no food-secure patients had BMIs in the highest levels (pre-obese or obese), suggesting that if people perceive themselves as food-secure, they do not overeat and/or the better quality of their diet keeps them at a healthy weight. This is in contrast to overweight people whose excess calories do not translate into a perception of having enough food.

Though seemingly contradictory, 11.72% of the food-insecure people were pre-obese and 4% were obese (Table 3). The explanation for this peculiar association between obesity and food insecurity may lie in the definition of food security itself. Food security implies both quantity and quality [13]. Thus, individuals must consume the appropriate amounts of food as well as food with the proper nutrients, in order to be considered food-secure. Consequently, coexistence of food insecurity and overweight may be attributable to poor food choices and compromised diets. Studies have shown that individuals who are unsure about their ability to acquire enough food often begin to compromise the nutritional quality of meals in exchange for quantity [41]. Reasons for the highest concentration of BMI within the moderate range in both-food secure and insecure patients, however, are unclear and invite further investigation.

One of the strongest relationships established by the HSQ was the relationship between BMI and age. More than three-fourths of the young patients had BMIs within the category of severe thinness, while none were pre-obese or obese. Over half of the adults, on the other hand, had BMIs in the moderate range, similar to the overall pattern of BMI discussed above (Table 5). These findings indicate that children and early adolescents on the Nyakach Plateau have a poorer nutritional state, in comparison to adults. When compared against all of the 2011 clinical patients, the same association

between age and BMI was shown, confirming that the sample answering the questionnaire was not biased for BMI and age (Table 7).

Additionally, this study analyzed age and BMI within the context of food security. In the younger age group, a strong pattern was not established between age and BMI within the food-secure group. Nevertheless, of the seven secure young people surveyed, three (42.86%) had BMIs in the very thin range, suggesting that even food-secure children are at risk of experiencing a poor nutritional state. A much stronger relationship was shown between age and BMI within the food-insecure youths. Over 50% of the young patients with food insecurity had BMIs in the range of severe thinness, while only 10% had BMIs in the moderate category (Table 8). According to the study's results, insecure children were more than three times as likely to be severely thin than children who were food-secure. These findings confirm the literature's claims that a child's nutritional state is greatly affected by low levels of food security [33, 50]. In additional studies, age should be further subdivided into several categories to observe the effects of food insecurity on specific ages of children, allowing for more focused interventions.

A much more distinct relationship was found between food security and BMI in adults (Table 9). Unlike the BMIs of food-insecure children, most BMIs of food-secure and insecure adults were concentrated in the moderate range. As expected, an overwhelming 92.86% of food-secure adults had BMIs corresponding to normal weight-for-heights. However, more than half of all the BMIs of food-insecure adults were also in the moderate range, implying that levels of food insecurity affect adults' BMIs less than the BMIs of children. Therefore, it is crucial for food-based interventions to target

children and early adolescents, during the time frame when people are most susceptible to food insecurity's derogatory effects.

In addition to age and food security, the data indicated a strong association between worms and BMI. Patients not infected with worms followed the sample's overall pattern of BMI, whereas those infected with worms had BMIs highly localized to level 1 (severely or very thin), comparable to BMIs relationship with food-insecure children (Table 4). Provided that the majorities of food-insecure children and people with worm infection both possessed BMIs in the most severe level, it is probable that the high frequency of food insecurity in young ages of Luo children is associated with worm infection, though it was not directly analyzed in the study. Worms absorb nutrients in an individual's digestive tract, critically decreasing his or her nutritional state [25]. In this survey sample, people infected with worms were likely consuming food or water that contained parasites. While this study analyzed the relationship between BMI and one type of infectious disease, there needs to be additional research to examine the effect of BMI on other specific infectious diseases, in order to establish which diseases most interact with undernutrition [46].

Unlike the clear correlations described above, there was a lack of association between food security and infectious disease. When analyzing infectious disease as whole and considering the individual diseases of malaria and parasitic infection, a common problem existed for the three cases: there were significantly higher percentages of food-insecure people with and without infectious disease. In all three cases, more than two-thirds of food-secure patients did not have infectious disease; however, the same relationship was seen in food-insecure patients. It is important to note that the majority

of the people with infectious diseases were food-insecure, suggesting a negative association between food security and infectious disease (Tables 10, 11, 12). Subsequent research is needed, however, to verify that this inverse relationship is not simply the result of having a large proportion of insecure people in the sample size.

While the HSQ demonstrated a distinct relationship with BMI and age and parasitic infection, it was not a valid indicator for overall acute infectious disease, possibly due to the extremely high frequency of food insecurity on the Nyakach Plateau. In order to achieve more statistically significant results, additional studies should consider finding a greater number of food-secure patients for comparison, or re-construct questions of the HSQ so that an operative scale of insecurity may be used in subsequent analyses, as opposed to one group.

Conclusion

This study provides key insight into the state of food insecurity on the Nyakach Plateau in western Kenya. By using the hunger scale questionnaire (HSQ) as a measurement for food insecurity, this study describes specific associations between food insecurity, anthropometric status, and infectious disease, unique to this sample Luo community. Specifically, the findings of this study demonstrate the severity of the hunger crisis on the Plateau, while illustrating the susceptibility of youth to food security's threatening consequences, such as low body mass index (BMI). Generalizable to other settings, this study adds support for the use of the HSQ as an effective predictor for BMI and for continued research investigating the potential role of the HSQ as a determinant of the occurrence of infectious disease. Further studies are needed to confirm the existence of a negative association between food security and infectious disease.

While feasible, cost-effective interventions exist to reduce food insecurity, they are not being actively delivered to the people in greatest need, particularly the Luo [29]. Thus, it is imperative for policy makers to increase efforts combating food insecurity, in order to stop its detrimental, inter-generational effects and close the widening gap between food-secure and food-insecure countries. By decreasing the prevalence of food insecurity, nation leaders can improve cognitive development, increase work productivity, stimulate economic growth, and reduce mortality from infectious disease [49]. Treatment of food insecurity is extremely possible with new, community-specific interventions; all that is needed is the political will and monetary support to eradicate hunger and instigate worldwide change.

APPENDIX

APPENDIX

HSQ Code Book

HS1	Hunger Survey Question 1: Does your household ever run out of money to buy food?
	0=no
	1=yes
	2=missing
HS1a	Hunger Survey Question 1a: Has it happened in the past 30 days?
	0=no
	1=yes
	2=missing
HS1b	Hunger Survey Question 1b: Has it happened 5 or more days in the past 30 days?
	0=no
	1=yes
	2=missing
HS2	Hunger Survey Question 2: Do you ever rely on a limited number of foods to feed your children because you are running out of money to buy food for a meal?
	0=no
	1=yes
	2=missing
HS2a	Hunger Survey Question 2a: Has it happened in the past 30 days?
	0=no
	1=yes
	2=missing
HS2b	Hunger Survey Question 2b: Has it happened 5 or more days in the past 30 days?
	0=no
	1=yes
	2=missing
HS3	Hunger Survey Question 3: Do you ever cut the size of meals or skip any because there is not enough food in the house?
	0=no
	1=yes
	2=missing
HS3a	Hunger Survey Question 3a: Has it happened in the past 30 days?
	0=no
	1=yes
	2=missing
HS3b	Hunger Survey Question 3b: Has it happened 5 or more days in the past 30 days?

		0=no
		1=yes
		2=missing
HS4	Hunger Survey Question 4: Do you ever eat less than you should because there is not enough money for food?	
		0=no
		1=yes
		2=missing
HS4a	Hunger Survey Question 4a: Has it happened in the past 30 days?	
		0=no
		1=yes
		2=missing
HS4b	Hunger Survey Question 4b: Has it happened 5 or more times in the past 30 days?	
		0=no
		1=yes
		2=missing
HS5	Hunger Survey Question 5: Do your children ever eat less than you feel they should because there is not enough money for food?	
		0=no
		1=yes
		2=missing
HS5a	Hunger Survey Question 5a: Has it happened in the past 30 days?	
		0=no
		1=yes
		2=missing
HS5b	Hunger Survey Question 5b: Has it happened 5 or more days in the past 30 days?	
		0=no
		1=yes
		2=missing
HS6	Hunger Survey Question 6: Do your children ever say they are hungry because there is not enough food in the house?	
		0=no
		1=yes
		2=missing
HS6a	Hunger Survey Question 6a: Has it happened in the past 30 days?	
		0=no
		1=yes
		2=missing
HS6b	Hunger Survey Question 6b: Has it happened 5 or more days in the past 30 days?	
		0=no
		1=yes
		2=missing

HS7	Hunger Survey Question 7: Do you ever cut the size of your children's meals or do they ever skip meals because there is not enough money to buy food?	
		0=no
		1=yes
		2=missing
HS7a	Hunger Survey Question 7a: Has It happened in the past 30 days?	
		0=no
		1=yes
		2=missing
HS7b	Hunger Survey Question 7b: Has it happened 5 or more days in the past 30 days?	
		0=no
		1=yes
		2=missing
HS8	Hunger Survey Question 8: Do any of your children ever go to bed hungry because there is not enough money to buy food?	
		0=no
		1=yes
		2=missing
HS8a	Hunger Survey Question 8a: Has it happened in the past 30 days?	
		0=no
		1=yes
		2=missing
HS8	Hunger Survey Question 8b: Has it happened 5 or more days in the past 30 days?	
		0=no
		1=yes
		2=missing
BRE	Breakfast: What do you (or your child if the child is the patient) usually eat and drink in the morning?	
		0=nothing
		1=water
		2=tea
		3=porridge
		4=bread
		5=tea and porridge
		6=tea or porridge
		7=tea and bread
		8=tea and cassava
		9=tea and potatoes
		99=missing
LUN	Lunch: What do you (or your child if the child is the patient) usually eat and drink at mid-day?	
		0=nothing

		1=water
		2=tea
		3=ugali
		4=kales
		5=porridge
		6=potatoes
		7=sweet potatoes
		8=vegetables
		9=mealie (maize)
		10=githeri
		11=ugali and kales
		12=ugali and dagaa
		13=ugali and vegtables
		14=ugali and meat
		15=ugali and fish
		16=ugali, kales and meat
		17=rice and beans
		18=beans and chapati
		19=ugali, meat, and eggs
		20=kales and mealie
		21=cassava and rice
		22=cassava and potatoes
		23=potatoes or porridge
		24=sweet potatoes and porridge
		25=sweet potatoes and ugali
		26=sweet potatoes and tea
		27=githeri and tea
		28=githeri and porridge
		29=ugali, vegetables, and bread
		30=ugali, vegetables, and meat
		31=ugali, vegetables, and porridge
		32=uagli, kales, and porridge
		33=ugali, omena, and meat
		34=ugali or mealie
		35=water and soft drinks
		97=depends
		98=any food available
		99=missing
DIN	Dinner: What do you (or your child if the child is the patient) usually eat and drink in the evening?	
		0=nothing

		1=milk
		2=tea
		3=ugali
		4=kales
		5=porridge
		6=potatoes
		7=sweet potatoes
		8=cassava
		9=dagaa
		10=fish
		11=ugali and kales
		12=ugali and dagaa
		13=ugali and vegtables
		14=ugali and meat
		15=ugali and fish
		16=ugali, kales, and meat
		17=rice and beans
		18=dagaa and fish
		19=dagaa and mealie
		20=fish and mealie
		21=ugali and beans
		22=ugali and meat stew
		23=ugali and porridge
		24=ugali and omena
		25=ugali, kales, and omena
		26=ugali, kales, and rice
		27=ugali, vegetables, or rice
		28=tea and bread
		29=tea and rice
		97=depends
		98=any food available
		99=missing
WS	Water Source: Where do you get your water?	
		1=rain
		2=tap
		3=well
		4=tank
		5=river
		6=stream
		7=spring
		8=pond

		9=dam
		10=borehole
		11=tap (boiled)
		12=rain and tap
		13=rain and well
		14=rain and river
		15=rain and stream
		16=tap and well
		17=tap and stream
		18=well and stream
		19=well and spring
		20=well and tank
		21=stream and borehole
		22=rain, tap, and well
		23=borehole and rain
		24=stream and spring
		99=missing

REFERENCES

[1] Adazu, Kubaje et al. “Health and Demographic Surveillance in Rural Western Kenya: A Platform for Evaluating Interventions to Reduce Morbidity and Mortality from Infectious Diseases.” *The American Journal of Tropical Medicine and Hygiene* 73.6 (2005): 1151–1158.

[2] Alderman, Harold, John Hoddinott, and Bill Kinsey. “Long Term Consequences of Early Childhood Malnutrition.” *Oxford Economic Papers* 58.3 (2006): 450–474.

[3] Benson, Todd, and Meera Shekar. “Chapter 8: Trends and Issues in Child Undernutrition.” *Disease and Mortality in Sub-Saharan Africa*.2nd edition. Ed. Jamison DT, Feachem RG, Makgoba MW et al. Washington (DC): World Bank, 2006.

[4] Black, Robert E et al. “Global, Regional, and National Causes of Child Mortality in 2008: a Systematic Analysis.” *The Lancet* 375.9730 (2010): 1969–1987.

[5] Black, Robert E, Saul S Morris, and Jennifer Bryce. “Where and Why Are 10 Million Children Dying Every Year?” *The Lancet* 361.9376 (2003): 2226–2234.

[6] “BMI Classification.” *Global Database on Body Mass Index*. World Health Organization, 2006.

[7] Bryce, Jennifer et al. “WHO Estimates of the Causes of Death in Children.” *Lancet* 365.9465 (2005): 1147–1152.

[8] Burton, Deron C. et al. “Healthcare-seeking Behaviour for Common Infectious Disease-related Illnesses in Rural Kenya: A Community-based House-to-house Survey.” *Journal of Health, Population, and Nutrition* 29.1 (2011): 61–70.

[9] Casey, Patrick H. et al. “Children in Food-Insufficient, Low-Income Families: Prevalence, Health, and Nutrition Status.” *Arch Pediatr Adolesc Med* 155.4 (2001): 508–514.

[10] Caulfield, Laura E et al. “Undernutrition as an Underlying Cause of Child Deaths Associated with Diarrhea, Pneumonia, Malaria, and Measles.” *The American Journal of Clinical Nutrition* 80.1 (2004): 193–198.

[11] Caulfield, Laura E, Stephanie A Richard, and Robert E Black. “Undernutrition as an Underlying Cause of Malaria Morbidity and Mortality in Children Less Than Five Years Old.” *The American Journal of Tropical Medicine and Hygiene* 71.2 Suppl (2004): 55–63.

[12] CC, Campbell. “Food Insecurity: a Nutritional Outcome or a Predictor Variable?” *The Journal of Nutrition* 121.3 (1991): 408.

[13] “Core Indicators of Nutritional State for Difficult-to-sample Populations.” *The Journal of Nutrition* 120 Suppl 11 (1990): 1559–1600.

[14] Dannhauser A et al. “National Food Consumption Survey in Children Aged 1-9 Years: South Africa, 1999.” *The National Food Consumption Survey* (2000): 1-15.

[15] “Developing Nutrition Information Systems in Eastern and Southern Africa.” *Food and Nutrition Bulletin* 31.3 Suppl (2010): S272–286.

[16] Ehrhardt, Stephan et al. “Malaria, Anemia, and Malnutrition in African Children—Defining Intervention Priorities.” *Journal of Infectious Diseases* 194.1 (2006): 108–114.

[17] van Eijk, A M et al. “Causes of Deaths Using Verbal Autopsy Among Adolescents and Adults in Rural Western Kenya.” *Tropical Medicine & International Health: TM & IH* 13.10 (2008): 1314–1324.

[18] Feikin, Daniel R et al. “The Burden of Common Infectious Disease Syndromes at the Clinic and Household Level from Population-based Surveillance in Rural and Urban Kenya.” *PloS One* 6.1 (2011): e16085.

[19] Floros, John D et al. “Feeding the World Today and Tomorrow: The Importance of Food Science and Technology.” *Comprehensive Reviews in Food Science and Food Safety* 9.5 (2010): 572–599.

[20] Food and Agriculture Organization of the United Nations. *FAO: The State of Food Insecurity in the World*. Rome: FAO, 2010.

[21] “Food Security in the United States.” *ERS/USDA Briefing Room.* United States Department of Agriculture: Economic Research Service, 2011.

[22] Frongillo, E A, Jr et al. “Questionnaire-based Measures Are Valid for the Identification of Rural Households with Hunger and Food Insecurity.” *The Journal of Nutrition* 127.5 (1997): 699–705.

[23] Garrett, Dean A et al. “Field-Friendly Techniques for Assessment of Biomarkers of Nutrition for Development.” *The American Journal of Clinical Nutrition* 94.2 (2011): 685S–690S.

[24] Gericke G, D Labadarios, and JH Nel. “Chapter 8: Hunger Scale Questionnaire.” *The National Food Consumption Survey (NFCS): Children aged 1- 9 years, South Africa, 1999.* Ed. D Labadarios. Stellenbosch: The National Food Consumption Survey, 2000. 636-664.

[25] Gillespie, Stuart. “Poverty, Food Insecurity, HIV Vulnerability and the Impacts of AIDS in sub-Saharan Africa.” *IDS Bulletin* 39.5 (2008): 10–18.

[26] “Good Nutrition is Essential for People on ART.” *Fighting Hunger Worldwide*. United Nations World Food Programme, 2011.

[27] Ho, Melissa D, and Charles E Hanrahan. “The Obama Administration’s Feed the Future Initiative.” *UNT Digital Library* (2011): 1-22.

[28] “Hunger Stats.” *Fighting Hunger Worldwide*. United Nations World Food Programme, 2011.

[29] Jones, Gareth et al. “How Many Child Deaths Can We Prevent This Year?” *The Lancet* 362.9377 (2003): 65–71.

[30] Kendall, Anne, Christine M Olson, and Edward A Frongillo. “Validation of the Radimer/Cornell Measures of Hunger and Food Insecurity.” *The Journal of Nutrition* 125.11 (1995): 2793–2801.

[31] “Kenya: Overview.” *Fighting Hunger Worldwide*. United Nations World Food Programme, 2011.

[32] Koethe, John R, and Douglas C Heimburger. “Nutritional Aspects of HIV-Associated Wasting in Sub-Saharan Africa.” *The American Journal of Clinical Nutrition* 91.4 (2010): 1138S–1142S.

[33] Kwena, Arthur M et al. “Prevalence and Severity of Malnutrition in Pre-School Children in a Rural Area of Western Kenya.” *The American Journal of Tropical Medicine and Hygiene* 68.4 Suppl (2003): 94–99.

[34] Labadarios, D, Np Steyn, et al. “The National Food Consumption Survey (NFCS): South Africa, 1999.” *Public Health Nutrition* 8.05 (2005): 533–543.

[35] Labadarios, Demetre, Zandile June-Rose McHiza, et al. “Food Security in South Africa: a Review of National Surveys.” *Bulletin of the World Health Organization* 89.12 (2011): 891–899.

[36] Loewenberg, Samuel. “Global Food Crisis Takes Heavy Toll on East Africa.” *Lancet* 378.9785 (2011): 17–18.

[37] “Low-Income Food-Deficit Countries.” *FAO Country Profiles*. Food and Agriculture Organization of the United Nations, 2012.

[38] Mockenhaupt, Frank P et al. “Manifestation and Outcome of Severe Malaria in Children in Northern Ghana.” *The American Journal of Tropical Medicine and Hygiene* 71.2 (2004): 167–172.

[39] “Notes from the Field: Malnutrition and Mortality --- Southern Somalia, July 2011.” *Morbidity and Mortality Weekly Report* 60.30 (2011): 1026-1027.

[40] Nowels, Larry. “Feed the Future: Navigating Through the U.S. Budget Tsunami.” *The Chicago Council on Global Affairs* (2011): 1-7.

[41] Olson, Christine M. “Nutrition and Health Outcomes Associated with Food Insecurity and Hunger.” *The Journal of Nutrition* 129.2 (1999): 521–521.

[42] de Onis, M., E. A. Frongillo, and M. Blössner. “Is Malnutrition Declining? An Analysis of Changes in Levels of Child Malnutrition Since 1980.” *Bulletin of the World Health Organization* 78.10 (2000): 1222–1233.

[43] Radimer, Kathy L, Christine M Olson, and Cathy C Campbell. “Development of Indicators to Assess Hunger.” *The Journal of Nutrition* 120.11 Suppl (1990): 1544–1548.

[44] Radimer, Kathy L, and Kathy L Radimer. “Measurement of Household Food Security in the USA and Other Industrialized Countries.” *Public Health Nutrition* 5.Supplement 6a (2002): 859–864.

[45] Rice, A. L. et al. “Malnutrition as an Underlying Cause of Childhood Deaths Associated with Infectious Diseases in Developing Countries.” *Bulletin of the World Health Organization* 78.10 (2000): 1207–1221.

[46] Scrimshaw, N. S., and J. P. San Giovanni. “Synergism of Nutrition, Infection, and Immunity: An Overview.” *The American Journal of Clinical Nutrition* 66.2 (1997): 464S–477S.

[47] Semproli, Samantha, and Emanuela Gualdi-Russo. “Childhood Malnutrition and Growth in a Rural Area of Western Kenya.” *American Journal of Physical Anthropology* 132.3 (2007): 463–469.

[48] Svedberg, Peter. “Declining Child Malnutrition: A Reassessment.” *International Journal of Epidemiology* 35.5 (2006): 1336–1346.

[49] United Nations World Food Programme. *World Hunger Series 2007: Hunger and Health*. Earthscan, 2007.

[50] Victora, Cesar G et al. “Maternal and Child Undernutrition: Consequences for Adult Health and Human Capital.” *Lancet* 371.9609 (2008): 340–357.

[51] “Vital Signs: Hospital Practices to Support Breastfeeding --- United States, 2007 and 2009.” *Morbidity and Mortality Weekly Report* 60.30 (2011): 1020-1025.

[52] Wahlqvist, Mark L. “Regional Food Diversity and Human Health.” *Asia Pacific Journal of Clinical Nutrition* 12.3 (2003): 304–308.

[53] Weinreb, Linda et al. “Hunger: Its Impact on Children’s Health and Mental Health.” *Pediatrics* 110.4 (2002): e41.

[54] “WFP and Nutrition: Right Food at the Right Time.” *Fighting Hunger Worldwide*. United Nations World Food Programme, 2011.