Abstract

A Cross-Sectional Study of the Effects of Goat Milk on Malnourished Children in a Community-Based Program

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In May-July of 2013, a cross-sectional research project was undertaken in rural western Kenya on the Nyakach Plateau in the Nyanza Province examining the effects of goat milk consumption on long-term and short-term growth among a group of orphans. The goal of the project was to see the effects of a community-based goat milk distribution program without the intervention of a foreign presence. There were a total of 61 orphans in the sample, 47 of them not receiving milk and 14 of them receiving milk. The background information was ascertained from each of the subjects via interview, and then trained individuals took anthropometric measurements. Resulting figures showed no statistical difference in the growth indices between those who consumed goat milk and those who did not. However, within the sample who did receive goat milk, those receiving goat milk for a longer, more recent period of time displayed greater short-term growth than those who did not, as indicated by their mean BMI z-scores (-0.62 vs -1.70; p = 0.0085). Additionally, though not as strong, when this was stratified among those receiving more than a cup of milk, the mean BMI z-scores were (-0.64 vs -1.70; p = 0.0167). This relationship was strengthened when stratified across older children (>9 years old), the mean BMI scores being (-0.62 vs -1.70; p = 0.0067). Future research will follow up these subjects and document the long-term effects of goat milk supplementation.

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A CROSS-SECTIONAL STUDY OF THE EFFECTS OF GOAT MILK ON MALNOURISHED CHILDREN IN A COMMUNITY-BASED PROGRAM

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By

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CHAPTER ONE

Introduction

Kenya, one of Africa's many developing countries, is a nation that has been afflicted by a multitude of developmental issues preventing its progression. Many of these third-world issues include corrupt or under-developed political systems, lack of healthcare services, scarcity of clean water sources, and lastly, a dearth of food to sustain a healthy, thriving population. The lack of adequate food resources has led to a malnourished population that is underweight and undersized, especially among the youth.

Unlike other concentrated areas of third-world countries, sub-Sahara Africa (including Kenya) has seen a deterioration of the growth of their children from 1985 to 2011(Stevens et. al., 2011). Though this trend seemed to slow during the 2000's, the height-for-age score for the typical child was still lower than it was in the late 1980's, resulting in an increase in stunted children in sub-Sahara Africa since 1980. This has seemed to be even more severe in rural regions. Additionally, it was calculated that the Millennium Development Goal 1 (MDG 1) of halving the prevalence of weight-for-age below two standard deviations by 2015, or lowering the prevalence to 2·3%,,was likely to be reached in less than 12% of the Sub-Sahara countries, including Kenya[1].

Straw to Bread is a nonprofit organization based in the United States dedicated to serving the people of the Nyakach Plateau in rural western Kenya. The organization aims to improve the lives of these people through the promotion of sustainable socioeconomic development, healthcare, education, agriculture, and clean water. Beginning in 2011, Straw to Bread provided the Bethlehem Home community on the Nyakach Plateau with several dairy goats for milk production, and two rams for reproduction and consequential expansion of the program. The project was a community-based effort in which the caretakers of the goats were Bethlehem Home-supported adults who also distributed the milk to orphans living nearby. The similar living conditions of the orphans who received goat milk and others who did not receive this supplement, coupled with the close network within the community, allowed for a baseline evaluation of this community-run dairy goat program in a cross-sectional study.

CHAPTER TWO

Review of Literature

Malnutrition

Malnutrition is a rampant affliction in much of the developing world, Sub-Sahara Africa being a major portion of this unfortunate problem. Malnutrition is a key factor in the high child mortality throughout the region, responsible for a third of all deaths of children under the age of five, a quantity almost reaching 6.9 million in the year 2011.[2]

Malnutrition is often divided into three categories to explain its effect on child growth: wasting, underweight, and stunting. The first is wasting, know as more of as an acute, extreme condition in which an individual is recently sick and unable to gain weight, or the sudden loss of weight. This is typically measured by a low weight-for-height or body mass index (BMI). Weight-for-height does not take age into consideration. This is useful when the age of an individual cannot be ascertained (i.e. lack of communication or child is unaware of age). Weight-for-height is particularly helpful in recognizing wasting in children, or an acute loss in weight, such as in a famine or drought. BMI is calculated from weight in kilograms divided by height in meters squared and is standardized based on age and gender norms. This is necessary as the fat free mass and fat mass vary between boys and girls of different ages, especially during puberty. The second way to categorize malnutrition is to label a child as underweight, describing children who have consumed less than enough nutrients, protein, and/or calories to maintain a healthy weight for their particular age, gender, and height. The third, stunting, is a more severe form of an underweight condition and typically conveys a history of poor nutrition, chronic illness, and impoverished settings over a long period of time. This will most typically be indicated by a low weight-for-age and height-for- age (height-for-age Z score <−2)[3,4].

One particular study, in which the usefulness of anthropometry to assess malnutrition was researched (1994), made cutoffs for three types of malnutrition in children under the age of 5. In the case of underweight, the prevalence among the population was considered low if less than 10% of the population had z-scores less than -2, or high if more than 30% of the population had z-scores less than -2. Respectively for stunting, this was less than 20% and more than 40%. For wasting, less than 5% was considered low, and greater than 15% was considered high [5]. On a global scale encompassing developing countries for children under the age of five, 55 million are wasted and 178 million are stunted using these definitions [2]. Though these numbers might be incredibly high, this is a reduction from 1985 to 2011. The prevalence of stunted children under the age of five in developing countries dropped from 47.2% to 29.9%, and the prevalence of underweight children dropped from 30.1% to 19.4% [1]. According to a 2002 study done in three villages in Siaya District of western Kenya,, 30% of children under the age of five were underweight, 47% were stunted, and 7% were wasted[3]. Clearly, this particular region is ravaged and has children who are in great need.

Causes of Malnutrition

The causes of malnutrition are wide-ranging and are often linked in a vicious cycle in which a detrimental factor fuels malnutrition, and the malnutrition worsens the causal factor. The major factors in malnutrition, in addition to the lack of calorie intake, include being a low birth weight baby (LBW), a lack of or insufficient breastfeeding of a child, a lack of micronutrient intake, and repeated and continual infection (diarrhea being a strong component)[2].

Inadequate intake of breast milk at an early age is a huge factor causing stunting in children. It is recommended that children be solely breastfed until six months of age and then continued with complementary feeding until at least one year of age. According to a 2012 study, in the developing world, 47% to 57% of infants are solely breastfed. Those who are not breastfed in the their first half-year of life have a relative risk of death of 14.4 compared to those who are exclusively breastfed. Children who are not breastfed from 6 months to 2 years have a 3.68 relative risk of death in comparison to those who are breastfed during that period. Total mortality was 1.4 million children under the age of 5 who had suboptimal breastfeeding in the first six months of life (Ahmed et. al, 2012) [6]. Diarrhea also increases as breastfeeding decreases, being a contributing factor to the higher rates of mortality and malnutrition. Complementary feeding after the 6-month mark is necessary to avoid stunting since that period of growth has a higher demand for nutrients, protein, and calories. The majority of stunting occurs in this period in developing countries [4]. A large portion of complementary feeding/weaning diets include porridge, bananas, potatoes, cow's milk and even commercial baby foods. In a nutritional study (Munoz, 1964,) it was shown that up to 64% of these weaning diets had absolutely no protein[7].

Effects of Diet

Protein is a macronutrient that is necessary for proper growth, reduced risk of morbidity, proper physiologic homeostasis, normal cognitive function, and a basic healthy lifestyle. For a healthy state of being, the average person is advised to consume at least 0.66 g of protein per kilogram of body weight per day[8]. However, the quality of the protein must also be adequate based on the amino acid content of the protein. It is necessary for humans to consume animal proteins as well as vegetable and cereal proteins in order to receive all the essential amino acids that the body cannot produce itself. Lack of protein, especially in early developmental stages, has been shown to be very damaging to the individual. Studies show that brain growth slows from lack of creation of synapses, neurons, myelin sheaths, and other components necessary to nerve development, which results in a lower IQ, slower learning rates, decreased concentration, and poor memory and social skills [9]. Loss of protein has also been shown to cause atrophy of the lymph system and loss of immunity capabilities. The shrinkage of lymph tissue, to a greater degree than general loss of body weight, was demonstrated in mice that were given a protein-restricted diet [21]. With this loss comes a lack of ability for the body to fight infections, resulting in frequent acute diseases and the perpetuation of chronic diseases. Unfortunately, Kenyan diets have been shown to be typically low in protein, especially animal protein. The Kenyan diet is very limited and mostly cereal-based. According to a UNICEF and WHO survey (Bohdal 1969)[11], vegetable protein, which accounts for about 12% of the total energy intake, accounts for a majority of protein intake. Animal protein makes up only 0.5 to 10% of all protein consumed by the average Kenyan. To compound this deficit, a majority of animal protein has been found to have a quality score lower than 65% on average. This is due to the fact that a large amount of the protein comes from fish, a lower quality protein in comparison to cows and pigs [7].

Micronutrients are a crucial to the growth of a child, and more often than not, children in developing countries are severely lacking in several of these. Vitamin A, iron, zinc, and iodine are the four major micronutrients that are typically deficient in diets. The deficiency of these four major vitamins and minerals accounts directly for 12% of the mortality of children under 5, while it accounts for over 50% of deaths in children under 5 when indirect causes are also taken into account [6]. Other less important micronutrients, yet still essential, include the B-vitamins [2].

The deficiency of vitamin A (VAD) is considered a major cause of morbidity and mortality worldwide for 251 million people [2]. The relative risk of mortality due to diarrhea related to VAD is 1.47, and the relative risk of mortality from measles related to VAD is 1.35. Xerophthalmia is also a leading cause of blindness from resulting from VAD [4]. The prevalence of VAD is widespread in Kenya. Among children six to eleven months old, one study found that 11.2% had <0.35 mmol/L of vitamin A, and 40.7% had <0.7 mmol/L. Twelve to twenty-four-month-old children were almost as bad off: 9.6% had <0.35 mmol/L of vitamin A, and 34.9% had <0.7 mmol/L [7].

Iron is another essential mineral the body requires, especially as a component of hemoglobin that picks up oxygen and carries it throughout the body via the red blood cells. Consequently, the lack of iron will result in anemia and the hypoxia of tissues within the body. Organs will be less efficient, and the affected person will have much less energy on a continuous basis. Iron deficiency is due to a low consumption of meat, fish, and poultry, where the majority of consumable iron is found [4]. As a result of the impoverished setting that causes iron-deficiency anemia, the health of the individuals is further jeopardized by compounding problems of chronic diseases, malaria, and helminthic diseases [2]. Normal serum iron levels in children should range from 9.0 to 21.0 μmol/L. In Kenyan children, 19.5% have been found to have serum iron levels that were less than 2.2 μmol/L. With the cutoff for anemia as 108 g/L, the average infant (<6 months) had hemoglobin levels 96.3 g/L, with 37.4%, 45.7% and 13.4% of infants having mild, moderate, and severe anemia, respectively. Children who were older (6 to 72 months) had hemoglobin levels that averaged 101 g/L. Older children had 17.1%, 41.5% and 11.0% of mild, moderate and severe anemia, respectively, showing that the severity of anemia slightly decreases with age, but still remains a problem throughout childhood [7]. To further narrow in, a recent study performed in rural western Kenya showed that for anemia cases among pre-school children, 16.8% was due to malaria, 8.3% was due to iron deficiency, and 6.1% was due to inflammation [12].

Iodine is an essential mineral that is necessary for proper health, especially during a child's development. Iodine deficiency disorder (IDD) is a major cause of developmental disabilities for children in developing countries and is the reason for an average decrease in IQ of 13.5 points in populations that are know to have chronic IDD [4]. Hypothyroidism is the result of iodine deficiency. Current estimates show that 130 countries and 13% of the world population are affected by IDD and that >2 billion people are at risk of developing IDD [2].

The lack of zinc, another vital micronutrient that the body utilizes, causes long-term and short-term repercussions. Zinc is imperative for normal growth of children because it is an essential part of the creation of DNA and proteins. Almost one-third of the world's population is believed to suffer from severe zinc deficiency [2]. Countries with stunting of the population at greater than 20 % are considered to be at high risk for zinc deficiency. In the short-run, zinc deficiency has been linked to higher susceptibility to diarrhea (RR=1.09), pneumonia (RR=1.25), and malaria (RR=1.56) [4].

Other essential substances include calcium, vitamin D, vitamin B12, and folic acid. Calcium deficiency is the primary cause of rickets and poor bone growth in much of Africa. Vitamin D deficiency leads to poor fetal growth and inadequate bone mineralization in infants. Lack of folic acid and vitamin B12 both contribute to neural tube defects in developing fetuses and are associated with low birth-weight and premature infants [2, 4].

Interaction of Malnutrition and Infection

Malnutrition causes infection, and infection causes malnutrition. Inadequate intake of food and nutrients results in lower immunity, weight loss, failure to develop, and the increased susceptibility to pathogens. These pathogens often cause diarrhea, malabsorption, loss of appetite, and use of nutrients to fight the pathogens. This results in a further, continual loss of nutrients and an even greater need for them. Malnutrition can lead to different infections through an acute and a chronic manner. Protein energy malnutrition (PEM) can result in many types of infection:, intestinal helminths, tuberculosis, measles, influenza, Pneumocystis carinii, malaria, AIDS, skin infections, and noma. Also in the reverse direction, there are several examples on infections that cause further malnutrition. Gastrointestinal diseases can cause diarrhea with water and vitamin loss. HIV/AIDS, TB, and other long-term infections can cause anemia and cachexia. Helminthic diseases can also cause anemia and rob the gastrointestinal tract of valuable nutrients before they can be absorbed [13,14].

In regards to HIV status, one study followed 454 children from Malawi who were severely malnourished and were either HIV-infected or uninfected. Those who were infected had a much higher mortality rate at 35.4%, compared to the uninfected at 10.4%, but all children who survived obtained a full nutritional recovery, regardless of HIV status [15].

As for malaria, there is conflicting research on how malnutrition and malaria interact, older studies hypothesizing even that iron deficiency allows for somewhat of a protective effect against malaria. However, more recent evidence has come to suggest that a lack of protein and micronutrients inhibits the immune system from mounting a response to the malaria, allowing a lesser chance for the malnourished children to clear the malaria from their systems than better nourished children can do [16]. In terms of relative risk of mortality from malaria in comparison to a healthy child, stunted children have a 2.4 relative risk, underweight children have a 2.7 relative risk, and wasted children have a 2.8 relative risk of death [17].

Additional Factors Affecting Growth

Other factors that might affect growth include gender, age, lead poisoning, and maternal malnutrition as a contributing factor to suboptimal breast milk. With respect to gender, a study done in 1993 to 2009 in Kenya analyzed the determinants of a child's nutritional status. The study showed that male children are much more like to be chronically and acutely malnourished, as well as being underweight, than female children. The z score of the average boy's height was 0.19 lower than the girl's height. Also, a boy was 7% more likely to be stunted than a girl would be (Masibo 2012) [18].

Age is an important contributor to the status of malnutrition. Younger children, those below two years of age, are less likely to be malnourished if they are breastfed. The likelihood of stunting goes up during weaning time. Once the child starts receiving outside food sources, growth slows, and the decline is worse as the need for further nourishment continues[23].

In terms of the effects of lead, a NHANES II study showed that a blood level of 4– 35 μg/dL in the blood among 2,695 children 7 years old and younger was a significant predictor of the anthropometric measurements of children. Children who had significantly detectable blood levels were 1.5% shorter than they should have been if there was no detectable lead in their blood. Also, on average, an increase in blood lead of 10μg/dL resulted in 1.57 cm decrease in stature and a 0.52 cm decrease in head circumference [20].

Further complicating the issue, the maternal provider is often malnourished as well, resulting in a lack of breast milk rich in micronutrients, especially vitamin A.

Nutritional Recovery in Children

Recovery from malnourishment is considered to be the laying down of new body tissue and repletion of energy stores. A study was done on 26 malnourished children who were assigned to treatments of either moderately paced weight gain (4-6 g/kg per day) or rapidly paced weight gain (12-16g/kg per day). When final healthy body mass was reached in each group, both had similar body compositions in terms of fat, protein, and water weight. However, the rapid group reached their goal at a much more accelerated pace, concluding that rapid weight gain is a healthy method for achieving an acceptable body mass index in malnourished children [21]. The implications of this study are that children are amazingly resilient, and rapid interventions produce rapid results. There are many approaches to improving children's nutritional status in the developing world, including the instigation of school gardens to teach children how to grow their own food (Durbin, 2014), efforts to eliminate disease, and the provision of clean drinking water. One effective strategy has been to use goat milk to supplement the diets of children in poverty.

Goat Milk as a Nutritional Supplement

Goat milk is currently served more frequently to the malnourished in the developing world than cow milk, and goat milk has qualities that make it especially favorable for consumption. Besides its wide spectrum of valuable nutrients, with a profile is similar to human milk, it is a very good substitute for those who might have allergies to cow milk (2.5% of all children 3 years old and younger). There was a substantial increase in the use of goats for their milk production between 1980 and 1999.

In that 20-year period, the number of total farm goats increased from 458 million to 710 million, or a +55% change, while total farm cattle only increased from 1216 million to 1338 million, or a +10% change. Accordingly, goat milk production increased from 7.72 to 12.161 million metric tons, or a +58% change, while cow milk increased from 423.034 to 480.659 million metric tons, or a +14% change. So while the number of cattle is still much larger than the farm goats, the use of goats is increasing very fast [22].

Goat milk only amounts to 2.3% of the total milk produced globally. However, its production and farming is highly concentrated in much of the developing world. This is a result of goats being reliable producers at all times, having quick reproduction rates, having lower calorie and nutritional requirements (coupled with a wide-ranging diet), and being well-priced at the market place. Most dairy goats in Asia and Africa are typically used to nourish those who raise them, not to produce milk to sell. Of the approximately 617 million goats in the world, 97.3% are found in the developing world, and 27.4% are found in Africa. However, the number of dairy goats is only 191 million goats, with only about 47.7% of those found in the 25 least developed countries [23]. In Kenya, goats make up 15.2% of livestock, which in turn makes up 4.8% of all household income in Kenya. The main breeds are Saanen, Toggenburg, Anglo Nubian, British Alpine, German, and Alpine, which were introduced by British farmers in the 1950's [24].

Depending upon the diet and care of the goat, the quality of milk can vary greatly. In a study reviewing the composition and characteristics of goat milk from 1968 to 1979 , the typical macronutrient and micronutrient profile of milk from healthy goats was analyzed. The cholesterol content of goat milk ranges from 10 to 20 mg per 100 mL. Goat milk has five principle proteins. These include β-lactoglobulin, β-casein, αlactalbumin, α_{s2}-casein, and *K*-casein. In terms of energy content, fat contributes 50%, protein contributes 25%, and lactose makes up the remaining 25%. There are 3.3g of protein per 100 g of milk, or 4.4g of protein for every 100 kcal. The daily requirement for humans is 1.8 g of protein per 100 kcal, and goat milk contains more than double this requirement. Goat milk is also noted for having milk fat consisting of up to 20% short and medium chain fatty acids (4-12 carbon chain), which are useful in combating several diseases and medical conditions.

In terms of micronutrients, goat milk contains around 1.2 g of calcium per liter (g/L) and 1 g/L of phosphorous. Goat milk is also abundant in vitamin A, niacin, thiamin, riboflavin, and pantothenate. However, it is deficient in vitamin C, D, B_{12}, pyridoxine and folic acid. Deficiency in vitamin B_{12} can lead to what is known as "goat milk anemia" if the vitamin is not supplemented. Folic acid content averages around a low of 6 μg/L (Jennes 1979)[25].

Several studies have been done to compare the benefits of goat milk versus cow milk. Besides the fact that goat milk helps those with allergies to cow milk, resolving the problem up to 40% of the time, the delivery of nutrients to the body is much greater in goat milk than in cow milk. A study done in 1952, following 38 children drinking either cow or goat milk over a five-month period, showed increased weight gain, height, bone mineralization, and blood serum contents of Vitamin A, calcium, thiamin, riboflavin, niacin and hemoglobin in those consuming goat milk (Mack, 1952) [26]. It also showed that goat milk helped decrease LDL cholesterol levels while maintaining HDL cholesterol levels to a greater degree than cow milk. This was due to the higher content of medium-chain triglycerides, 36% in goat milk versus 21% in cow milk. In an Algerian study done in 1993, 64 infants with malabsorption syndrome showed much greater rates of intestinal fat absorption when consuming goat milk instead of cow milk (Hachelaf et al., 1993)[27]. In another study in which 30 malnourished, hospitalized children from Madagascar were given goat or cow milk, those consuming goat milk outgained those on cow milk in body weight by 9% in a two-week period (Razafindrakoto et al., 1993)[28].

Additionally, some of the essential amino acids have been shown to be present in higher proportions in goat milk over cow milk: +4% difference in isoleucine, +9% for threonine, +9% for valine, +11% for lysine, +13% for tyrosine, and +53% for cystine [22]. Another study, done by the University of Ilorin in Nigeria during 2002, showed the difference in mineral content between human, cows and goat milk (cows and goats were grazed on the same field) (Belewu, 2002) See TABLE 1.

TABLE 1

Mineral Content in Different Types of Milk (concentration shown in parts per million)			
Mineral	Human Milk (ppm)	Cow Milk (ppm)	Goat Milk (ppm)
Sodium	150	51.92	210.41
Potassium	1.60	1.3	1.55
Calcium	6.26	4.03	5.56
Magnesium	3.33	1.03	2.30
Phosphorous	1.50	0.92	1.20
Iron	1.40	1.07	1.30
Zinc	2.95	0.11	0.80
Copper	0.34	0.25	0.56
Manganese	5.19	1.59	3.29

Goat milk proved to be similar on average to human milk in mineral content, and it surpassed cow milk on almost all accounts [29]. It has also been demonstrated that goat milk aids in absorption and retention of copper, zinc, and selenium to a much greater degree than cow milk allows [30].

Effects of Social Context upon Growth

Household Size

It has been speculated that the size of a household that a child from a third-world country lives in is a determinant of growth in the child; that is, as the size of the household increases, there is an inverse correlation with the growth of the child. In a study performed in Timor-Leste, this was found to be true in regards to height. With every additional child that lived in the house, the child fell -0.18 in terms of z-score ($p = 0.001$), though an increase in BMI was seen. The researchers speculated that this was due to denominator portion (height) of the BMI equation decreasing and consequently making the BMI larger (Reghupathy et. al., 2011)[31]. Another study, which took place in Southern Brazil, attempted to find the determinants of growth retardation. It found for a child with a subsequent sibling, the odds ratio of being below the second negative standard deviation for height-for-age was 1.91 (95%CI: 1.16-3.13) (Aerts et. al., 2004)[32].

Sanitation Practices

In many developing countries, homes often lack modern toilet facilities. In many places, such as Kenya, the typical person will either use a latrine or simply relieve himself or herself in the environment. Due to these kinds of sanitation practices, the possibility of diseases and unsanitary living conditions can arise. These can result in negative effects on a child's growth. A cohort study in rural Sudan that followed 25,483 children aged 6 – 72 months and their sanitation practices over an 18-month treatment period found that non-stunted children with lavatories and access to household water had an RR = 0.79, (95% CI 0.69–0.90) of becoming stunted compared to children without either of these facilities. On the flip side, children who were stunted at baseline but did have lavatories and access to household water had a RR =1.17, (95% CI 0.99–1.38) of recovering than children without either of these commodities (Merchant et. al., 2003)[33].

Mosquito Nets

Mosquito nets provide a form of protection for those located in mosquito endemic areas during the nighttime. Female mosquitoes tend to take blood meals during the evening, particularly when people are sleeping and most vulnerable. Mosquito nets prevent mosquitoes from feeding if used and maintained properly, and consequently lowering the risk of malaria transmission. A 1996-1998 study observed the impact of insecticide (permethrin)-treated bed nets (ITNs) in malaria endemic parts of western Kenya. The study was an intervention that randomly supplied parts of the population with ITN's as to create a randomized control trial. Those with INT's were found to have +0.5 g/dL differential of hemoglobin (95% CI = 0.2–0.8 g/dL) in comparison to those without INT's (mean = 10.0 g/dL versus 9.5 g/dL; P = 0.0005). The prevalence of malaria was 44% (95% CI:6–66%) lower in villages utilizing INT's. Children (3-35 months) utilizing INT's had a +0.16 weight-for-age Z-score in comparison to children who were not (95% CL: 0.01–0.31, p = 0.04)(Kuile et. al., 2003)[34].

The Gap

The qualities and beneficial attributes of goat milk have long been known, and the effects that the milk have had on malnourished populations have been meticulously studied in the past half-century. Furthermore, malnourished children in impoverished settings receiving goat milk have been of particular interest. However, the method of this type of research has typically been that of a randomized control trial in which the children are given milk by researchers. Alternatively, longitudinal studies are performed in which a meticulous meal and milk plan is established by the researcher. The goal of the present study was to observe the effects of a community-based approach. Money was provided to the community to purchase their own dairy goats, organize their care, and plan a program of distribution for a group of orphans. This approach allowed for the assessment of the efficacy of a goat milk program, and also to observe the power of a community-driven intervention. The thought process behind this particular method is that the typical community will be attempting to provide for itself. Outside providers or sources cannot constantly have a presence within communities in need of these kinds of programs. Consequently, the goal of this study was to observe a self-sustained program and how it progressed.

Finally, this study took the additional step of assessing goat milk supplementation in this small sample while studying a number of other variables known to modify growth, including demographic variables, diet, health status, and environmental exposures. An in-depth study of a small sample is limited in generalizability, but it provides rich data to guide future research. Any lack of significant findings might be accounted for by low statistical power. However, statistically significant results in spite of a small sample will be particularly notable.

CHAPTER THREE

Hypotheses

All of the following research questions are concerned with children's growth over time. However, this cross-sectional study only allows for the comparison of children's nutritional status at one point in time after supplementation had begun, without the availability of baseline measurements. This is a limit of community-based research designed after a service project has been implemented. Several assumptions seek to address this limitation. The assumption is that, from the start, the children drinking goat milk were smaller or at least not larger than the children who were not supplemented, because it was the neediest children who were sought out to receive milk. There is no way to verify this assumption, however, so the next best strategy was to test for differences *among* those who drank goat milk, studying differences in size attributable to the amount and/or duration of milk supplementation.

In light of this limitation, the research questions and hypotheses are not stated in terms of children's growth, implying a change over time, but instead are couched in terms of size alone. Because size in children is a complex indicator of nutritional status, the following anthropometric measurements were derived from the subjects' height and weight: body-mass index (BMI), height-for-age (HFA), and weight-for-age (WFA). These measurements must be standardized for age and gender, because children's proportions change normally over time, and the natural growth trajectory of girls is different than that of boys. Algorithms have been developed for these comparisons, and z-scores provide standardized numbers. These measures were used in the present study and will be collectively referred to in the hypotheses as “growth indices”.

In spite of a small sample, it is still important to examine the potential modifying or confounding effects of other variables known to impact growth so that any conclusions about the intervention have taken into account the effect of these other variables. Therefore, the hypotheses 1 and 3 below assume that the associations have been adjusted for demographic factors (household size, age, gender), diet (protein intake), health status (HIV, malaria, worms, diarrhea), and environmental exposures (toilet, mosquito net).

Research Question 1

Will the growth indices of children supplemented with goat milk be higher than those of children who did not receive goat milk?

Hypothesis 1: There is a positive association between consumption of goat milk and children’s growth indices.

Research Question 2

Do factors known to affect children’s size have the predicted effect in this sample?

Hypothesis 2: Factors known to affect children’s size will have the predicted effect in this sample.

2A- Children with lower protein intake will have lower growth indices than children with higher levels of protein intake.

2B-Children from a larger household will have lower growth indices than children from a smaller household.

2C- Children with no mosquito nets will have lower growth indices than children with mosquito nets.

2D-Children with poor sanitation practices will have lower growth indices than children with better sanitation practices.

2E-Children with a poorer health status will have lower growth indices than children with a better health status.

Research Question 3

After adjusting for the effects of other known factors, will there be a difference in size *among* children receiving goat milk, based on quantity of milk, duration and recency of supplementation, age, or gender?

Hypothesis 3. Among children receiving goat milk, after adjusting for other factors:

3A. Children with longer, more recent consumption will have higher growth indices than children with shorter, less recent consumption.

3B. Children consuming larger quantities of milk will have higher growth indices.

3C. Older children will have higher growth indices than younger children.

3D. Older boys with goat milk supplementation will have a higher growth indices than older girls with goat milk supplementation.

Research Question 4

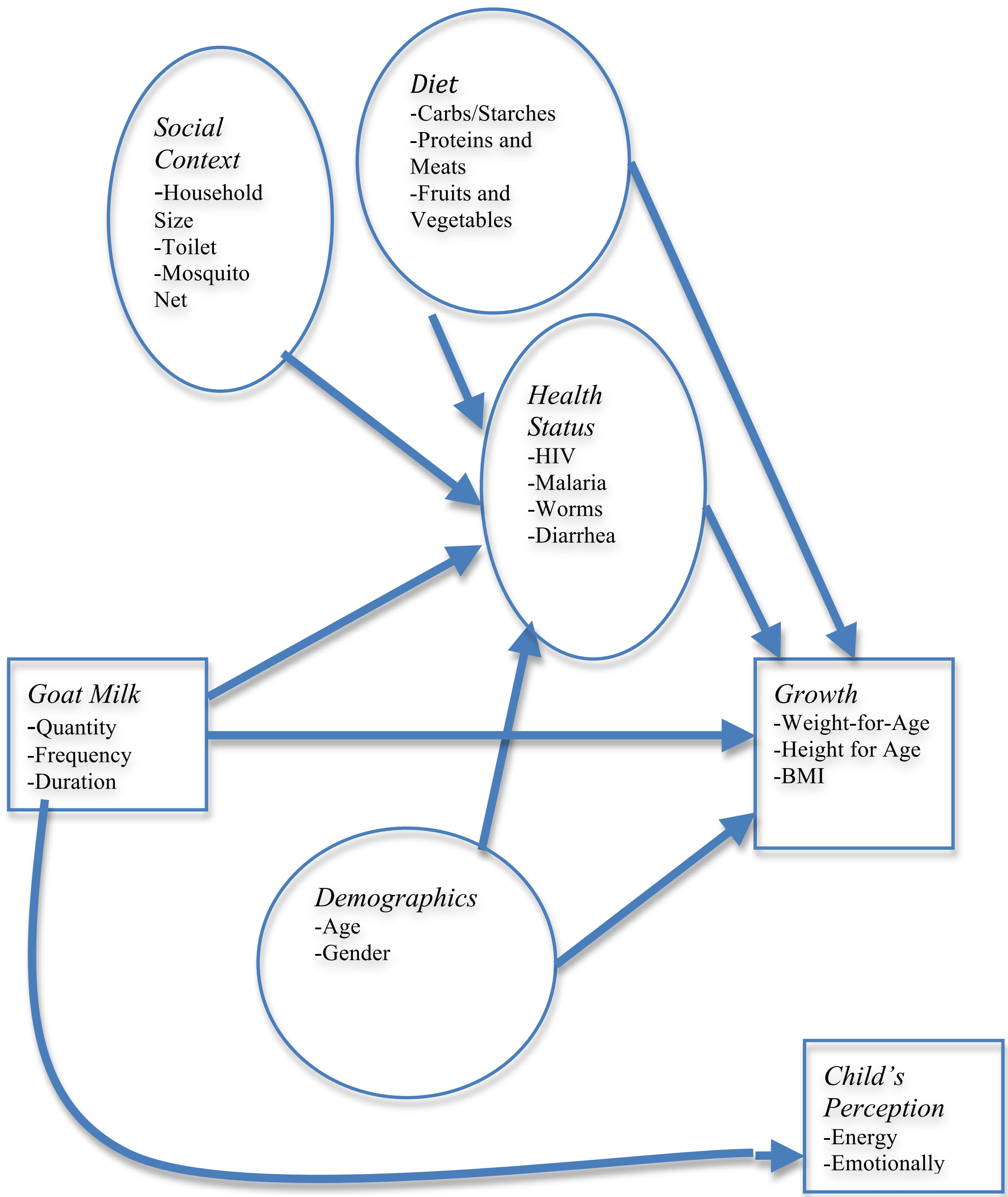
Will the consumption of goat milk have a positive influence on children's perceptions of their energy level and feelings?

Hypothesis 4A: Children with goat milk supplementation will report higher energy levels and more positive feelings than children without supplementation.

Hypothesis 4B: Among children with goat milk supplementation, children will report that their energy is higher and their feelings more positive on days when they have goat milk to drink.

FIGURE 1

Description of Study



CHAPTER FOUR
Methods

Setting

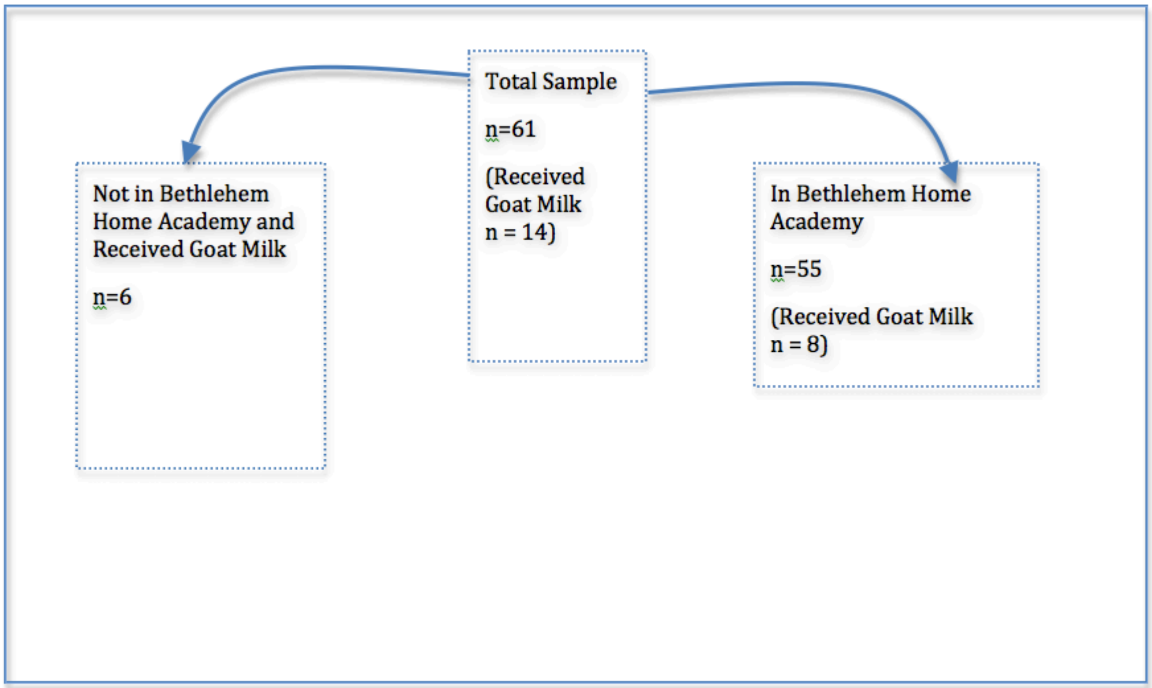
Straw to Bread is a non-profit organization that sponsors a team who work for two weeks each year on the Nyakach Plateau in rural western Kenya among the Luo tribe. This annual activity is part of ongoing development projects and research in this area that encompass health care, food and sustainable agriculture, safe water sources, education, and small business development.

Sample

The study subjects were intended to be the orphans attending the Bethlehem Home School. However, when it became apparent that the sample was very small (n=8) and that other children in the same area were receiving goat milk, a decision was made to include them as subjects in the study (n=6). These children had similar diets and living conditions to the original sample. This addition brought the sample size to 14 children receiving goat milk (see FIGURE 2). None of the orphans was excluded. The following flowchart shows the division of the total sample.

FIGURE 2

Sample Distribution



Research Design

This study followed a cross-sectional format in order to test the effect of goat milk supplementation on growth using a standardized growth curve to compare the children who received goat milk and those who did not receive it.. Measurements were taken at a single point in time.

Procedure

Informed consent was obtained for each subject from the designated guardian. A structured interview (see Appendix A) was done with the child and with the guardian (when available) about the child's goat milk consumption, health status, diet, and sociodemographic variables. To gather further data on the potential perceptive knowledge that the goat milk had on participants within the study, general mood and daily energy were investigated. For those who did not receive goat milk, the typical mood and energy of each subject was asked. For those who did receive goat milk, the typical mood and energy of each subject was asked for when receiving milk and when not receiving milk. In order to execute this survey among younger, elementary age children, simple graphs that visually depicted certain moods and used different activities to represent energy levels were utilized (Appendix). After the interview, the child's height and weight were measured.

The questions were asked by the researcher through an interpreter who spoke both English and Luo.

Anthropometric Measurements

All anthropometric measurements were taken by the researcher.

Height was measured in centimeters by establishing a height marker using a tape measure on a single wall that was used for all the subjects to lessen potential bias from instrumental error.

Weight was measured using one locally acquired, commercial scale for all subjects.

BMI: BMI was calculated as weight/height (m2).

Height-for-age and weight-for-age were also used as outcome measures.

Statistical Analysis

Data Entry

The data was double-entered into Microsoft Excel and then imported into SAS 9.3, the statistical program that was used for data analysis.

Descriptive

Frequencies, percent and cumulative percent, mean and standard deviation (when applicable), and range were reported for each variable.

Analytic

Bivariate. To test measures of association, contingency tables were used for discrete variables using odds ratio and chi square analysis. For continuous variables, Pearson's r correlation was used, and a t test was used to test the difference between means in two groups.

Multivariate. Multivariate analysis was used to assess interaction effects and the relative contribution of each predictor variable to the outcome variable. Multiple regression, logistic regression, and analysis of variance were used. In some cases, data were stratified and contingency table analyses were done to assess the modification of the relationship between the predictor and the outcome variables.

IRB

The Baylor University Institutional Review Board approved this study before data collection began. All data from human subjects was anonymous. Informed consent was obtained before a subject provided data for the study.

CHAPTER FIVE

Results

Descriptive Statistics

Sample

The sample in this study consisted of 61 children of Luo ethnicity who resided in the Nyanza Province of rural western Kenya. Fourteen of these children received goat milk supplementation.

Demographics

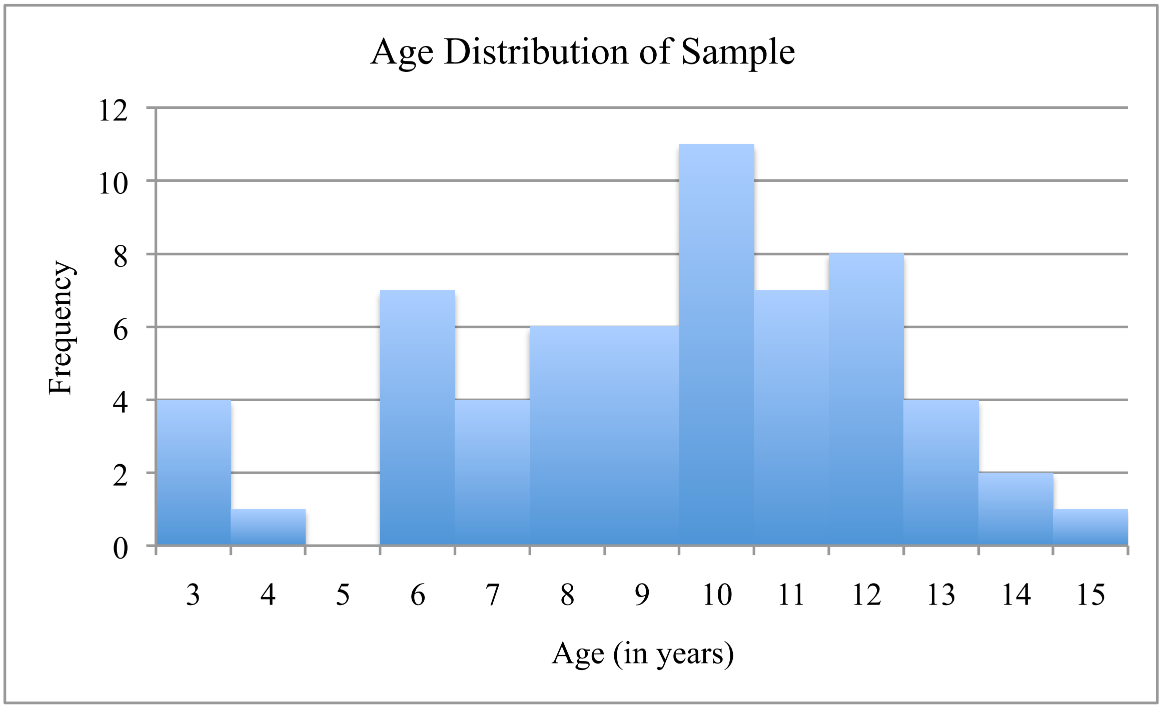
The age and gender frequencies are shown in TABLE 2.

TABLE 2

Predictor Variables	Percentage % (n)	Mean (SD)	Range
Gender			
Total Sample			
Male	60.66% (37)		
Female	39.34% (24)		
No Goat Milk			
Male	57.44% (27)		
Female	42.55% (20)		
Goat Milk			
Male	71.43% (10)		
Female	28.57% (4)		
Age			
Total Sample		9.26 (2.89)	3 to 15
No Goat Milk		10.0 (3.19)	3 to 14
Goat Milk		9.04 (2.80)	3 to 15

Age. The age of the sample ranged from 3 to 15 years of age with a mean age of 9.26 years (SD=2.89) (see FIGURE 3).

FIGURE 3



There was no significant difference in age (p=0.2806) or gender (p=0.3472) between the goat milk and non-goat milk sample.

Social Context

The frequencies of household size, the use of a mosquito net, and the type of toilet system are seen in TABLE 3.

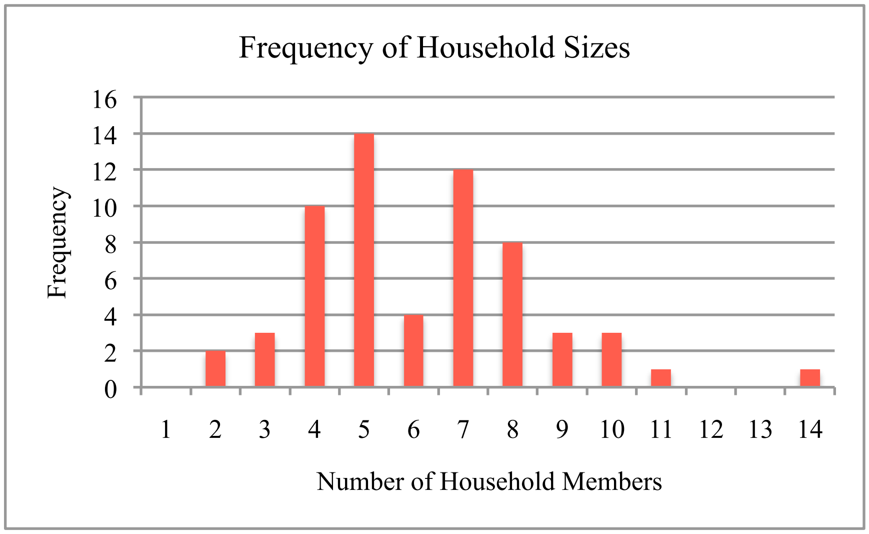
TABLE 3

Predictor Variables	Percentage % (n)	Mean (SD)	Range
Household			
Total Sample		6.81 (2.31)	2 to 14
No Goat Milk		6.40 (2.36)	2 to 14
Goat Milk		5.42 (2.03)	2 to 8
Mosquito Net			
Total Sample			
Yes	67.21% (41)		
No	32.79% (20)		
No Goat Milk			
Yes	57.47% (27)		
No	42.55% (20)		
Goat Milk			
Yes	100% (14)		
No	0.00% (0)		
Toilet			
Total Sample			
Bush	26.23% (16)		
Latrine	72.13% (44)		
No Goat Milk			
Bush	27.66% (13)		
Latrine	72.34% (34)		
Goat Milk			
Bush	23.08% (3)		
Latrine	76.92% (10)		

Household. In terms of household size, the range of occupants (including the subject) varied from 2 to 14, and the typical household had a mean of 6.18 occupants

(SD=2.31). There was no significant difference between the two groups (p=0.1665). See FIGURE 4

FIGURE 4



Mosquito Netting. Two-thirds of the study (67.12%) reported using mosquito nets when sleeping. However, among the GM subjects, 100% used mosquito nets compared to 57% of nonGM subjects. There was a significant difference between goat milk and no goat milk ($\chi^2 = 8.86$, $p = 0.0029$), with the goat milk drinkers having more mosquito nets.

Toilets. Since the sample subjects had no access to plumbing and/or flush toilets, the categories of toilets were divided into 'bush' and 'latrines'. Bush means that the subject simply relieved himself or herself straight on the ground or a bush. Latrines meant that either a hole was dug first, or there was access to a constructed latrine where waste was left in the ground. About one-fourth of the sample did not have access to a latrine and only used the bush. There was no significant difference between the two groups (p=0.7409).

Diet

The frequency of dietary protein intake is shown in TABLE 4.

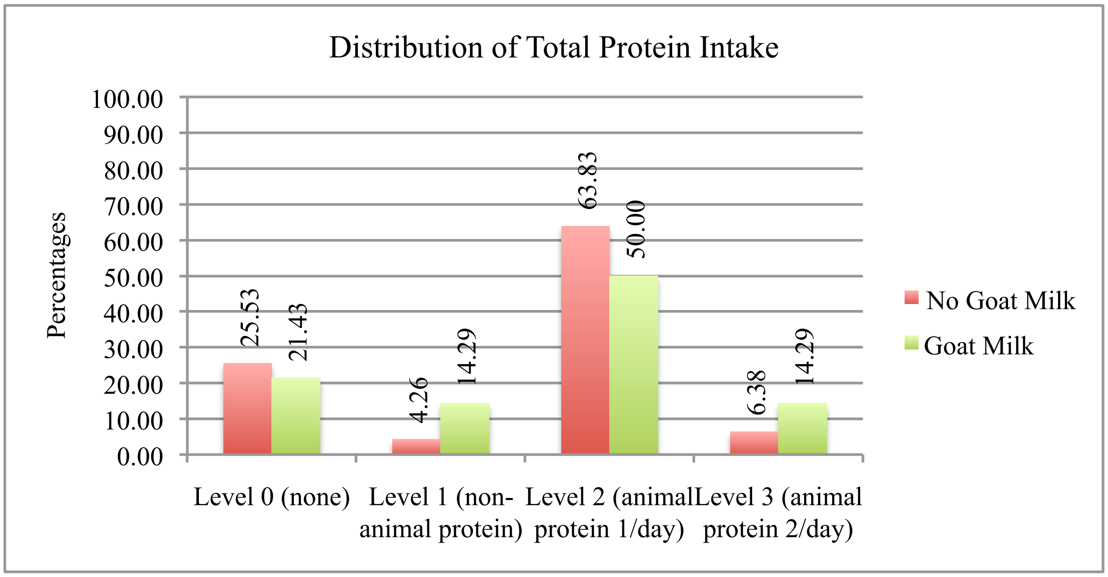
TABLE 4

ANIMAL PROTEIN		NON-ANIMAL PROTEIN	
	Percentage % (n)		Percentage % (n)
AM		*AM*	
Total Sample		Total Sample	
Yes	0%(0)	Yes	0.00%(0)
No	100%(61)	No	100.00%(61)
No Goat Milk		No Goat Milk	
Yes	0%(0)	Yes	0.00%(0)
No	100%(47)	No	100.00%(47)
Goat Milk		Goat Milk	
Yes	0%(0)	Yes	0.00%(0)
No	100%(14)	No	100.00%(14)
Midday		*Midday*	
Total Sample		Total Sample	
Yes	13.11%(8)	Yes	11.48%(7)
No	86.89%(53)	No	88.52%(54)
No Goat Milk		No Goat Milk	
Yes	12.77%(6)	Yes	12.77%(6)
No	87.23%(41)	No	87.23%(41)
Goat Milk		Goat Milk	
Yes	14.29%(2)	Yes	7.14%(1)
No	85.71%(12)	No	92.86%(13)
PM		*PM*	
Total Sample		Total Sample	
Yes	63.93%(39)	Yes	14.75%(9)
No	36.07%(22)	No	85.25%(52)
No Goat Milk		No Goat Milk	
Yes	63.83%(30)	Yes	14.89%(7)
No	36.17%(17)	No	85.11%(40)
Goat Milk		Goat Milk	
Yes	64.29%(9)	Yes	14.29%(2)
No	35.71%(5)	No	85.71%(12)

A majority of the subjects faced an inadequate diet. None of the participants reported receiving any form of protein in the morning. Out of all the subjects, only 13.11% received protein from a meat source (typically omena, a small, dried fish) during midday, and 11.48% received protein from a non-meat source (typically beans). Consumption of protein from a meat source increased during the evening among the participants, amounting to 63.93%. Consumption of protein from a non-meat source in the evening however did not vary greatly, amounting to 14.75%.

In order to get a better grasp of how the type and amount of protein might have affected the subjects in different ways, we consolidated the intake of protein into different variables. The first consolidation divided the amount of protein into a categorical variable that consisted of 4 levels. The higher the level, the better quality and quantity of protein that particular participant received. Amounts referred to eating protein daily or several times a week for Levels 0-2, and Level 3 was defined as twice daily intake. Level 0 indicated that the person did not receive any kind of protein. Level 1 indicated that the person only received protein from a nonmeat source. Level 2 indicated that the person received protein from a meat source. Level 3 indicated that the person received protein from a meat source as often as twice a day. The following table (FIGURE 5) shows the levels and frequencies of the levels controlled for by consumption of goat milk.

FIGURE 5



Additional variables were made to attempt and see the various ways in which protein had an effect on growth. The next variable was dichotomous between those that received some form of protein (Level 1) versus no protein (Level 0) in their daily diet (TABLE 5).

TABLE 5

Protein Present in Diet	
	Percentage % (n)
Total Sample	
Yes	24.59%(15)
No	75.41%(46)
No Goat Milk	
Yes	25.53%(12)
No	74.47%(35)
Goat Milk	
Yes	21.43%(3)
No	78.57%(11)

The frequencies of vegetable and starch consumption are shown in

TABLE 6.

VEGETABLES		STARCHES	
	Percentage % (n)		Percentage % (n)
Vegetables in the Morning		*Starch in the Morning*	
Total Sample		Total Sample	
Yes	1.64%(1)	Yes	40.98%(25)
No	98.36%(60)	No	59.02%(36)
No Goat Milk		No Goat Milk	
Yes	2.13%(1)	Yes	38.30%(18)
No	97.87%(46)	No	61.70%(29)
Goat Milk		Goat Milk	
Yes	0.00(0)	Yes	50.00%(7)
No	10.00(14)	No	50.00%(7)
Vegetables in the Noon		*Starch in the Noon*	
Total Sample		Total Sample	
Yes	80.33%(49)	Yes	93.44%(57)
No	19.67%(12)	No	6.56%(4)
No Goat Milk		No Goat Milk	
Yes	82.98%(39)	Yes	91.49%(43)
No	17.02%(8)	No	8.51%(4)
Goat Milk		Goat Milk	
Yes	71.43%(10)	Yes	100.00%(14)
No	28.57%(4)	No	0.00%(0)
Vegetables in the Evening		*Starch in the Evening*	
Total Sample		Total Sample	
Yes	70.49%(43)	Yes	95.08%(58)
No	29.51%(18)	No	4.92%(3)
No Goat Milk		No Goat Milk	
Yes	65.96%(31)	Yes	93.61%(44)
No	34.04%(16)	No	6.38%(3)
Goat Milk		Goat Milk	
Yes	85.71%(12)	Yes	100.00%(14)
No	14.29%(2)	No	0.00%(0)

To further delve into the diet of the sample, additional information was gathered about consumed goods besides solely foods of large protein sources. Other important staples of the diets examined included fruit, vegetables, and starches. Fruits were almost non-existent in the daily diet of the sample. Less than 4% of the entire sample even received fruit once a day or several times a week. However, a large portion of the sample did receive vegetables once or even twice on a daily basis. Only one child in the entire study received vegetables in the morning. However, 80.33% of the study did consume vegetables during midday. In the evening, 70.49% of the study received vegetables as well.

As stated earlier, the Kenyan diet is cereal-based. Throughout the study, this fact was found to be true in the reality that every subject of the study received some form of starch at least once a day, in comparison to other necessary food types that were not consumed regularly. These starches typically came in the form of ugali (a ground corn meal that is cooked) or porridge. A surprising 40.98% of the study received some sort of starch in the morning. Midday and evening are typically the time of any major food consumption, as is evident in the fact that over 90% ate a starch at midday, and over 90% ate a starch in the evening.

In addition to grouping children into those who had goat milk supplementation and those who did not, other variables were identified that were potential confounders (see FIGURE 1). Most of the children (n=55) attended the same school, Bethlehem Home Academy. However, 6 children who received the goat milk intervention attended a different school closer to where they lived, and this variable was included in the analysis. Among the total sample, the Straw to Bread organization was sponsoring 35 children, and 26 children were not sponsored. The significance of this distinction is that, though all of these children come from very poor homes, the researchers were confident that the diets of the sponsored children were virtually identical since their meals all came from the same source. These sponsored children were fed only one meal a day, consisting of maize, beans, and, sometimes, vegetables. All but one of the children receiving the goat milk intervention was sponsored by Straw to Bread.

Health

The frequencies for malaria episodes, worm treatments, and diarrhea episodes are shown in TABLE 7,8,9.

TABLE 7, 8

Predictor Variables	Percentage % (n)
Malaria	
Total Sample	
0	23.33%(14)
1 to 2	51.67%(31)
3+	25.00%(15)
No Goat Milk	
0	28.26%(13)
1 to 2	47.83%(22)
3+	23.91%(11)
Goat Milk	
0	7.14%(1)
1 to 2	64.29%(9)
3+	28.57%(4)

Predictor Variables	Percentage % (n)
Worms Treatment	
Total Sample	
<6 months	73.77%(45)
>6months	26.33%(16)
No Goat Milk	
<6 months	78.72%(37)
>6months	21.28%(10)
Goat Milk	
<6 months	57.14%(8)
>6months	42.86%(6)

TABLE 9

Predictor Variables	Percentage % (n)	Predictor Variables	Percentage % (n)	Predictor Variables	Percentage % (n)
Diarrhea					
Total Sample		No Goat Milk		Goat Milk	
Last Week		Last Week		Last Week	
Yes	24.59%(15)	Yes	23.40%(11)	Yes	28.57%(4)
No	75.41%(46)	No	76.60%(36)	No	71.43%(10)
Last Month		Last Month		Last Month	
Yes	34.43%(21)	Yes	29.79%(14)	Yes	50.00%(7)
No	65.57%(40)	No	70.21%(33)	No	50.00%(7)
Last 3 Months		Last 3 Months		Last 3 Months	
Yes	44.26%(27)	Yes	40.43%(19)	Yes	57.14%(8)
No	55.74%(34)	No	59.57%(28)	No	42.86%(6)

The health status of each subject was ascertained in order to see if any diseases might have a possible effect on growth. The three main diseases that were included were HIV, malaria, and helminthic infection. Diarrhea is the outcome or result of many diseases, so it was examined as well in see if it had an effect on growth.

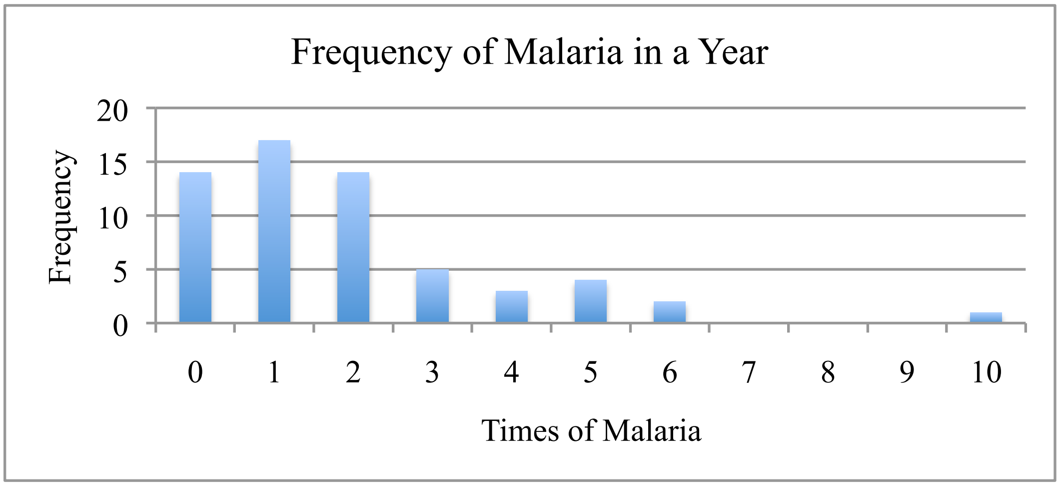
HIV. The report of a caretaker of a child's negative HIV status was difficult to authenticate because of the social stigma of being HIV-positive in the Kenyan culture. This reluctance to report is coupled with the fact that many children have not been tested. The HIV prevalence in the Nyanza district of Kenya according to official statistics is

14.9% of the population (USAID, 2007), much higher than this study indicated. Out of the entire sample, only 3.28% of the subjects reported being HIV-positive, 45.90% reported not having HIV, and 50.82% had not been tested for HIV, so they were unaware of their official condition[35].

Malaria. While HIV may be underreported, the number of episodes of malaria during the last year may be overestimated. A high prevalence was expected, but it also appears to be the case that many people believe that malaria is the cause of many acute symptoms encountered by the subjects. However, the fact that the GM group had a greater percentage of net use and a greater percentage of children without malaria lends credence to the self-report of malaria episodes.

The reported number of malaria episodes in the last year ranged from 0 to 10 episodes, with a mean of 1.90 (SD 1.94), but a median of 1.00, indicating a skewed distribution (see Figure 6). There was no significant difference between the goat milk and non-goat milk subjects (p=0.9504).

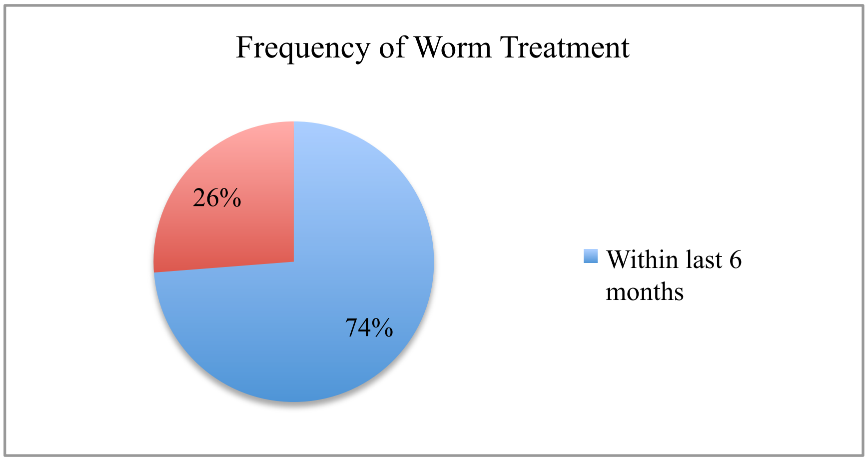
FIGURE 6



72.13% of the sample reported having received medication for malaria, and 11.48% reported that they had not received medicine, even though they had contracted malaria.

Helminthic Diseases. Only 26.23% had received treatment for worms within the past six months, while 73.77% had not received a treatment in the past six months. However, a larger proportion of the goat milk sample had received treatment than the non-goat milk sample (42.86% vs. 21.28%), though the chi-square test was not significant, most likely because of the small sample size of the goat milk consumers (p=0.1071). It is unknown whether this increased frequency among GM subjects indicates more disease or more preventive treatment with medication. This finding may be analogous to the increased use of mosquito nets among GM subjects and may be another indication that they are being better cared for than the nonGM subjects. SEE FIGURE 7

FIGURE 7



Diarrhea. The occurrences of diarrhea for each of the subjects were recorded for the past week, past month, and the past 3 months. Once again, the p-values proved to be not significant, most likely because of the small sample size of the goat milk consumers. The below chart (TABLE 10) shows the percentages of each group sorted by the number of episodes of diarrhea in the given period. What is striking in these results is that the lowest percentage for any of the time periods in either group is 23.4% (nonGM subjects having diarrhea during the last week), and the highest is over 50% (GM subjects having diarrhea in last 3 months).

TABLE 10

Comparisons between Groups of Diarrheal Occurances				
	Diarrhea	Last Week	Last Month	Last 3 Months
Non-Goat Milk	YES	23.40%	29.79%	40.43%
	NO	76.60%	70.21%	59.57%
Goat Milk	YES	28.57%	50.00%	57.14%
	NO	71.43%	50.00%	42.86%
Difference (p-value)		0.6935	0.1623	0.2690

INTERVENTION: GOAT MILK

Goat Milk: Quantity, Frequency, and Duration. Of the entire study, 14 children received goat milk and 47 did not, as mentioned above. Of the 14, only 7 were officially sponsored by Straw to Bread, but all of the children had similar living situations.

While surveying each elder who oversaw the distribution of goat milk to a given subject, it was found that each subject received milk daily during the time when the dairy goat was lactating. The daily serving size was estimated for each subject and was recorded in reference to a standard cup size (1 cup = 250mL). Among the 14 subjects, the average child received 1.29±0.56 cups. The median was 1.5 cups with a range of 0.375 to 2.5 cups. However, out of the 14 subjects, 10 of the subjects received a reduced amount of milk as the goat's milking period progressed. In order to account for this reduction, a variable was created to incorporate the reduction. This adjusted amount was formulated by averaging the original serving size for the period it was produced and the reduced serving size for the period it was produced:

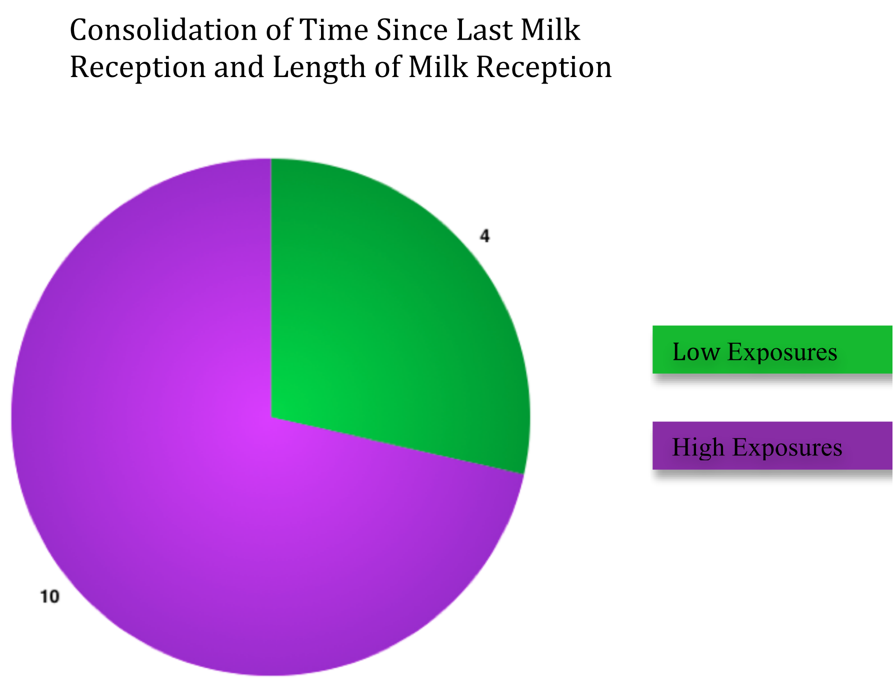
Adjusted Cups = [(Original Serving Size * (Months Produced/Total Months Produced)] + [(Reduced Serving Size * (Months Produced/Total Months Produced)]

After adjusting for serving size, the typical daily serving resulted in 1.25±0.57 cups. The median was 1.3 cups with a range of 0.35 to 2.5 cups.

The frequency and duration of milk reception of the subjects was also recorded. All but one of the subjects had only received 1 interval of milk (1 interval = the lactation period during which milk was produced after birthing). The remaining subject had received three intervals of milk, though this was accounted for in the study by averaging the length of the intervals. The average interval length was 4.5±0.90 months with a range of 3.5 to 6.0 months. In addition, it was noted whether or not the subject was currently receiving milk. Seven children were currently receiving and the remaining 7 were not. For reference, the study took place at the end of May 2013 through the beginning of June 2013. In order to measure the impact of time, the number of months since last receiving milk was also recorded. If the participant was still receiving milk, then the length of time since last receiving milk was marked as 0. The mean time in last reception was 2.89±3.73 months, with a range of 0 to 8.5 months.

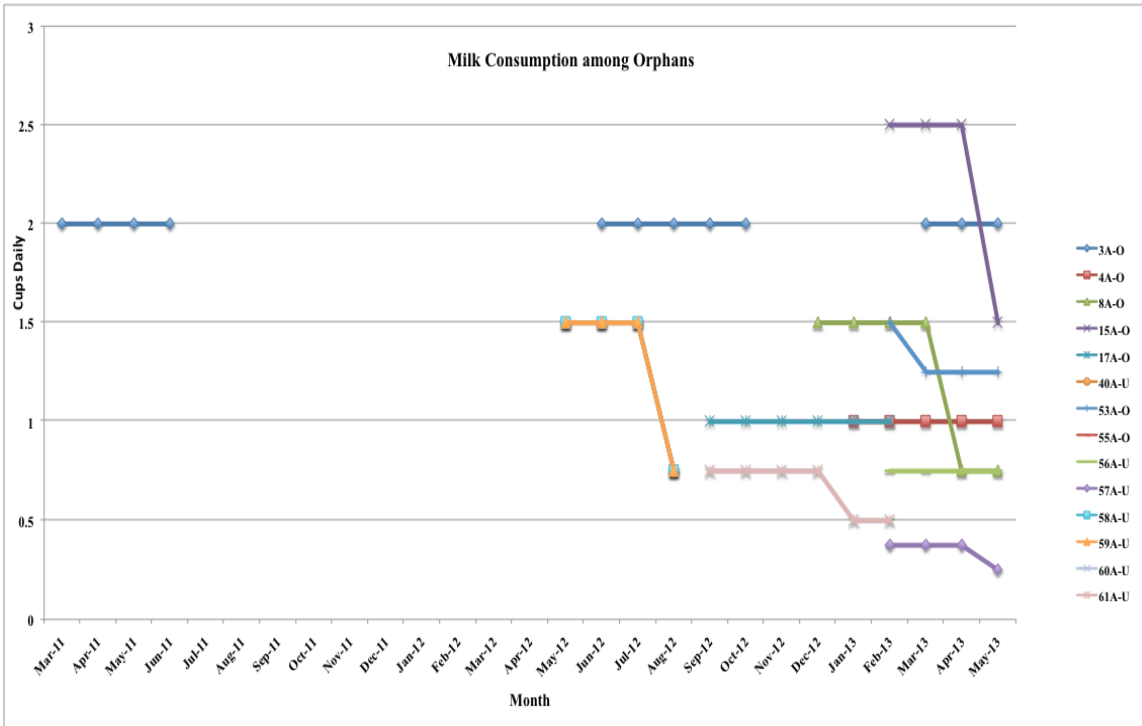
A consolidated variable combined two facets of the milk consumption: amount time since last receiving milk and the period of time to have received milk. This was made into a dichotomous, categorical variable (FIGURE 8). The more beneficial representation of the variable indicated: the subject was still receiving milk or had only been off goat milk for 2 to 3 months -- and -- the subject had received milk for a period of 4 to 6 months (high exposure). The less beneficial representation of the variable indicated that the subject had not received milk for 8 to 8.5 months --and--the subject only received milk for 3.5 months (low exposure).

FIGURE 8



In order to fully visualize the consumption of milk among each consumer--the intervals, the interval lengths, and the amount of milk -- the following chart showing the variables (FIGURE 9) was plotted over the given time period. Each colored line represents the consumption history of an individual child.

FIGURE 9


Milk Consumption among Orphans
Cups Daily
Month
3
2.5
2
1.5
1
0.5
0
Mar-11
Apr-11
May-11
Jun-11
Jul-11
Aug-11
Sep-11
Oct-11
Nov-11
Dec-11
Jan-12
Feb-12
Mar-12
Apr-12
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Nov-12
Dec-12
Jan-13
Feb-13
Mar-13
Apr-13
May-13
3A-O
4A-O
8A-O
15A-O
17A-O
40A-U
53A-O
55A-O
56A-U
57A-U
58A-U
59A-U
60A-U
61A-U

OUTCOME

The three outcome variables were : BMI-for-Age z-scores, Height-for-Age z-scores, and Weight-for-Age z-scores. See TABLE 11 for frequencies.

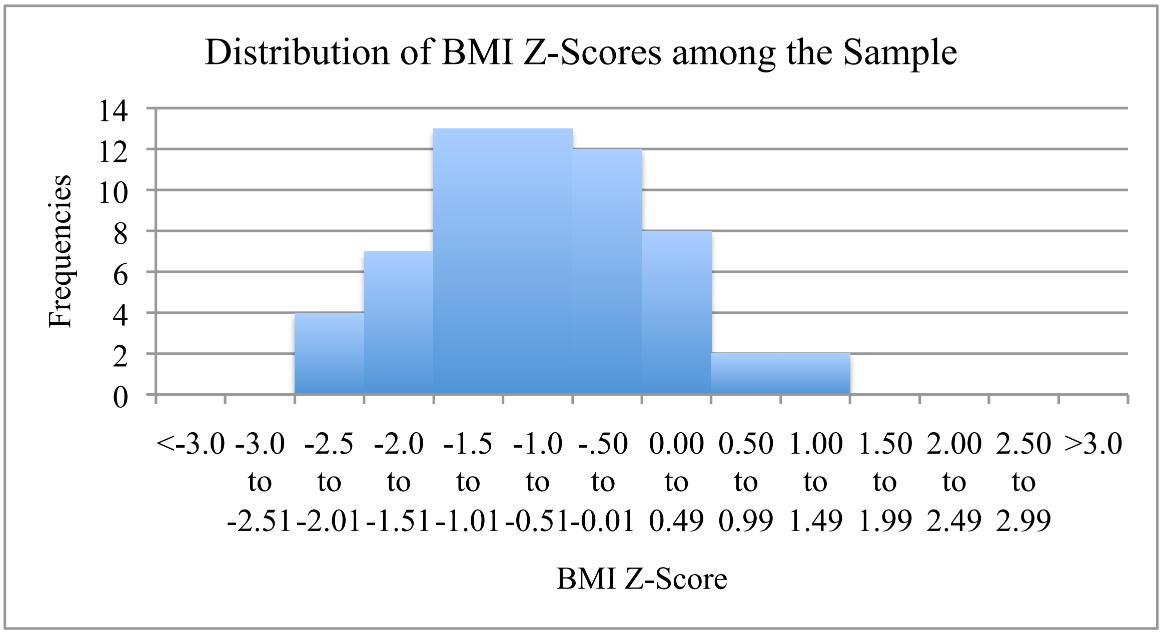
TABLE 11

Outcome Growth Indices:	Mean (SD)	Range
BMI-for-Age		
Total Sample (n = 61)	-0.72 (0.83)	-2.44 to 1.20
No Goat Milk (n = 47)	-0.66 (0.85)	-2.44 to 1.20
Goat Milk (n = 14)	-0.93 (0.75)	-2.17 to 0.34
Height-for-Age		
Total Sample (n = 61)	0.17 (1.36)	-3.43 to 2.66
No Goat Milk (n = 47)	0.21 (1.50)	-3.43 to 2.66
Goat Milk (n = 14)	0.02 (0.74)	-1.35 to 1.26
Weight-for-Age		
Total Sample (n = 61)	-0.42 (0.89)	-3.30 to 1.33
No Goat Milk (n = 47)	-0.35 (0.95)	-3.30 to 1.33
Goat Milk (n = 14)	-0.64 (0.62)	-1.44 to 0.29

In order to achieve these standardized scores, anthropometric measurements were obtained on each of the subjects. These included height and weight, which were entered into a CDC SAS macro provided on the CDC website (Centers for Disease Control and Prevention, 2011). The macro calculated the standardized variables mentioned above, adjusting for gender and age.

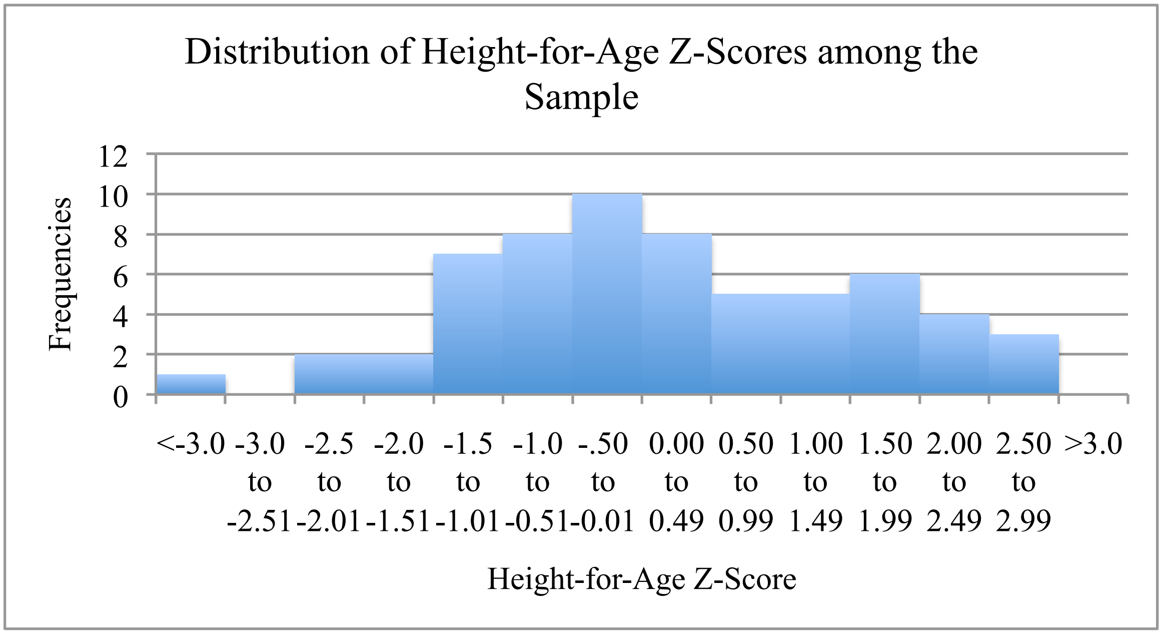
BMI-for-Age. The first growth indicator examined was the BMI-for-Age, a standardized variable that compares the weight of a person relative to his height (weight in kg/height in meters^2). The graph below shows the distribution of the BMI-for-Age among all subjects (FIGURE 10).

FIGURE 10



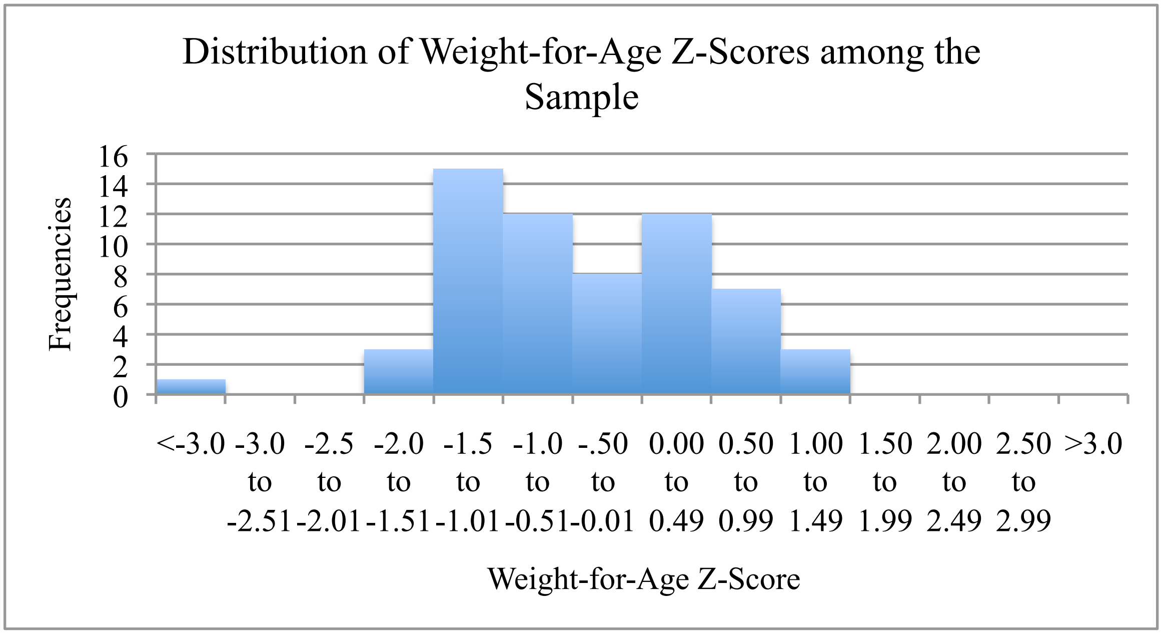
Height-for-Age. Height-for-age, an indicator of long-term growth or stunting, was the second standardized variable that was calculated and examined. The finding that a number of children were at or above the 50th percentile was surprising considering the diet and living situation of the typical subject in the study. An average z score above 0 indicates a subject who is taller than the 50th percentile for his age. However, this does not account for malnourishment that might result from wasting. The graph below shows the distribution of the Height-for-Age among the entire study (FIGURE 11).

FIGURE 11



Weight-for-Age. The last growth indicator examined was the Weight-for-Age, a standardized variable that is an important indicator for seeing if the individual is of proper weight for their age, underweight, or wasted (extremely thin regardless of height). The graph below shows the distribution of the Weight-for-Age among the entire study (FIGURE 12).

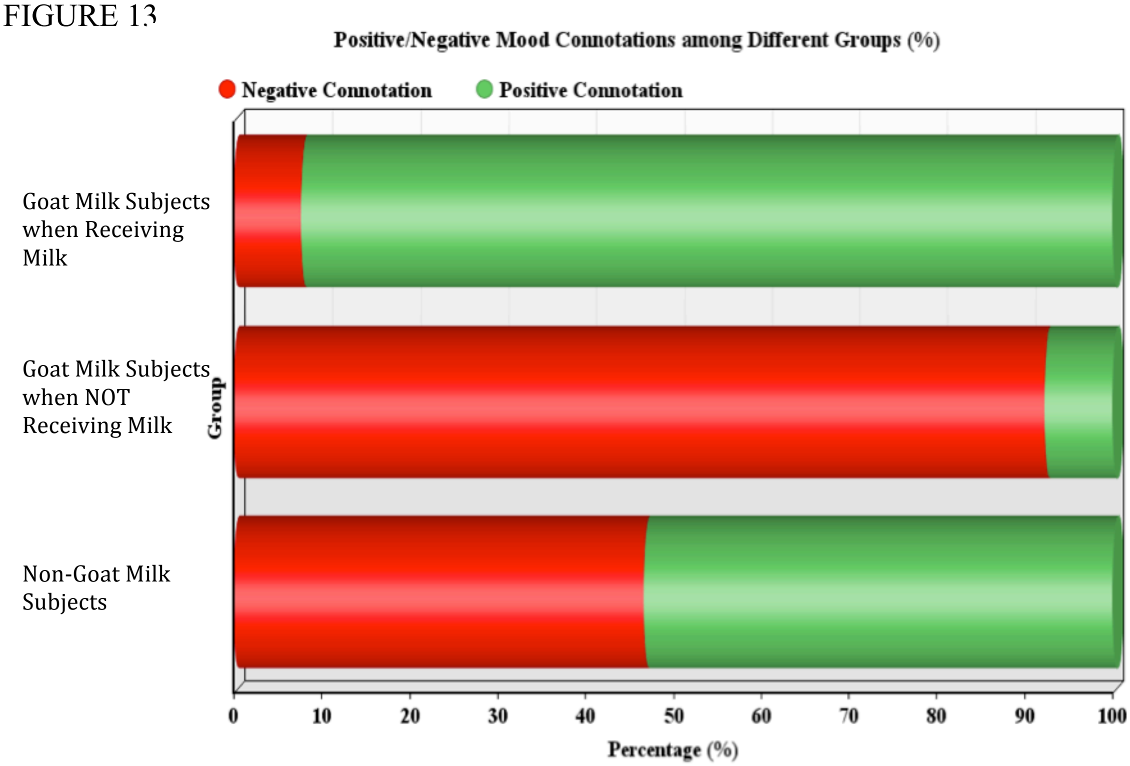
FIGURE 12



Child Perception

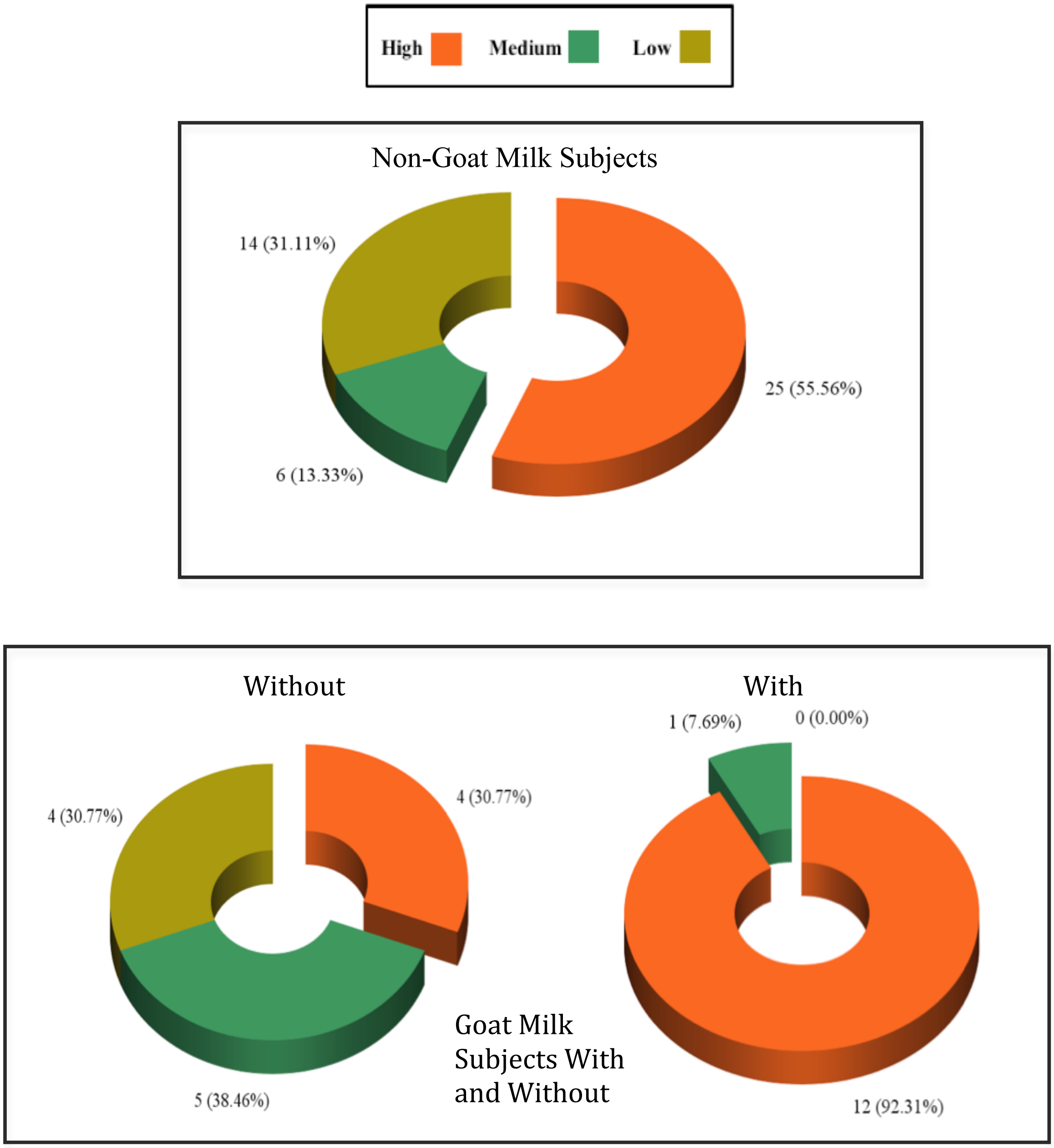
General Self-Perception of Mood. As described in Chapter 3, a chart with different emoticons was used to depict the general day-to-day mood/attitude of an individual. The moods were originally a gamut of emotions that were divided into a dichotomous variable that indicated either a positive connotation or a negative one. Moods or emotions with a negative connotation included: sick, mad, sleepy, so-so, tired, hungry, sad, and bad. Moods, or emotions, with a positive connotation (1) included: happy, super, good, okay, and fine (FIGURE 13).

FIGURE 13



Energy Level. As described in Chapter 3, a chart with different activities representing different energy levels were used to survey the day-to-day perceived energy of each participant. The original graph depicted six consecutive levels of energy. Depending on which level he or she chose, the participant was placed in: High (the top two levels), Medium (the middle two levels), or Low/None (the last two levels). (FIGURE 14)

FIGURE 14



Energy Levels among Different Groups

Analytical Statistics

With the hypotheses as a foundation, statistical tests were used to analyze possible relationships between the predictor and outcome variables. Appropriate tests were utilized depending upon the type of variable being used, the number of variables being used, and the relationship that was being found.

IMPACT OF GOAT MILK

Hypothesis 1. There is a positive association between consumption of goat milk and children's growth indices. See TABLE 12

TABLE 12

Outcome Growth Indices:	Mean (SD)	Range	t	p-value
BMI-for-Age			1.04	0.3009
Total Sample (n = 61)	-0.72 (0.83)	-2.44 to 1.20		
No Goat Milk (n = 47)	-0.66 (0.85)	-2.44 to 1.20		
Goat Milk (n = 14)	-0.93 (0.75)	-2.17 to 0.34		
Height-for-Age			0.47	0.6376
Total Sample (n = 61)	0.17 (1.36)	-3.43 to 2.66		
No Goat Milk (n = 47)	0.21 (1.50)	-3.43 to 2.66		
Goat Milk (n = 14)	0.02 (0.74)	-1.35 to 1.26		
Weight-for-Age			1.08	0.2834
Total Sample (n = 61)	-0.42 (0.89)	-3.30 to 1.33		
No Goat Milk (n = 47)	-0.35 (0.95)	-3.30 to 1.33		
Goat Milk (n = 14)	-0.64 (0.62)	-1.44 to 0.29		

As demonstrated in FIGURE 15,16,17 there is no statistically significant relationship between the consumption of goat milk and any of the growth indices. Therefore, we cannot reject the null hypothesis.

FIGURE 15

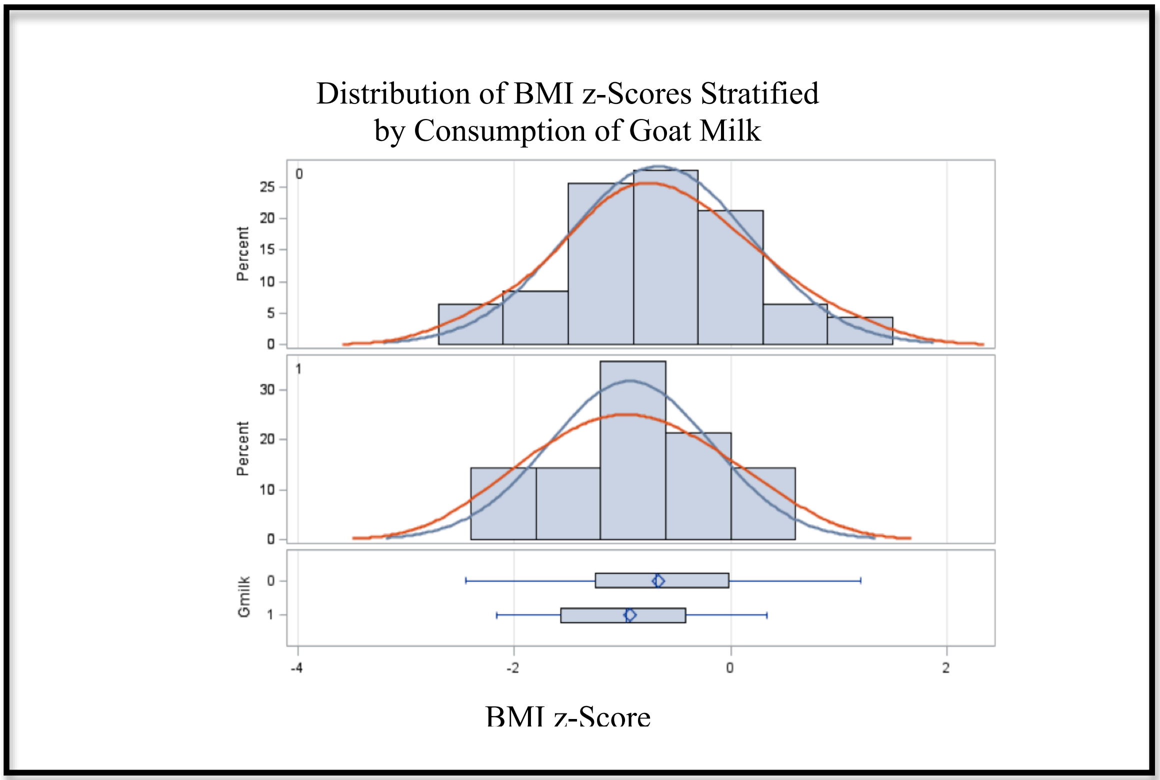


Figure 16

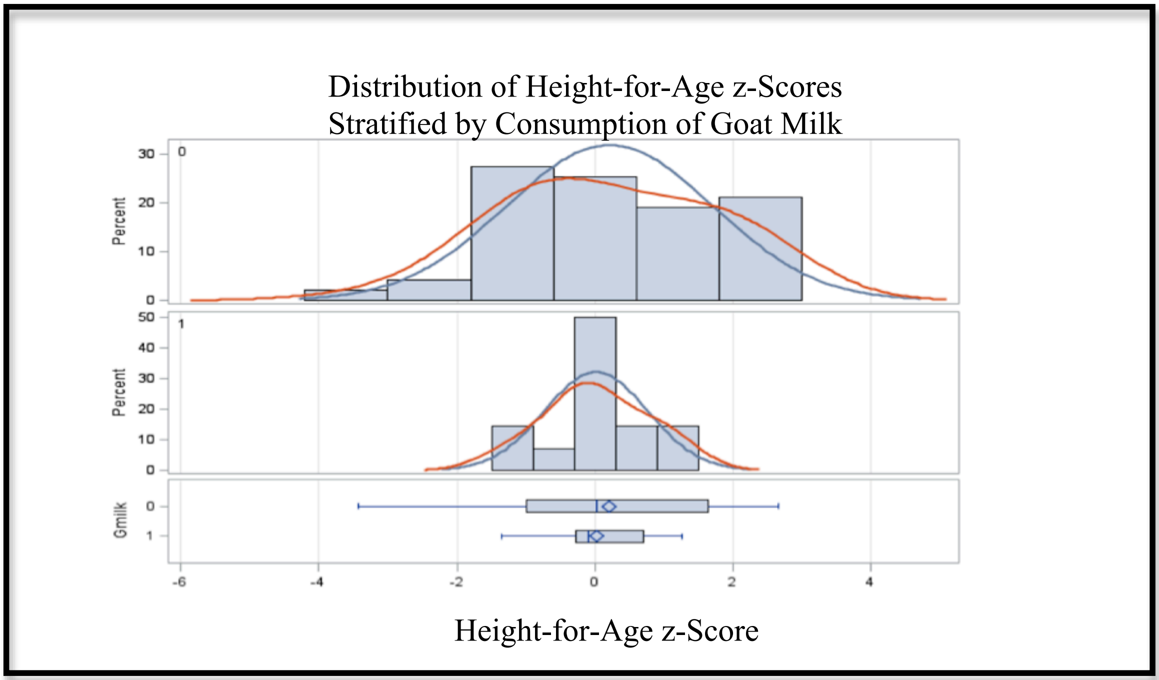
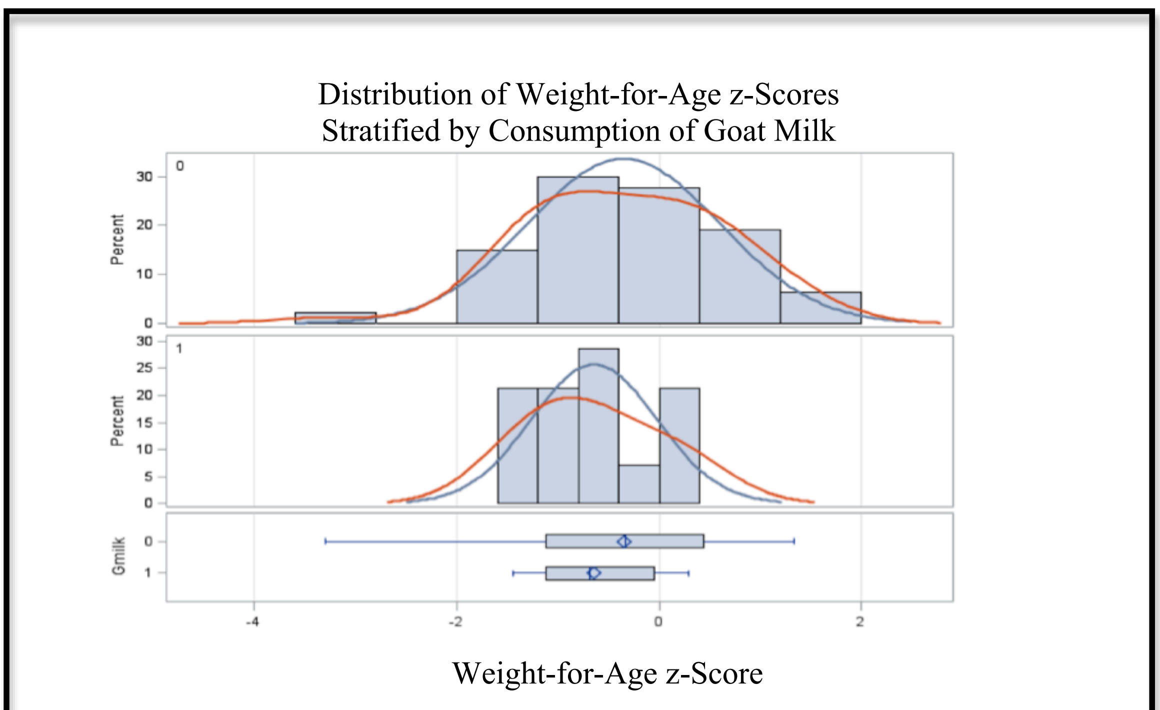


Figure 17



Hypothesis 2. Factors known to affect children's size will have the predicted effect in this sample.

IMPACT OF DIET

2A. Children with lower protein intake will have lower growth indices than children with higher levels of protein intake.

In order to see the impact of diet diversity upon growth among the children receiving goat milk, the variables concerning protein intake were used. Since only two children received fruit weekly, fruit was considered negligible in considering growth. All the children received starches and vegetables daily; thus, the amount of protein was the only food intake with marked variation.

For the first comparison, the Total Protein Intake with levels 0 through 3 was first tested to see if there was a correlation between it and the three growth variables (TABLE 13). None of the three tests proved to be significant, but the test for weight-for-age Z score nearly came back significant.

TABLE 13

Growth Tested by Total Protein Intake			
Outcome Growth Variable:	F Value	R^2	p Value
BMI-for-Age	1.83	0.353856	0.2062
Height-for-Age	1.35	0.287993	0.3137
Weight-for-Age	3.47	0.510101	0.0587

In the other comparison, significant results were only found when comparing the presence or absence of any protein (not including the goat milk) in the diet with the BMI-for-Age z-scores of those receiving goat milk in a t-test (p = 0.0458) (TABLE 14, 15). Children with no protein were significantly lower on the BMI-for Age measure.

TABLE 14, 15

Growth Tested by Protein Presence		
Outcome Growth Variable:	t	p Value
BMI-for-Age	0.29	0.7760
Height-for-Age	-1.31	0.1968
Weight-for-Age	-0.92	0.3636

Growth Tested by Protein Presence (in children receiving goat milk)		
Outcome Growth Variable:	t	p Value
BMI-for-Age	-2.23	0.0458
Height-for-Age	-0.39	0.7066
Weight-for-Age	-1.77	0.1027

IMPACT OF SOCIAL CONTEXT

2B. Children from a larger household will have lower growth indices than children from a smaller household.

A regression model was used to compare the size of the household for the three dependent growth variables. All three models produced not significant results (TABLE 16).

TABLE 16

Growth Regressed on Household Size among All Subjects (n = 61)			
Outcome Growth Variable:	F Value	R^2	p Value
BMI-for-Age	0.00	0.0001	0.9534
Height-for-Age	1.11	0.0184	0.2967
Weight-for-Age	1.10	0.0182	0.2993

In addition, a regression model was also used to compare the size of the households of only goat milk subjects to the three dependent growth variables. All three models also produced not significant results (TABLE 17). Therefore, we cannot reject the null hypothesis.

TABLE 17

Growth Regressed on Household Size among Subjects Consuming Milk (n = 14)			
Outcome Growth Variable:	F Value	R^2	p Value
BMI-for-Age	0.00	0.0010	0.9162
Height-for-Age	0.00	0.0003	0.9565
Weight-for-Age	0.00	0.0000	0.9829

2C. Children with no mosquito nets will have lower growth indices than children with mosquito nets.

When a t-test was performed for the three growth variables, none produced significant results. SEE TABLE 18

TABLE 18

Growth Tested by Worm Treatment		
Outcome Growth Variable:	t	p Value
BMI-for-Age	0.05	0.9580
Height-for-Age	0.90	0.3728
Weight-for-Age	0.87	0.3888

2D. Children with poor sanitation practices will have lower growth indices than children with better sanitation practices.

Subjects were surveyed on their sanitation practices, with the use of a bush considered to a poorer sanitation practice and the use of any form of latrine to be a better sanitation practice. A t-test was run to see if there was a difference in the type of practice for any of the outcome variables, however no significant results were yielded. SEE TABLE 19.

TABLE 19

Growth Tested by Sanitation Practice		
Outcome Growth Variable:	t	p Value
BMI-for-Age	-1.35	0.1823
Height-for-Age	0.56	0.5758
Weight-for-Age	-0.29	0.7712

IMPACT OF HEALTH STATUS

2E. Children with a poorer health status will have lower growth indices than children with a better health status.

HIV

Due the small number of children who had been tested, no meaningful results can be found for this hypothesis.

Malaria

An ANOVA test was used to see if there was a relationship between reported incidences of malaria and a subject's BMI-for-age or weight-for-age. The condensed variable as discussed in the descriptive section was used. Level 0 indicated that the subject had no reported cases of malaria in the past year. Level 1 indicated that the subject had one to two cases of malaria in the past year. Level 2 indicated that the subject had greater than two cases of malaria in the past year. The test produced no significant results when testing for BMI-for-age or for weight-for-age. See Table 20

TABLE 20

Growth Tested by Reported Malaria Episodes			
Outcome Growth Variable:	F Value	R^2	p Value
BMI-for-Age	0.29	0.010213	0.7463
Weight-for-Age	0.02	0.000871	0.9755

Helminthes

A t-test was done in order to see if there was a correlation between the dichotomous worm treatment variable (0 meaning the last deworming treatment occurred over 6 months ago, or 1 meaning the last treatment happened 6 or less months ago). None of the tests produced significant results. See TABLE 21

TABLE 21

Growth Tested by Worm Treatment		
Outcome Growth Variable:	t	p Value
BMI-for-Age	-0.48	0.6355
Height-for-Age	-1.14	0.02576
Weight-for-Age	-1.36	0.1780

IMPACT OF QUANTITY AND DURATION OF GOAT MILK

Hypothesis 3. Among children receiving goat milk, after adjusting for other factors:

3A. Children with longer, more recent consumption will have higher growth indices than children with shorter, less recent consumption.

As stated above, a consolidated time variable (exposure variable) was created to analyze this hypothesis among the subjects who had received goat milk. This dichotomous variable was partitioned as follows (TABLE 22):

TABLE 22

Consolidated Time Variable Classes		
	0 (Low Exposure)	1 (High Exposure)
Time Since Last Receiving Milk	8-8.5 Months	0-3 Months
Amount of Time to Receive	≤3.5 Months	4-6 Months

A t-test was performed within this sample of 14 subjects receiving goat milk to see if there was a significant difference in BMI z-scores. The test showed that there was a significant difference between the two groups ($t=-3.14$, $p = 0.0085$). The low exposure group had a mean score of -1.7 with a 95% CL (-2.47, -0.93) and the high exposure group had a mean score of -0.62 with a 95% CL (-1.05, -0.18). See TABLE 23

In order to see if any other variables modified this relationship, the exposure variable was stratified by several other predictor variables. One variable that showed a significant relationship was quantity of milk. Quantity of milk was also a dichotomous variable of 0 and 1, where (0) received less than 1 cup of milk as a daily serving, and (1) received 1 or more cups of milk as a daily serving. However, since none of the subjects who received less than one cup fell into the low exposure category of the exposure variable, only the subjects who received 1 or more cups were tested. A t-test was performed between the exposure variable of the subjects receiving one or more cups and the outcome BMI z-scores. The low-exposure group had a significantly lower BMI z score compared to the high-exposure group ($t=-3.29$, $p = 0.0167$). The subjects of the low exposure group had a mean BMI z score of -1.70 with a 95% CL (-2.47, -0.93). The subjects of the high exposure group had a mean BMI z score of -0.64 with a 95% CL (-1.32, 0.04).

Additionally, when the exposure variable was stratified by the age of the subject, further significant results were found. The age variable was dichotomized, with the younger group being 9 years old or younger, and the older group being older than 9 years of age. However, once again, since none of the subjects 9 years old or less fell within the low exposure category of the consolidated time variable, only subjects who were older than 9 years old were tested. The results were significant with a ($t =-3.81$, $p = 0.0067$). The subjects of the low group had a mean BMI z score of -1.71 with a 95% CL (-2.47, -0.93). The subjects of the high exposure group had a mean BMI z score of -0.62 with a 95% CL (-1.08, -0.16). The strength of this relationship in this case is even more powerful than the original one (with only the exposure variable versus BMI z-score). With this, it can be said that the older children who have received larger quantities of milk more recently and for a longer period of time will have a healthier BMI than older children who have not.

TABLE 23

The Relationship between Goat Milk and BMI z-Score among Goat Milk Subjects		
	Mean BMI Z-Scores	95% Confidence Intervals
EXPOSURE GROUPS (all goat milk subjects)	t=-3.14, p = 0.0085	
High (more recent and longer consumption) n = 10	-0.62	(-1.05, -0.18)
Low (less recent and less consumption) n = 4	-1.70	(-2.47, -0.93)
EXPOSURE GROUPS (among children receiving more milk)	t=-3.29, p = 0.0167	
High n = 4	-0.64	(-1.32, 0.04)
Low n = 4	-1.70	(-2.47, -0.93)
EXPOSURE GROUPS (among older children)	t =-3.81, p = 0.0067	
High n = 5	-0.62	(-1.08, -0.16)
Low n = 4	-1.70	(-2.47, -0.93)

When testing the Height-for-Age (p = 0.9937), no significant results were found indicating that the exposure variable had no substantial effect upon this outcome.

The final growth variable, weight-for-age, when tested against the exposure variable, yielded significant results indicating the higher exposure group had higher weight-for-age indices. See TABLE 24

TABLE 24

The Relationship between Goat Milk Exposure and Weight-for-age z-Score among Goat Milk Subjects		
	Mean Z-Scores	95% Confidence Intervals
EXPOSURE GROUPS (all goat milk subjects)	t=-2.59, p = 0.0237	
High (more recent and longer consumption) n = 10	-0.42	(-0.83, 0.00)
Low (less recent and less consumption) n = 4	-1.21	(-1.59,-0.83)

3B. Children consuming larger quantities of milk will have higher growth indices.

When a correlation was sought solely between the quantity of milk consumed by a subject and an increase in growth, no significant results were found. The dichotomous, categorical approach to quantity yielded nothing of significance for any of the three growth variables (p = 0.1740 for BMI z-scores,). Additionally, when the three growth variables were tested against the adjusted cups that each subject consumed daily using a multiple regression analysis, all results were nonsignificant. See TABLE 25

TABLE 25

Growth Tested by Quantity (Adjusted Cups)			
Outcome Growth Variable:	F Value	R^2	p Value
BMI-for-Age	0.15	0.0120	0.7095
Height-for-Age	2.27	0.1592	0.1575
Weight-for-Age	2.74	0.1860	0.1237

IMPACT OF AGE AND GENDER

3C. Older children will have higher growth indices than younger children.

When adjusting for the quantity of milk, two different approaches were taken. The milk quantity was entered as a dichotomous variable (0 being below one cup; 1 being one cup of greater), and as a continuous variable. None of the models proved to be significant. In order to categorize the subjects between younger and older, a dichotomous variable divided them between 9 years or less, and older than 9 years. A factorial ANOVA test was used for the dichotomous quantity variable, and an analysis of covariance was used for the adjusted cups to see if there were any independent or additive relationships between quantity and age when predicting growth (TABLE 26).

TABLE 26

Growth Test By Age and Quantity: Individually and Additively						
Adjusted by	Outcome Variable	Model	F-value	R^2	p-value	Significant
Dichotomous Low/High	BMI Z	Overall	0.96	0.149219	0.4111	No
		Quantity	1.92		0.1936	No
		Age	0.01		0.9137	No
	HA Z	Overall	1.02	0.156765	0.3915	No
		Quantity	0.07		0.7917	No
		Age	1.97		0.1879	No
	WA Z	Overall	2.24	0.289046	0.1532	No
		Quantity	3.42		0.0914	No
		Age	1.05		0.3273	No
Adjusted Cups	BMI Z	Overall	2.92	0.867915	0.1572	No
		Quantity	3.25		0.1348	No
		Age	0.27		0.6325	No
	HA Z	Overall	0.60	0.573153	0.7614	No
		Quantity	0.67		0.7108	No
		Age	0.04		0.8494	No
	WA Z	Overall	0.91	0.672958	0.5841	No
		Quantity	1.02		0.5311	No
		Age	0.08		0.7867	No

No model was able to predict, individually or overall, any type of growth among the subjects receiving goat milk.

3D. Older boys with goat milk supplementation will have a higher growth indices than older girls with goat milk supplementation.

When comparing the impact of goat milk on older boys versus older girls, the challenge of having too few girls within this particular sample made running tests difficult. As in the previous tests, older subjects were considered to be children older than the age of 9. There were only three girls within this particular sample, compared to five boys, so it was not surprising that there were no significant differences between boys and girls on any of the three dependent variables. See TABLE 27

TABLE 27

Growth Tested by Gender among Older Milk Consumers			
Outcome Growth Variable:	F Value	R^2	p Value
BMI-for-Age	1.28	0.154476	0.2954
Height-for-Age	0.07	0.009377	0.8043
Weight-for-Age	0.50	0.066641	0.5024

IMPACT OF GOAT MILK ON ENERGY AND POSITIVE FEELINGS

Hypothesis 4A. Children with goat milk supplementation will report higher energy levels and more positive feelings than children without supplementation.

The moods reported by the children who received goat milk tended to be more positive than those reported by children who did not receive goat milk (χ^2 =6.5075, p=0.0107). However, this only held true whenever the subjects were receiving milk. Only 7.69% subjects perceived themselves with a positive mood when not receiving milk, but this jumped to 92.31% subjects when they were receiving milk. This is in comparison to the subjects who were not receiving milk, with only 53.33% subjects reporting a positive mood.

Hypothesis 4B. *Among children with goat milk supplementation, children will report that their energy is higher and their feelings more positive on days when they have goat milk to drink.*

A similar transition was seen in perceived energy levels among subjects receiving goat milk ($p=0.0656$, $\chi^2 = 5.4475$). Though the p-value for the chi square test is not technically significant, it is very close to being so, and the lack of significance is probably due to the fact that there were no subjects in the lowest energy level category who received goat milk. When the goat milk subjects were not receiving milk, only 30.77% subjects reported having high energy, but this jumped to 84.62% subjects when they were receiving milk. This is in comparison to the subjects who were not receiving milk, with only 55.56% subjects reporting high levels of perceived energy.

CHAPTER 6

Discussion

Organization of Data

The discussions section will first be a dialogue upon the data and analysis of the project, and the implications of it. Limitations and errors in the study will be covered, and recommendations for future research will be addressed.

Growth among the Entire Sample

After extensive statistical testing of the entire sample, no significant results were procured when comparing the sample of subjects drinking milk versus the sample not drinking milk. This result was speculated to be due to several reasons. First and foremost, the discrepancy in size of the two samples was very obvious, with the goat milk sample unfortunately being the smaller of the two (14 versus 47). This did not facilitate statistical testing, as significant results are harder to produce with smaller sample sizes. Secondly, previous anthropometric measurements of the children receiving goat milk were not ascertained, making it difficult to distinguish how malnourished (or not) they previously were in comparison to the children not receiving goat milk. These points will be further discussed in the limitations of the study. However, from this brief speculation, there was no statistical difference in when comparing milk consumers versus non-milk consumers in *this* study.

Growth among Children Receiving Milk

However, as the results reveal, the nutritious effects of milk could be observed within the sample of subjects receiving milk relative to each other. Though long-term growth was not observed in the form of such growth scores as height-for-age, increased BMI-for-age scores were correlated to milk consumption in certain aspects.

The most important determinant on whether an increased BMI-for-age Z score was seen depended on how long the subject received milk and the duration of time since receiving milk. Those who consumed milk more recently for a longer period of time were observed to have higher BMI scores in comparison to those who did not ($p = 0.0085$). In addition to this, when this variable was stratified across children who received more than one cup or greater, or who were above the age of nine, significant results were further found to strengthen this relationship ($p = 0.0167$ and $p = 0.0067$ respectively). Furthermore, an increase in weight-for-age score was seen to be significant when relying upon the length of time the subject received milk and the duration of time since receiving milk.

Speculation on these finding can lead the observer to some possible conclusions. The results might imply that the initial biological reaction of the body is to concentrate on short-term, homeostatic growth before attempting long-term growth resulting in increases in height. If we are to follow this assumption, it would support the finding (and vice versa) why an increase in weight (weight-for-age) and filling out of the body frame (BMI-for-age) was perceived, but an increase in height (height-for-age) was not significant.

The idea that the body would concentrate on short-term growth before attempting long-term growth seems logical. If the body were to attempt an increase in height as soon as it had the possible nutrients, then the resulting physique would require an even heavier calorie/nutrient load to support itself. Consequently, it seems to follow reason that the short-term growth, such as the filling out of the body to reasonable proportions, would come before upward growth.

The additional stratified factors that showed significant increases in BMI-for-age additionally were appropriate in the context that larger amounts of milk would lead to higher BMI scores. As for the case of the age factor, though this did not technically satisfy the hypothesis that older children will see more beneficial effects than younger children, it did act as a possible support for the argument in favor of it.

An additional factor found to be a determinant in BMI-for-age among children receiving goat milk was the presence or absence of any form of protein ($p = 0.0458$). An increase in protein, and consequently an overall in increase of nutrient quality intake, was accompanied by an increase in growth. The fact that this increase in protein showed a positively correlative affect upon BMI-for-Age, but not height-for-age, further goes to show reinforce the argument that short-term growth trumps long-term growth.

In addition to the argument for favoring short-term growth, another reason for not seeing any significant data supporting growth in height or overall long-term growth might stem duration and quantity of milk received. In the current circumstance, this program of providing dairy goats to this particular Kenyan community is relatively recent; the duration of milk production has not yet been for an extensive period yet. This might be an appreciable reason in why long-term growth has not been seen yet. This particular topic is also further covered under limitations.

Finally, though more of a serendipitous finding, the consumption of goat milk seems to have a positive effect upon the perceived energy levels and moods of the children consuming it. Though this might be written off as a simple placebo effect, the fact that a higher percentage of the children receiving milk reported higher energy and better moods still stands to reason that is having a potentially beneficial psychological effect upon the subjects, even if milk consumption is minimal.

Future Considerations

Measurements

Other data collection that could be done to further my research is the implementation of other types of anthropometric measurements. One type of measurement is skinfold thickness to measure subcutaneous fat and total fat [36]. The thickness of subcutaneous adipose tissue has been found to be an excellent indicator of long-term energy stores within the body.

It is standard for skinfolds to be measured on the right side of the body, and for a singular person to make the measurements, or a group of trained individuals, for consistency purposes. In method, the measurements of skinfold is most useful in individuals whose weight-for-height is greater than the 90^{th} percentile or less than the 10^{th} percentile. It is not typical among well-child care, but is an excellent measurement among malnourished children. Research has shown that a combination of tricep and subscapular skinfold thickness is a better indicator of total body fat in children than height and weight is. The subscapular skinfold was found to be the best indicator of relative fitness among teenagers. Longitudinal studies have shown that the skinfold thickness of infants below two have no predictive value of skinfold measurements later in life, so are considered to be of little value. However, after the age of two, there is an increasing correlation between year to year and thickness of skinfold measurement. In the recording of a skinfold thickness, the measurement should be plotted against a graph of exact age and sex [37]. Though skinfolds might not be an excellent indicator of growth in many cases, it would be an excellent indicator of long-term energy stores.

Goat Care.

The quality and quantity of goat milk that an individual receives from the goat greatly based upon how the goat is raised, nurtured and cared for. According to the article "Dairy Goat Production Guide" in the *Dairy Goat Journal*, the breed of dairy goat is not particularly important in terms of milk production or quality, just mainly in preference. Does (female dairy goats) cannot commence lactation until they have given birth. They typically reach reproductive age at 7 to 10 months, or about 2 months after puberty. However, puberty in goats usually correlates with the size of the goat, not the age.

Once the goat is ready to breed, the time period between conception and birth is about 5 months. The kid(s) should receive colostrum from the mother with the first 18 hours of birth, a very nutritious and immuno-protective substance produced by the mother. Shortly after birth, the doe will start producing milk. The advanced, well-informed goat farmer who has the proper knowledge on how to properly nurture and feed the doe will be able to get their goat to produce up to 9-10 months. In the peak months right after giving birth, the doe can give up to 2 to 3 quarts in a single day. This does decline over time however. The initiation of the dry period in the best case scenario will only last about 2 months (after the 10 months of milking), followed by the birthing of her next kids and the consequential production of more milk. However, in less than optimum settings, such as in third-world countries such as Kenya, farmers often do not have the resources to properly care for their dairy goats. This often results in the goats drying out in 4 to 6 months while only producing a few cups a day sometimes.

Furthermore, the article gives a brief insight into the optimal diet of a dairy goat in which the individual wishes to have a high milk production. High-quality hay (legumes for example) and a mix of grains fortified with vitamins are needed for the production of quality milk and larger quantities of milk. Also, a certain amount of the diet must consist of good quality fiber in order to boost the quantity of milk produced. [38]

Creation of an Incentive System.

In order to improve care of the dairy goats to the greatest degree, an incentive program among the caretakers might be considered. This would be utilized to improve milk production to the fullest potential possible within the setting. This could be accomplished through a simple manner, which we determined after communicating with the Kenyan coordinator of the Straw-to-Bread coordinator.

The goal would be to make a system in which the caretaker was required to keep a log of the daily activities with the goat. This would include the feeding schedule: how many times a day, what the goat was fed (including quantities), and how much water they receive. Also, they would be required to record when they milked the goat, how much they received each day, and for what period of time was the goat producing milk. A prepared calendar could be used in facilitating this process. Miscellaneous details that the caretaker could also record would include the health status of the goat and any noticeable change in the size of the goat.

For each month that a caretaker kept a complete record on upkeep of the goat, a large bar of soap would be given to the caretaker. For every six months, a larger incentive, such as needed cooking or washing utensils, would be given to the caretaker.

Not only would this system help incentivize the upkeep of the goats, it would also hold the caretaker accountable for the care of the goat. It would create a visual reference for them to see how well the goat is producing. In addition to this, it might help foster relationships between the caretakers that will further work to nurture the goals. One caretaker who happens to be more successful might be able to convey tips or diets to another caretaker for his/her respective goat. An auxiliary support system from other caretakers would also strengthen accountability.

Limitations

The foremost limitation in this study was the restricted ability to measure the growth of the subjects. Since the study was cross-sectional, instead of longitudinal, growth markers for each subject was only ascertained at one point in time. It might be possible to scavenge data from past trips on the same subjects, but the likelihood of finding information on a large enough portion of the same subjects is relatively low.

However, since the growth status of each subject was assessed at a singular point in time, no comparison could be made to see the increase, or rate of growth, over a given time period. A comparison of growth *rates* would provide a better indicator for the true progress of growth among the sample. The cross-sectional approach leaves this only for speculation, for it cannot be said with certainty if the milk has sped up growth for a subject in comparison to a subject who has not received growth. This would require at least two growth markers over a certain period to truly calibrate the potential effect of the milk.

To further upon this previous point, it might also be noted that the period of time that subjects received milk would not have allowed for a perceivable affect upon growth.

Another limitation of the study was the size of the sample, especially among children receiving milk. In consequence to the small sample size, many tests that *might* have been significant with a larger sample size, returned as not significant. The probability for random error or chance increased as the size of the sample decreased. This especially held true when comparing subjects receiving goat milk in comparison to those who were not. A larger sample receiving goat milk would have facilitated precise testing.

Potential Error

As talked about throughout the study, potential error might have risen from difficulty in communication and reluctance to discuss certain topics. During surveying, the requirements for a translator created a certain unfortunate barrier between the interviewer and interviewee. The inability for direct communication between the two often meant that the intended question or response might have been muddled in translation. Often, cultural or language barriers did not allow the translator himself to understand the implications or meaning of a question, once again resulting in miscommunication.

Conclusion

Through significant increases in short-term growth measured by the BMI-for-age indicator, the findings of this study found that relative consumption, in terms of duration and time since receiving milk, was the primary cause for this increase. In addition to this, older children and children who received larger quantities of milk were seen to more favorable increases in growths.

The significance of this study is that it demonstrates the effects of relatively small supplements over relatively short periods of time. By looking at the study through this lens, we can start to see the benefits of even a limited system of milk supplementation among children in rural, Western Kenya. Since we were able to decipher the basic structure of the system, we can now decided how the system should be configured and managed to make it a much more efficient system. Whether this would be through an incentive system or the further education of goat caretakers, the end goal would be to produce results that showed not only increased short-term growth, but long-term growth that would demonstrate significant catch-up growth. However, not only would adjustments need to be made to the dairy goat system of production and distribution, but further field research would have to be done in follow up. This research would preferably build upon the foundation research, therefore emerging as a longitudinal cohort study allowing for a more in-depth study with the ability to track not only growth, but also rates of growth.

APPENDIX

<u>Orphan Background Information (to be answered by supervising guardian)</u>

1-Date: ___________(mo/dy/yr) 2-Interviewer: ____________________ 3-Patient ID: ________________

4-Date of birth___________________(mo/dy/yr)

5-Age: ________yrs (proportion of year if <1 yr, e.g. 6 mon = .5 yr)

6-Gender: __M(0) __F(1)

Medical History

Malaria
8-Number of times since S2B last visit (May 2012):
_______ times
09-Take medicine to treat it?
____ N/A(99)
____ No(0)
____ Yes(1)
10-Time since last episode:
_______ I have it right now (0)
_______ wks ago
_______have not had it (99)

11-Does patient have HIV?
____No(0) ___Yes(1)
____Don't know(99)

12-When diagnosed? ____N/A(99)
___yrs (proportion of year if <1 yr)
13-When last tested? Da/Mo/Yr or 0
14-Treatment now?
___yes(1) ____No(0) ___N/A(99)

15-How long? ____N/A(99)
___yrs (proportion of year if <1 yr)

16-Last time treated for worms :
___months ago ___not treated(99)

17. Has the patient experienced diarrhea (three or more loose or liquid stools in one day) within the past:
a. week? Y [1] N[0] If so, how many times? _________
b. month? Y[1] N[0] If so, how many times?_________
c. three months? Y[1] N[0] If so, how many times?___________
+Diarrhea can also be defined as "more loose stools passed in one day than is normal for an individual". This excludes loose stools of breastfed babies.

Social History (cont.)

18-Still enrolled in school ____No(0) _____Yes(1)
19-How much school completed
_____adult, but never went to school(0)
_____ primary(1)
_____secondary or trade school(2)
_____ university(3)
_____too young for school(4)

20-Number living in household (including pt): _____

Diet and Nutrition

Patient ID:

Mark with 'x' when applicable

	21-Morning	22-Mid-day	23-Evening
a.Protein (Meat/fish/Poultry/ Dagaa/Omena/ Eggs)			
b.Other Protein (beans)			
c.Milk			
d.Green Vegetables, Tomato Onion, Sweet Potato			
e.Fruit			
f.Starch (bread/porridge, ugali, maize, rice, chapati, pots, sweet pots, cassava, beans)			
g.Added Sugar? (tea or other)			
h.Soft Drinks?			

24-Use **iodized** salt?
____yes(1) ____no(0) ____do not know(99)

25-Has the pt ever eaten "soft rocks"?
_____No (0) ____Yes, but only rarely (1)
____Yes, frequently (2)

26-Has the pt ever eaten other things besides "soft rocks" that were not food, such as mud or dirt?
_____ no(0) _____Yes, but only rarely (1)
____Yes, frequently (2)

27-When was the last time the pt ate something that was not food (e.g. mud)?
____ never(0)
____ in the last week(1)
____ not in the last week, but in the last month(2)
____ not in the last month, but in the last year(3)
____ years ago when you were a child(4)

Water and Miscellaneous

28. What is the one **main** source of drinking water for pt?
_____ ground water(1) Location: ______________
_____ Tank(2) Location: ______________
_____ Tank + filter(3) Location: ______________
_____ Filtered ground water(4) Location: ______________
_____ rainwater caught in buckets(5)

29-Do you usually sleep under a mosquito net? ____Yes(1)
____No(0)

30-How would pt describe their health in general?
____very good(1)
____good(2)
____fair(3)
____poor(4)
____very bad(5)

31-What kind of toilet facilities do you use when you are at home?
____none, go in the bush(0)
____community latrine(1)
____open pit latrine(2)
____closed pit latrine(3)
____flush to piped sewer system(4)

BETHLEHEM HOME ELDER QUESTIONS

1. How many orphans does this goat serve? #________

   ID: _________________________ Started receiving milk:____________________(mo/dy/yr)

   ID: _________________________ Started receiving milk:____________________(mo/dy/yr)

   ID: _________________________ Started receiving milk:____________________(mo/dy/yr)

   ID: _________________________ Started receiving milk:____________________(mo/dy/yr)

   ID: _________________________ Started receiving milk:____________________(mo/dy/yr)

   ID: _________________________ Started receiving milk:____________________(mo/dy/yr)

   ID: _________________________ Started receiving milk:____________________(mo/dy/yr)

   ID: _________________________ Started receiving milk:____________________(mo/dy/yr)

   ID: _________________________ Started receiving milk:____________________(mo/dy/yr)

2. When it is producing, how many cups does this goat usually yield total on a given day?
   [0][1]
   [0][1][2][3][4][5][6][7][8][9]
3. How big is the serving of goat milk that you receive?
   < ½ Cup [1] ½ Cup [2] 1 Cup [3]
   2 Cup [4] >2 Cups [5]

4. How often do you feed the goat a day_?
   Once [1] Twice [2] Thrice[3] Don't; Just Grazes [4]
   a. What do you feed it?
   +____
5. How does it get water?
   Bowl [1] Trough [2] River/Stream [3] Pond[4]
6. Has it been sick at all?
   Y [1] / N [0]

How much milk did the orphans you care for receive in the months that the goat has been under your care?

YEAR 2010	Consumed Y[1] / N[0]	Full [1] Partial [2] N/A [3]	Notes
January			
February			
March			
April			
May			
June			
July			
August			
September			
October			
November			
December			

YEAR 2011	Consumed Y[1] / N[0]	Full [1] Partial [2] N/A [3]	Notes
January			
February			
March			
April			
May			
June			
July			
August			
September			
October			
November			
December			

YEAR 2012	Consumed Y[1] / N[0]	Full [1] Partial [2] N/A [3]	Notes
January			
February			
March			
April			
May			
June			
July			
August			
September			
October			
November			
December			

YEAR 2013	Consumed Y[1] / N[0]	Full [1] Partial [2] N/A [3]	Notes
January			
February			
March			
April			
May			
June			

Additional Notes: ____

Goat Milk Orphan Questions Patient ID:________________________

Date: ____________________(mo/dy/yr)
Age: ________________
Birthday:___________________(mo/dy/yr)
Gender: ____male (0) ____female (1)

"I want to find out some things about how you usually feel and how much energy you usually have, so I'd like to ask you a few questions with some pictures to help you answer. Drinking the goat milk might make you feel better, or it might not make any difference. There is not a right or wrong answer. I just want to see what it is like for you."

1. In an evening when you have NOT had any goat milk to drink, which one of these pictures shows what kind of things you feel like doing? (Interviewer circle ONLY ONE picture.)

In an evening after you HAVE had some goat milk to drink, which one of these pictures shows what kind of things you feel like doing? (Interviewer circle ONLY ONE picture.)

"Here are some more pictures to help you say how you usually feel. Drinking the goat milk might make you feel better, or it might not make any difference. There is not a right or wrong answer. I just want to see what it is like for you."

2. In an evening when you have NOT had any goat milk to drink, which one of these pictures best shows how you usually feel? (Interviewer circle ONE picture.) Are there any other pictures that also show how you usually feel on an evening when you have NOT had any goat milk to drink? (Interviewer circle as many pictures as needed.)

In an evening when you HAVE HAD goat milk to drink, which one of these pictures best shows how you usually feel? (Interviewer circle ONE picture.) Are there any other pictures that also show how you usually feel on an evening when you HAVE HAD goat milk to drink? (Interviewer circle as many pictures as needed.)

Non-Goat Milk Orphan Questions Patient ID:________________________

Date: ____________________(mo/dy/yr)
Age: ________________
Birthday:__________________(mo/dy/yr)
Gender: ____male (0) ____female (1)

1. "I want to find out some things about how much energy you usually have, so I'd like to ask you a few questions with some pictures to help you answer. There is not a right or wrong answer. I just want to see what it is like for you."

   In the evening, which one of these pictures shows what kind of things you usually feel like doing? (Interviewer circle ONLY ONE picture.)

2. "Here are some more pictures to help you say how you usually feel. There is not a right or wrong answer. I just want to see what it is like for you."

   In the evening, which one of these pictures shows how you usually feel? (Interviewer circle ONLY ONE picture.) Are there any other pictures that also show how you usually feel in the evening? (Interviewer circle <u>as many pictures as needed.</u>)

Child Measurement Chart

Measurement Date				
Patient ID				
Gender	Male [0] / Female [1]			
Age				
DOB (Date of birth)	(dy/mo/yr)			
GM (Goat Milk Supplementation vs. None)	No goat milk supplementation [0] Goat milk supplementation given [1]			
Height (cm)				
Weight (kg)				
MUAC (Mid-upper arm circumference) (cm)				
WC(Waist circumference)(cm)	1.	2.	3.	AVG:
SSF (Sub-scapular skin fold) (mm)	L1. R1.	L2. R2.	L3. R3.	L AVG: R AVG:
TSF (Triceps skin fold) (mm)	L1. R1.	L2. R2.	L3. R3.	L AVG: R AVG:
WSF (Waist skin fold) (mm)	1.	2.	3.	AVG:
Malaria	Negative [0]	P. Falciprum [1]	P. Vivax [2]	Both [3]
Lead (µg/dL)				
Hemoglobin				

If past data is available for child:

Height (cm)	2010:	2011:	2012:
Weight (kg)	2010:	2011:	2012:
MUAC (Mid-upper arm circumference) (cm)	2010:	2011:	2012:
WC(Waist circumference)(cm)	2010:	2011:	2012:
SSF (Sub-scapular skin fold) (mm)	2010:	2011:	2012:
TSF (Triceps skin fold) (mm)	2010:	2011:	2012:
WSF (Waist skin fold) (mm)	2010:	2011:	2012:
Malaria	2010:	2011:	2012:
Lead (µg/dL)	2010:	2011:	2012:
Hemoglobin	2010:	2011:	2012:

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