Nutritional Assessment of Rural Mossi People in Burkina Faso: A Comparison of Pre- and Post-Harvest Status

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NUTRITIONAL ASSESSMENT OF RURAL MOSSI PEOPLE IN BURKINA FASO:

A COMPARISON OF PRE- AND POST-HARVEST STATUS

By

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A thesis submitted to the Department of Health Science in partial fulfillment of the requirements for the degree of

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ABSTRACT

The purpose of this study was to compare the nutritional status of a rural population of Mossi people in Burkina Faso during the pre- and post-harvest seasons. Comparisons were made between the sample population and the American population, between the pre- and post-harvest seasons, between males and females in the sample population and between the various age groups in the sample population.

This nutritional assessment consisted of collecting demographical information, anthropometrical measurements such as weight and height, a clinical assessment to evaluate physiological signs of nutritional deficiencies and a food frequency questionnaire to describe the dietary practices of the population. Due to the potential risks of handling human blood, urine and feces, biochemical analyses were not performed in this study. Special attention was given to the nutritional problems most common in Africa: protein energy malnutrition, vitamin A deficiency, iron deficiency and goiter.

Adults in this study had an average body mass index of 19.1, classifying the adult population as "underweight". The population of American adults, however, has a tendency toward a body mass index in the slightly overweight category. The BMI range of adults in the study population was 12.9 to 27.8. A total of 36.9% of the adult population presented with some level of protein energy malnutrition while only 2.7% were slightly obese.

Seventy percent of children were below the 50th percentile on the 2000 Centers for Disease Control weight-for-height growth chart. A third of all children were below the 3rd percentile of weight-for-height. The vast majority of children in this study had a
weight-for-height below the median, or “average”, American child. The mean percent of median body weight-for-height for the child population in the lean season was 85.2% indicating that the median child in this sample population was mildly wasted. The mean percent of median weight-for-height rose to 94.6% in the post-harvest season indicating that the median child of the sample population was “normal” concerning wasting status.

The results of this study indicate that this rural population of Mossi people was less well-nourished than their American counterpart and that their nutritional status differed based on season ($F=[4,177] 4.77, p=.03$ for adults and $F=[4,51] 8.56, p=.005$ for children) but not gender ($F=[4,177] .04, p=.83$ for adults and chi square $= 4.37, p=.22$, df=3 for children) or age group for adults ($r=.10, p=.29$). In children, nutritional status was based on age group (but contrary to the expected outcome) with prepubescent children having lower weight-for-height percentiles than the under-five population (chi square $= 40.34, p=.02$, df=24). Nutritional status improved as predicted during the post-harvest, or plentiful, season.

Due to the lack of biochemical analyses, the potential vitamin and mineral deficiencies indicated in the brief physical examination were not confirmed. Vitamin A deficiency was the most likely nutrient deficiency; symptoms occurred in 51% of the population, primarily in adults and older children. PEM, although indicated by the anthropometric measures to affect 37.1% of the adult population and 55.4% of the child population, did not greatly manifest itself in clinical symptoms. The incidence of iron deficiency anemia was also relatively low with only 7% of the population presenting with pale conjunctivae, a potential, but non-specific sign of iron deficiency anemia. The goiter rate was also very low with only two cases occurring during the post-harvest season.
INTRODUCTION

Burkina Faso

Burkina Faso is a landlocked West African country located just south of the Sahara Desert. It has a Sudanian climate with a contrasting wet and dry season. Mean annual rainfall in the area surrounding Ouagadougou, the capital, is approximately 700 millimeters. The majority of this rain falls in the months of July and August, limiting the production of staple crops to those months (1).

Burkina Faso is approximately 274,000 km$^2$ in area (about the size of the state of Colorado) and has a 2000 estimated population of 12 million people (1). Sixteen percent of the population resides in urban centers and 84% lives in rural villages (2).

The life expectancy at birth is 45.2 years for females and 43.6 years for males. Burkina Faso's fertility rate is 6.5 children per female and its infant mortality rate is 99 per 1000 live births (3, 4). The maternal mortality rate is 566 per 100,000 live births (1).

Five percent of the Burkinabé female population and 4% of the male population are over the age of 60. Forty-seven percent of the total population is under the age of 15 (5). The gross domestic product is $221 per person (6).

Cereals (millet, sorghum, corn, fonio and rice) are the staple food crops and occupy over 85% of the country's cultivated land. The Burkinabé eat an estimated average of 180 kg of grain per person per year (1).

In 1996, the country devoted only 4.96% of its budget to health. Nearly 7% of the population is thought to be affected with HIV. Another serious health problem is malaria and its related high mortality rate (1).
Mossi people

The population of Burkina Faso is comprised of some 60 ethnic groups of various sizes. The largest group are the Mossi people. The Mossi constitute approximately 48.6% of the population of Burkina Faso - about 5.8 million people (1). The Mossi people are located primarily in rural villages on the Mossi Plateau in central Burkina Faso, but many have migrated to the Ivory Coast in search of work. Smaller groups can be found in Benin, Ghana, Niger and Togo.

Most families (70 to 80%) still support themselves by subsistence agriculture. Grain provides most of the food but peanuts, peas, okra, corn, and other crops are also grown. Livestock is raised primarily for cash and is rarely eaten except for special occasions. Men are responsible for maintaining order in the family and securing fields, but the women and older children do most of the agricultural work (7).

Forms of malnutrition in Africa

Very little nutritional research has been conducted on rural Mossi people in Burkina Faso (West Africa). Studies done in Africa have shown that four main forms of malnutrition are prevalent on the continent: protein energy malnutrition (PEM), xerophthalmia resulting from a deficiency of vitamin A, iron deficiency anemia, and endemic goiter and cretinism (resulting from a deficiency of iodine) (8). It is not known to what extent these deficiencies affect the rural population of Mossi people.
Nutritional Assessment

Nutritional assessment is an evaluation of the nutritional status of individuals or populations through measurements of food and nutrient intake and evaluation of nutrition-related health indicators (9). This nutritional assessment of a rural Mossi population consisted of anthropometrical measurements such as weight and height, a clinical assessment to evaluate physiological signs of nutritional deficiencies and a food frequency questionnaire to describe the dietary practices of the population. Due to the potential risks of handling human blood, urine and feces, biochemical analyses were not performed in this study.

Objectives

1) To assess the overall nutritional status of a group of rural Mossi people including the prevalence of protein energy malnutrition, vitamin A deficiency, iron deficiency anemia and endemic goiter and cretinism.

2) To determine seasonal variations in the nutritional status of a group of rural Mossi people.

3) To compare the overall nutritional status of rural Mossi males versus females.

4) To compare the overall nutritional status of rural Mossi adults versus children.

Hypotheses

H1) The prevalence of protein energy malnutrition in rural Mossi adults and wasting in rural Mossi children will be higher than that of persons in the United States.
H2) The prevalence of protein energy malnutrition in rural Mossi adults and wasting in rural Mossi children will decrease during the post-harvest season as compared with the pre-harvest season.

H3) The prevalence of protein energy malnutrition in rural Mossi adults and wasting in rural Mossi children will be greater in females than in males.

H4) The prevalence of protein energy malnutrition in rural Mossi will be greater in older adults than in adults under the age of 60. The prevalence of wasting in rural Mossi children will be greater in the under 5 population than in other sub-populations of children.

Importance of Study

Very little is known about the nutritional status of rural Mossi people. The Mossi number approximately 5.8 million and the majority of them live in rural, isolated villages. The results that are obtained from this study will increase awareness of the nutritional and health status of rural Mossi people. This research will also hopefully encourage others to target future interventions based on empirically determined needs and to improve the overall health and nutritional status of rural Mossi people in Burkina Faso.
LITERATURE REVIEW

Protein Energy Malnutrition

Protein energy malnutrition (PEM) is the most critical nutritional disease in developing countries. It has a high prevalence and is associated with mortality in children, impaired physical growth and inadequate social and economic development (10).

Social, economic, biological and environmental factors may be underlying causes for the insufficient intake of calories or for the consumption of foods with poor quality proteins that lead to PEM. The sub-populations at greatest risk for PEM are the young, the elderly, and pregnant and lactating females. Those members of society who are considered the most productive (adolescents, males and non-pregnant and non-lactating females) tend to have lower prevalences of PEM and exhibit the mildest forms of the disease (10). In rural areas in the Congo, Delpeuch found that the major risk factors for PEM was old age followed by the female gender and lack of education. In the city of Brazzaville, poverty and youth (<25 years old) were the main risk factors (11).

The global prevalence of underweight among preschool children in the developing world is estimated to be 35.8%. In Western Africa, countries are mostly affected by high and very high prevalences of underweight. Out of 10 regions studied by Onis et al., Western Africa ranks second for wasting, third for underweight and fifth for stunting (12).

Protein energy malnutrition, commonly referred to as "malnutrition", manifests itself in its mild and moderate forms as a loss of weight and a decrease in subcutaneous fat. In its severe form, PEM has three manifestations: marasmus (generalized muscular
wasting and absence of subcutaneous fat), kwashiorkor (the prominent feature is edema) and marasmic kwashiorkor (a clinical combination of marasmus and kwashiorkor with muscle wasting and edema).

When weight alone is used to assess malnutrition, it is not possible to distinguish children who are short for their age, but who otherwise have normal body proportions, from children who are emaciated with inadequate muscle development and deposited fat. For some years, stunting (low height-for-age) and wasting (low weight-for-height) have been used to account for this distinction (13). Stunting is a sign of past protein energy malnutrition while wasting is a sign of current PEM.

Growth failure is the most common sign of malnutrition in children. Children who survive the first 2 years of life have often adapted to the limited nutrient supply and health risks of their environment through stunted growth (14). Inadequate nutrition, malabsorption of nutrients, loss of nutrients and increased needs for nutrients during growth are all possible causes of the failure to gain weight and height (10).

The effects of malnutrition on an individual continue into adulthood. In women, stunting is a matter of great concern in terms of increased obstetric risks (12). Baqui et al. studied the levels and correlates of maternal nutritional status of women living in the slums of Dhaka. The risk of child death increased sharply if the maternal height was below 145 cm (15).

Vitamin A deficiency

A deficiency of vitamin A can result in xerophthalmia ("dry eye") and permanent blindness, cerebrospinal fluid pressure increase, keratinization, inanition and death (16).
Vitamin A status has been shown to affect growth and morbidity and mortality in children. Vitamin A is essential for the activity of cells in the epiphyseal cartilage that must undergo a normal cycle of growth, maturation and degeneration to permit normal bone growth of long bones (17). Among children with severe vitamin A deficiency and xerophthalmia, mortality is extremely high (18).

Eye signs of vitamin A deficiency can be relatively mild, can take the characteristic form of Bitot's spots, or can progress into serious and ultimately irreversible corneal ulceration. In older children and adults, Bitot's spots may be evidence of an earlier deficiency or may be entirely unrelated to vitamin A deficiency (10). Xerophthalmia progresses in the following order: (1) night blindness, (2) conjunctival xerosis, (3) Bitot's spots, (4) corneal xerosis, (5) corneal ulceration/keratomalacia, (6) corneal scar and (7) xerophthalmic fundus.

Vitamin A deficiency, even subclinical, seems to affect resistance to infection and childhood mortality even before it is sufficiently severe to cause xerophthalmia (19). A study in Indonesia showed that children with night blindness were at three times the risk of dying while children with Bitot's spots were at seven times the risk. A combination of night blindness and Bitot's spots put children at nine times the risk (18).

Mild vitamin A deficiency and xerophthalmia occur in a substantial proportion of children who appear otherwise healthy. Sommer et al. showed that mild vitamin A deficiency was directly associated with at least 16% of all deaths in study children aged one to six (18). It is estimated that improving vitamin A status of all deficient children in the world would prevent one to three million deaths every year (20).
Iron Deficiency anemia

Iron intake is frequently inadequate in four populations: (1) infants and young children, (2) adolescents, (3) females during childbearing years, and (4) pregnant women (21). Anemia, together with malnutrition, is among the major causes of childhood morbidity and mortality in many developing countries (8).

It is estimated as well that 60% of pregnant women and 45% of non-pregnant women in developing countries are anemic. Iron deficiency in women of childbearing age increases the hazards associated with complications of pregnancy, premature birth and low birth weight (8).

The symptoms of anemia are varied and may be caused by other conditions, making a clinical determination in the absence of biochemical analysis difficult. Physical symptoms of anemia include palmar creases and pallor of the conjunctivae, nails, face, tongue and palms. The pallor associated with anemia is also associated with a deficiency of folic acid, vitamin B₁₂ and copper.

Some effort has been made to develop methods of detecting anemia in an individual or population when laboratory tests are either not practical or not possible. Pallor of the conjunctivae in combination with pallor of the face, palms, tongue or nails has been effective at confirming the presence of anemia (22, 23). A brief diet history has been shown to be 97% effective in identifying children who are at low risk for anemia (24). In spite of these findings, biochemical analysis of the blood, particularly hemoglobin levels, remains the most accurate method of determining iron deficiency anemia.
Endemic Goiter and Cretinism

Iodine deficiency disorders (IDD) including goiter and endemic cretinism still affect millions of people throughout the world. An estimated 86 million people in Africa alone are thought to be affected by goiter (8).

Iodine deficiency stems from an insufficient intake of iodine in the diet. In many places where IDD is endemic, there is often a low iodine content in the soil and drinking water which perpetuates the problem. Low levels of iodine in the soil cause low levels of iodine in crops that are produced. The problem also affects livestock.

Iodine deficiency exhibits an effect on growth and development, particularly in the fetal stage, neonatal stage and infancy due to rapid growth. School children living in iodine deficient areas from a number of countries show impaired school performance and lower IQs (10).

The assessment of iodine nutritional status of a population includes the goiter rate, determination of urine iodine excretion and level of serum thyroxine (10). A study in Sudan showed a goiter rate of 22.3% despite iodine sufficiency indicating that consumption of millet, vitamin A deficiency and protein energy malnutrition are all possible etiological factors in the area (25). In the Plateau State of Nigeria, results of a study indicated that about 2/3 of the region is goiter endemic (26). In the Ivory Coast, 52.7% of the Yacouba and 28.6% of non-Yacouba participants in a study had goiter (27).

Endemic cretinism occurs with an iodine intake below 25 μg per day (10). Cretinism, in its most common form, is characterized by mental deficiency, deaf mutism, and spastic diplegia. The less common form, myxedematous, is characterized by hypothyroidism with dwarfism (10). The prevalence of cretinism discovered by Kouame
et al. in the Ivory Coast was 1.5% (27). Das et al. found 9 cretins (0.21%) in their study in Nigeria (26).

**Anthropometry**

Anthropometric indicators that express the magnitude and distribution of undernutrition are most effectively used to describe the nutritional status of populations rather than individuals. However, in many field situations, it is possible to use anthropometry as a screening device to identify individuals at risk of undernutrition (13).

Protein energy malnutrition (PEM) can be diagnosed by relatively simple anthropometry (14). The combination of weight-for-height, as a measure of wasting (current PEM), and height-for-age, as a measure of stunting (past PEM), can provide the distinction between tall thin and short fat children, which weight-for-age cannot (28).

Most anthropometric surveys are conducted on preschool children because they grow fast and thus demonstrate changes in nutritional status more rapidly than any other age group (13). Anthropometry has also been used to assess the nutritional status of adults, in particular to evaluate obesity and related problems of overnutrition (13). Limited research has been done to assess the use of anthropometry as a measure of undernutrition in adults.

**Use of International Standards**

The World Health Organization (WHO) has adopted American reference figures first published by the Centers for Disease Control (CDC) as an international reference and these are widely used (28). The validity of using American reference figures in
assessing individuals from other countries, particularly individuals from developing
countries, is still under debate.

Many populations in developing countries are shorter and leaner than their
American counterparts. The children in Sigman and Neumann's Kenyan study were quite
small and thin by comparison with the National Center for Health Statistics data, with
mean weights and heights around the fifth percentile (29).

Macfarlane emphasized the extent of the problems in interpreting weight-for-
height which are associated with the use of the CDC/WHO reference. She suggests that
serious consideration be given to the use of an alternative index of wasting, and to the
development of alternative reference figures (28).

Kow et al. investigated the validity of using international standards of reference
for developing countries. Graphic and chi square analyses of Kow's data indicate that the
international cut-off standards of 80% weight-for-age, 90% height-for-age and 80% mid-
upper arm circumference-for-age and mid-upper arm muscle circumference-for-age are
not set too high (30).

Ideally, individuals should be compared with reference data from their own
population. In the absence of reference data for a given population, the American
reference figures are widely used and accepted.

Weight-for-age

Many countries use weight-for-age charts for the surveillance of individual
children. Weight-for-age charts are of value only in so far as they show the direction of
growth, that is the velocity of the child's weight gain (31).
Below the age of 36 months, weight-for-age is an excellent parameter of the nutritional status. Beyond that, age weight-for-age becomes a progressively less sensitive indicator but continues to remain quite specific. This deterioration of sensitivity is mainly due to the body's physiologic adaptation to chronic undernutrition through deceleration of linear growth, i.e. stunting (32).

Weight-for-age deficits in older preschoolers may be due to stunting or chronic malnutrition as well as actual thinness. Where stunting is common in a population, weight-for-age may lead to an inaccurate diagnosis of current malnutrition (14).

To determine the percent median weight-for-age for an index child, the weight of the child is divided by the weight of the median child of that same age. Cut-off values for determining malnutrition based on weight-for-age have been determined. A value greater than 80% median weight-for-age is considered "normal"; 60 to 79% is considered "moderate" malnutrition and less than 60% is considered "severe" malnutrition (32).

Height-for-age

Since the first thing that happens in the undernourished child is a slowing down of growth, the relevant thing to monitor is growth velocity (33). Growth assessment is the single measurement that best defines the health and nutritional status of children; disturbances in health and nutrition, regardless of their etiology, invariably affect child growth (12).

An estimated 43% of under-5-year olds in developing countries have low heights-for-age (stunting or past malnutrition) (12). Using reference data provided by the National Center for Health Statistics, Sigman and Neumann found that about 25% of the...
sample were considered stunted in that their heights-for-age were less than 90% of the median (29).

The accepted cut-off points for determining malnutrition (stunting) based on percent median height-for-age are: 95 to 105% ("normal"), 90 to 94% ("mild stunting"), 85 to 89% ("moderate stunting"), and less than 85% ("severe stunting") (10).

**Weight-for-height**

Weight-for-height is the most commonly used single measure of acute (current) malnutrition in children. It is also convenient for use in refugee and emergency situations as it does not require knowledge of the child's age (28).

Weight-for-height is defined on the same basis as weight-for-age comparing the child's weight with the median weight of a reference child with the same height. Anderson concluded that weight-for-height appears to be the best single anthropometric indicator of current nutritional status in preschool children greater than 1 year old. His survey findings show that a 90% of reference weight-for-height limit provides a useful cut-off point for defining malnutrition (14).

The cut-off points used to determine the degree of wasting (current malnutrition) based on percent median weight-for-height are: 90 to 110% ("normal"), 80 to 89% ("mild wasting"), 70 to 79% ("moderate wasting"), and less than 70% ("severe wasting") (10).

**Body Mass Index**

Body composition information obtained through direct measurement methods such as densitometry and hydrometry is quite limited for groups of non-European origin
Body mass index (BMI), defined as weight/height$^2$ or Quetelet's Index, has become the index of choice when direct methods of obtaining body composition information are unavailable. It is more highly correlated with percentage fat, and less well correlated with stature than other weight/height indices (35).

Delpeuch et al. suggest that the analysis of BMI population data must be done by age groups and by gender as each group may be affected differently over time without a change in the total population's BMI (11). Berdasco analyzed the effect of low BMI in relation to the gender, age, height, dwelling, educational level and physical working activity of Cuban adults. Correlation analysis of the various weight-for-height indices with weight, height, triceps and subscapular fat-folds and with the sum of both, showed that the Quetelet index or BMI was the one that at each year of age, tended to have the highest correlations with weight, fat-folds and their sum, and lower correlations with height. The distribution of individuals showed that over 50% of Cuban men and a little over 40% of women fell into a normal BMI range (36).

Norgan compared studies conducted in rural areas of the Third World to investigate the relationship between estimated body composition and BMI using group mean data. The relationship between percent fat and BMI appeared linear in men and in women. At any BMI, women have a higher percent fat than men do. In men, the 10 samples with the lowest percent fat were Africans (34).

In Britain, Norway, Finland and the USA, the average BMI for adults is around 23-25. Most of the adult groups from developing countries are in the range of 19-21 (37). In a study of rural Ethiopian women conducted by Ferro-Luzzi et al., the women were
short, light and had low BMI (19.0). Sixteen percent of all the women were classifiable based on their BMI as second or third degree chronic energy malnutrition (38).

In 1988, James et al. established three cut-off points for determining protein energy malnutrition in adults using body mass index: 18.5, 17.0 and 16.0. Prior to the identification of these cut-off points for PEM in adults, BMI was primarily used in determining the degree of obesity. The currently accepted BMI ranges and classification for adults are: <16.0 (grade 3 PEM), 16.0 to 16.9 (grade 2 PEM), 17.0 to 18.4 (grade 1 PEM), 18.5 to 19.9 (underweight), 20.0 to 24.9 (normal), 25.0 to 29.9 (grade 1 obesity), 30.0 to 39.9 (grade 2 obesity) and ≥40.0 (grade 3 obesity) (10). James et al. also proposed that a BMI of about 12 may be the absolute lower limit compatible with life (39).

Criteria have not been established to classify the severity of protein energy malnutrition in adolescents. Between the ages of 11 and 13, a body mass index of less than 15.0 indicates the presence of PEM. For adolescents aged 14 to 17, a BMI of less than 16.5 is used as the cut-off for determining PEM (10).

**Mid-Upper Arm Circumference**

Various researchers have sought a simple and quick substitute for body mass index in determining the severity of protein energy malnutrition in adults in developing countries. James et al. examined the usefulness of mid-upper arm circumference (MUAC) as a substitute for BMI. In all of the countries studied, there was an excellent linear relationship between MUAC and BMI. A MUAC of >24.3 cm (243 mm) in men, corresponding to BMI >18.5, included 85% of adults as normal. Conversely, in men with
a BMI < 16.0 a MUAC < 22.3 cm (223 mm) included 85% of the men in grade 3 PEM. In
women the situation was very similar with 85% included in the normal category and 76%
in grade 3 PEM. The ability to discriminate intermediate PEM was poor (40).

Liljestrand and Bergstrom studied the value of mid-upper arm circumference in
assessing maternal nutrition in pregnant women. There was a strongly significant
association between estimated pre-pregnant weight and mid-upper arm circumference.
The study indicated that mid-upper arm circumference is a useful parameter for the
assessment of the nutritional status of pregnant women in poor countries where
alternative methods are often neither feasible nor practical (41).

Ferro-Luzzi and James studied the use of simple assessment techniques for use in
emergencies. They looked for a relationship between mid-upper arm circumference and
BMI. They identified the MUAC values that correspond to the three cut-off points of
BMI now used to categorize the grades of underweight. They developed a set of cut-off
points that can be used for screening adults under famine conditions. Less than 230 mm
in men and < 220 mm in women is considered undernourished; < 200 mm in men and
< 190 mm in women is considered severe wasting and < 170 mm in men and < 160 mm in
women is considered extreme wasting (42).

James et al. proposed a new classification of PEM based on the use of MUAC and
BMI. In this scheme, those with a BMI of 17.0 to 18.4 (grade 1 PEM) but with a MUAC
above the cut-off point may be considered normal but vulnerable. An individual with
< 16.0 BMI (grade 3 PEM) would be classified as grade 2 PEM should their MUAC be
near the cut-off (40).
Mid-upper arm circumference can also be used as a screening tool for determining malnutrition in children (31). Anderson found that MUAC showed a strong positive correlation with weight, weight-for-age and weight-for-height, except in Costa Rica and the Dominican Republic where the correlation with both measures was positive but weak. Anderson's data suggest that mid-upper arm circumference may be a more accurate measure of PEM than weight-for-age in a population with high rates of stunting (14).

There is some discussion as to whether arm circumference in children is age- or gender-dependent. Since the arm circumference of normal children changes very little between the ages of 1 and 5, MUAC cut-off values are frequently applied to this age group. The cut-off values established by Shakir in 1974 are still commonly used in rapid assessment situations where the exact age of the child is unknown. For children aged 1 to 5, a mid-upper arm circumference of >135 mm is considered normal. Between 125 mm and 134 mm is considered mild malnutrition and less than 125 mm is considered moderate to severe malnutrition (43). In Anderson's study, the 13.5 cm (135 mm) arm circumference limit rarely missed a child with third degree malnutrition (14).

Gozal et al. studied the use of MUAC in identifying children under the age of one who were at risk of higher morbidity. Babies with a MUAC ≤ 9.5 cm had a 9-fold increase in the risk of developing symptoms than infants with a MUAC >9.5 cm (44).

**Chest Circumference**

At birth, the chest circumference of an infant may be the same size or slightly smaller than the circumference of his head. Between the ages of 1 and 2, the chest and
head circumferences are approximately equal. After the age of 2, a child's chest measurement should be larger than his head circumference (45).

A WHO collaborative study compared the performance of mid-arm and chest circumference as predictors of low birth weight in a number of countries and recommended standards for the identification of low birth weight babies. The correlation between birth weight, arm circumference and chest circumference were high. In 18 of the 22 centers, the correlation between birth weight and chest circumference was greater than those for arm circumference. The WHO collaborators recommended the use of chest rather than arm circumference as a surrogate for birth weight. A measurement of <29 cm would be diagnosed as "high risk" and between 29 cm and 30 cm as "at risk" (46).

**Clinical assessment**

The medical history and physical examination of an individual can be used to detect signs and symptoms of disease and malnutrition. Iodine deficiency, for example, can be detected in a physical examination if the thyroid gland is enlarged. Painful cracks in the angles of the mouth indicate possible niacin or riboflavin deficiency (9). Examining skin quality is another important aspect of the physical examination. The presence of edema indicates fluid retention that is common in some forms of malnutrition (45). The presence of significant fat loss should be assessed by observing the areas where adipose tissue is normally present (10). Other key physical signs of malnutrition include protruding bones and a pale, gaunt look (45). A listing of other physical indications of malnutrition can be found in Appendix A.
Dietary assessment

Assessing dietary status includes a study of the types and amounts of foods consumed to determine the nutrient intake of the individual or population in question. Food and nutrient intake data are important in studying the relationship between nutrition and disease.

The World Health Organization's study group on diet, nutrition, and the prevention of chronic diseases has emphasized the need to develop country and culture specific dietary assessment methods that take different food-consumption practices into consideration (47). Because food and nutrient intakes vary among different ethnic groups and also differ within ethnic groups by migrant status, dietary practices offer a likely explanation for the diversity of disease outcome (48).

The primary dietary measurement techniques include: the 24-hour recall, food records or diaries (including weighed food records), food frequency questionnaires and diet histories. Some research in developing countries has employed the use of researcher observation as a means of obtaining dietary information (47).

Difficulties in Dietary Assessments in Developing Countries

There are many difficulties in applying western research techniques to the developing world. The fact that most rural people in developing countries are non-literate or semi-literate eliminates the possibility of using techniques that require the individuals under study to record their own food consumption. Only face-to-face interviews between research team members and study subjects and techniques that rely on observed records may be appropriate (47).
Most rural people in developing countries have little or no knowledge of units of measurement of weight or volume used internationally. To obtain quantitative or semi-quantitative dietary information, the researcher must either learn the international equivalents of local measures or must observe food preparation and consumption firsthand (47).

In some communities in Africa, all family members eat from a single or “common pot” with the contents being modified and served repeatedly throughout the day. This custom may make it relatively easy for a researcher to determine total household food consumption but difficult to measure an individual’s intake (47). If people eat from a “common pot”, especially when the contents are being modified throughout the day, the recall method cannot be used to describe individual intake (49).

The correct interpretation of data collected from dietary studies depends on the availability of up-to-date databases, such as food-consumption tables for specific countries or regions. These are lacking for many countries and those that do exist may be outdated (47).

The large seasonal differences in the intake of some nutrients indicate that food-consumption data collected during only one season can be misleading with respect to overall dietary status, especially in farming communities, where the availability of food is determined by weather conditions (47).

Food Frequency Questionnaires

To simplify data collection and analysis and to increase objectivity, most diet histories today are based on lists of selected foods and groups of items with similar
nutrient values that are used interchangeably in the diet (48). Food-frequency questionnaires (FFQs) are pre-coded forms that supply respondents with a list of 60-120 food lines (50). The food-frequency questionnaire assesses energy and/or nutrient intake by determining how frequently a person consumes a limited number of foods (9).

The two most widely used FFQs, the Health Habits and History Questionnaire (H HHQ) and the Harvard Diet Assessment Form, were validated in predominantly Euro-American adults living in urban and suburban areas in the United States. These FFQs were not designed to record frequency of food consumption in culturally diverse or culturally distinct populations and the validity of these questionnaires in epidemiological studies in such populations has not been thoroughly tested (50).

It is essential in any dietary study to collect prior dietary information for a sample of people from the target population and make lists of foods frequently consumed (48). Culture specific food groups should be determined from the food lists. To facilitate dietary reporting, food groups should fit within the context of the respondents. A database for the nutrient-composition of foods consumed by the population should be developed. When published nutrient values are not available, the nutrient content of samples should be analyzed.

Seasonality and negative energy balance

The majority of the rural populations in lesser-developed countries experience seasonal scarcity of food. The period of food shortage usually occurs at the end of the rainy season just before the main food harvest. This often coincides with the peaking of agricultural labor and creates competing demands on the allocation of the scarce energy
resources and results in energy stress (38). During the pre-harvest season, people may come into a state of negative energy balance (the intake of energy is less than the expenditure of energy) resulting in a loss of body weight (51).

In Ethiopia, Ferro-Luzzi et al. found lower weights during the lean season before the harvest of maize and increasing weights thereafter as fresh maize became available. The trend peaked between December and February when the sales of coffee provided ready cash. The observed body weight changes confirmed the existence of a seasonal disturbance in the energy balance of the community brought about by depletion of domestic food availability and possibly aggravated by a simultaneous increase in energy output (38).

Removal of energy from body stores and decrease of basal metabolic rate were found to be the two early and favored responses to energy restriction (38). Another proposed coping strategy has been a decrease in physical activity level and thus a reduction in total energy expenditure.

**Negative Energy Balance and BMI**

Adults living in rural areas of the Third World tend to have body mass index (BMI) values at the very low end of the distribution of BMIs seen in Western societies. This places rural villagers at risk and even a modest seasonal weight loss might have undesirable nutritional and functional implications (52).

In Ethiopia, the largest swings in body weight were recorded for the fatter, presumably richer women, while the women with the lower BMIs showed only small changes of weight (38). This finding suggests that either the poorer, leaner women lead
a marginally hungry existence all year round or that they employ coping strategies other than weight loss when dealing with seasonal variations in food availability. A previous study conducted in Burkina Faso showed that male farmers have a net change in BMI of 1 unit between seasons and for female farmers, the net change is .3 units (53, 54).

Negative energy balance and total energy expenditure

A large between-individual variation in pre-harvest weight loss suggests either that not all individuals experience the same seasonal food shortage, or that individuals may change their energy expenditure to different levels (51).

Panter-Brick studied the impact of seasonality, pregnancy and lactation on habitual physical activity. All women showed significant work seasonality. In relationship to total energy expenditure, pregnant women achieved lower values relative to predicted basal metabolic rate when pounding grain and hoeing fields. Total energy expenditure values showed significant seasonality regardless of pregnancy and lactating status, increasing to remarkably high amounts in the spring and monsoon seasons in Nepal (55).

A study by Durnin on the effects of low body mass index on physical work capacity and physical activity levels did not imply that work capacity was necessarily limited nor that physical activity was necessarily restricted. The possibility is that such negative effects would not appear until BMIs reached 17 or less (56).
**Negative energy balance and basal metabolic rate**

Ferro-Luzzi et al. found a highly significant seasonal trend concerning the basal metabolic rate in Ethiopia. Minimal values were recorded during the pre-harvest months and the highest values in the plentiful season (38). These results indicate that a lowering of the basal metabolic rate is one way that individuals cope with seasonal energy stress.

Schultink et al. studied the seasonal weight loss and metabolic adaptation of Beninese women. Although energy intake decreased during the pre-harvest season, physical activity level did not change significantly during the different seasons throughout the year in any of the study groups. Only thin women (BMI <17) showed metabolic adaptation (by lowering their basal metabolic rate) to a loss of body weight, while women with larger body energy stores only decreased body weight in response to a moderate reduction in energy intake (51).

**Nutritional status and mental development**

Bénéfice et al. studied the effects of anthropometric differences on the motor characteristics of Senegalese children with different nutritional histories. The Senegalese children, as a group, had lower performances than American children of the same age did. Well-nourished Senegalese children performed as well as the American children. The results confirm the significance of reduced body dimensions in motor performances of undernourished children (57).
Nutritional Status and Age

Allain et al. studied the effect of diet on the nutritional status in elderly (>60 years) Zimbabweans using a simple food frequency questionnaire. The frequency of eating meat, any protein and bread all declined with age. Body mass index, skin fold thickness, and waist-to-hip ratio all showed a significant decline with age (58).

In rural areas in the Congo, the prevalence of low BMI in women increased regularly from 18 years through older ages, from 12% up to 50%. For men the situation was different with the prevalence of low BMI decreasing during young adulthood, but then rising sharply over 40 years, up to 37% (11).

Garcia and Kennedy showed the impact of age and aging on low BMI in developing countries although this relationship was non-linear. The prevalence of low BMI was higher in the 15-30 year age range than in the 30-35 age group but increased thereafter (59).

Nutritional Status and Gender

When analyzed by gender, Anderson's data from five developing countries showed little difference in rates of malnutrition by weight-for-height between male and female children (14). The narrowing of the gender differential in child mortality might be attributed to the effect of health education on the family's traditional system for allocating health and nutrition resources preferentially to males (60).

In Ghana, overweight and obesity were mainly prevalent in women living in urban areas, while the prevalence of protein energy malnutrition was much higher for the overall population in rural compared to urban areas. The prevalence of a BMI lower than
18.5 was rather similar in men and women despite the considerably higher mean BMIs of women (61).

In Bangladesh, Pryer found that a slightly higher proportion of mothers had a BMI below 16, whereas a slightly higher proportion of fathers had a BMI greater than 18.5 (37). Ferro-Luzzi et al. found that rural Ethiopian women were short, light and had a low BMI (19.0). Sixteen percent of all the women were classifiable as second or third degree protein energy malnutrition based on their BMI (38).

**Nutritional Status and Socio-economic Level**

At the individual level, Nube's data revealed significantly positive relationships between BMI and the various indicators of the standard of living. At the population level, the same relationships were much stronger. Under the conditions of the study, differences in mean BMI or differences in mean weight between population groups were considered as indicative of differences in the standard of living, with the highest standards of living in those population groups with the highest BMI or highest weight (61).

Delpeuch et al. studied the sensitivity of body mass index as an indicator of socio-economic status in the Congo. Rural men and women (lower economic status) were shorter and lighter than those living in the capital (higher economic status) and their BMI was also lower (11).

In Asia, there were statistically significant positive associations between BMI and levels of education and income as well as with occupation. These relationships were stronger for education and occupation in rural than in urban areas (62). In Zimbabwe, the
frequency of eating meat, any protein and bread among the elderly was affected by mean annual cash income. BMI and skinfold thickness also correlated positively with income (58).

**Nutritional Status and Education**

Maternal education is often singled out as an important factor in child mortality. A study by Findley et al. in Burkina Faso showed a higher reduction in infant and child mortality rates in 13 villages with multi-sectorial programs (literacy, etc) than in those villages with either one or no non-health programs (60).

In men in Berdasco's study, there was no relation between educational level and percentages of grades 1, 2, or 3 protein energy malnutrition, nor in those classified as underweight (36). In the normal BMI range there were higher percentages in the higher educational groups but obesity was not related to educational level (36).

The frequency of eating meat, bread, milk and fried food were all significantly higher in elderly Zimbabweans with more years of education. BMI, skin fold thickness and waist-to-hip ratio (WHR) all related significantly to the frequency of eating meat and fried food, and BMI was significantly higher in those with more years of education (58).

**Nutritional Status and Household Size**

In a study by Pelto et al., children in larger households were significantly shorter and heavier for their height than children from smaller households. They also consumed significantly less food from animal sources (63). Tanner found that within each
occupational group the larger the number of siblings there were in the household, the shorter the children (33).

The findings from the bivariate correlation analysis of Pelto's data suggest that children from larger families are at substantially greater risk of poor nutritional outcomes. If larger families are poorer than smaller ones, the results could be explained simply as a function of household economic status; however, the correlation analyses revealed no statistically significant associations between the measures of economic status and family size (63).
METHODS

Research design

The research design of this study was a "one group, pre-test post-test" where each individual served as his own control and the "intervention" was a change in seasons. The study consisted of four parts: demographics, anthropometrics, clinical evaluation and a one-month food frequency questionnaire. Each subject was interviewed on two occasions: once during a time of low nutrient availability (October) when the previous season's crops were running low but the current season's were yet to be harvested and once again approximately five months later (March) when there was a relatively high nutrient availability.

Instruments

All the survey instruments used in this study were administered orally in the language of the Mossi (Mooré). The instruments included: a demographic data sheet, a clinical observations record, an anthropometry worksheet and a food frequency questionnaire (FFQ). The FFQ was the primary instrument used and was developed based on the 131-Item Willett Food Frequency Questionnaire (WFFQ) (9). The WFFQ was altered to be culturally appropriate to rural Mossi people. Cultural appropriateness was determined by researching the dietary habits of rural Mossi people. This included information acquired in language and culture classes, trips to the local markets to collect information on food and nutrient availability and personal interviews to determine ingredients found in common dishes. The revised food frequency questionnaire was pilot tested on 12 Mossi individuals before being used in the field setting.
Equipment

The primary equipment used in this study included a stadiometer, flexible tape measure, adult bathroom scale, baby weighing scales, tympanic thermometer and a blood pressure cuff.

Subject selection and sampling

Study participants were members of the Mossi tribe of Burkina Faso living in the rural village of Songnkom. All participants were of Mossi descent and had lived in Mossi villages their entire lives. Songnkom was selected for several reasons: (1) rural location, (2) population was entirely Mossi, (3) proximity to the capital, and (4) the researcher had an established relationship with a member of the community. Songnkom has a population of approximately 400 and about 25% of the villagers made up the convenience sample for this study.

The study included 100 individuals from all ranges of the life span (infants through the elderly). The subjects were classified as follows: neonates and infants (up to 12 months), toddlers to preschoolers (12 to 36 months), preschoolers (37 to 59 months), pre-pubescent (5 to 10 years for females and 5 to 11 1/2 years for males), adolescents (11 to 16 years for females and 11 1/2 to 17 years for males), adults (17 to 59 years for females and 18 to 59 years for males) and older adults (over 60).

Permission was obtained from Mr. Gomkoudougou BILOGO, the chief of Songnkom, on August 21, 1999 to begin research in the area. Preliminary permission to begin data collection was obtained from the Institutional Review Board of the University
of North Florida on September 27, 1999. Final IRB approval was received from the Full Board on October 21, 1999.

**Information about Songnkom**

Songnkom is a small, rural Mossi village located approximately 11 kilometers south of Ouagadougou, the capital of Burkina Faso. The village has approximately 400 inhabitants. Although it is in close proximity to a main road and not far from the capital, electricity and running water are not available in the village. Water is drawn either from a well or from the dam, both of which are near the village. The dam is dry during the dry season months.

**Informed consent**

An informed consent form was prepared in French and in the Mooré language. Informed consent was obtained from all adult participants and parental consent was obtained from the parents of minor participants. Minor children aged 7 to 17 were asked to give their assent to participate. According to Mossi culture, a female is considered an adult at the age of 17 or at the time of her marriage whichever comes first. Parental consent was sought for all females under the age of 17 who were still living in their father's courtyard. Males are considered adult in the culture if they have undergone an initiation ceremony or if they are married. Parental consent was obtained for all males under the age of 18 who were still living in their father's courtyard.

In the event that the participant was unable to read, a statement of informed consent/assent was read to the individual in Mooré. Those participants who were unable
to sign their name indicated consent/assent by placing an inked fingerprint on the form. A Mossi witness signed all consent/assent forms. Participants were given a copy of the form in either French or Mooré. Copies of the informed consent/assent in English, French and Mooré are in Appendix B.

**Demographics**

Families were interviewed privately in their courtyards. Participants were asked to provide limited demographic information that was used to determine statistical variations. All adults were asked to provide information concerning their gender, age, marital status, educational level, occupation, and animal ownership. Females were asked about their number of co-wives, age at first birth, if they were currently pregnant or breastfeeding, total number of live births, number of stillbirths, number of living children and their ages, and number of deceased children and their ages at death. Males were asked about their current number of wives. (This is a polygamous society).

Parents answered the demographic questions for their young children. Children were asked their gender, age, educational level, rank among mother's living children, if they had a twin sibling, if they were breastfeeding, spacing between the child and the next oldest sibling and who looks after the child when the mother is absent from the household. Household information was obtained as well: number of adults and children on the compound, total number of children under five on the compound, maternal/paternal marital status, number of father's wives, maternal/paternal education level, maternal/paternal occupation and mother's/father's age, if mother is pregnant or
lactating, total number of births for the child's mother and the ratio of deaths to births for the mother.

Appendix C, D and E contain a detailed list of the demographic information that was obtained.

**Anthropometrics**

**Weight**

Weight for adults and older children was obtained in kilograms using a Health-o-Meter strain gauge digital bathroom scale (model 800). Participants were weighed barefoot and their weight was recorded on the adult anthropometric worksheet (Appendix F). Neonates and infants were weighed using a TALC (Teaching Aids at Low Cost) plastic hanging baby scale. Children who were too large for the baby scale and who could not or would not stand on the bathroom scale were weighed while being held by an adult. The weight of the adult was subtracted from the weight of the adult plus child to obtain the child's weight.

**Height/length**

Standing height for children and adults was measured using a portable Seca brand stadiometer (Hite-Roller model 208). The portable stadiometer was affixed to a wooden pole at a distance of 2 meters from the bottom. The pole was held vertical behind the individual and the stadiometer was lowered to the top of the head to get a reading of the height. The participants were measured barefoot. Children who were unable to stand
were measured in centimeters using a flexible tape while being held by their mothers. Height/length was recorded on the appropriate anthropometric worksheet.

**Mid-upper arm circumference**

Upper arm circumference was obtained in centimeters for all participants over the age of one using a flexible tape measure. The tape was placed around the left arm, perpendicular to the long axis, at the level of the triceps skinfold site. The measurement was recorded on the appropriate anthropometric worksheet (Appendix F for adults and G for children).

**Head circumference**

Head circumference was measured for all child participants under the age of three. This measurement was obtained in centimeters using a flexible tape measure. The tape was placed so that the lower edge of the tape was just above the eyebrows and ears, around the occipital prominence of the head, tight enough to compress the hair. The measurement was recorded on the child anthropometric worksheet (Appendix G).

**Chest circumference**

The chest circumference was measured for all children under the age of three. This measurement was obtained in centimeters using a flexible tape measure. This measurement was taken at the level of the nipples with the tape measure firmly pulled without causing an indentation in the skin. The measurement was noted between
inspiration and expiration and recorded to the nearest 0.1 cm. The measurement was recorded on the child anthropometric worksheet (Appendix G).

**Blood pressure/pulse**

Blood pressure and pulse were measured for adult participants using an Omron Automatic Oscillometric Digital Blood Pressure Monitor (model HEM-713C). The cuff was placed on the right arm with the tube positioned on the inside of the arm. The systolic and diastolic measurements were taken in mm Hg and the pulse rate was measured in beats per minute. The measurements were recorded on the adult anthropometric worksheet (Appendix F).

**Temperature**

Body temperature was measured for all participants using a digital Omron tympanic thermometer (Model MC-505) that automatically converts to an oral equivalent. The probe was covered with a disposable protective sheath and placed inside the external ear canal with firm but gentle pressure. A new protective sheath was used with each participant. The thermometer was removed after the audible signal occurred and the temperature reading was displayed, about 2 to 3 seconds. The temperature was read in degrees Celsius. The measurement was recorded on the appropriate anthropometric worksheet (Appendix F for adults and Appendix G for children).
Clinical evaluation

Each individual was examined for physiological signs of malnutrition. Particular attention was paid to the hair, skin, eyes, mouth, lips, gums and teeth of the individual. The results of the clinical evaluation were recorded on Appendix H.

Hair

Each participant's hair was examined for signs of protein energy malnutrition (PEM) which include hair that is easily plucked, dyspigmented or lackluster.

Additional signs of PEM

Participants were examined visually for additional signs of protein energy malnutrition. These signs include "moon face", thin muscles with fat present and edema for kwashiorkor and "old man's face" and thin muscles with thin fat for marasmus.

Skin

A visual exam of the skin of each participant was performed to look for signs of essential fatty acid deficiency (xerosis, dry scaling), vitamin A deficiency (hyperkeratosis, plaques around hair follicles), and vitamin K and C deficiency (echymoses, petechiae).

Eyes

The eyes were examined visually for pale conjunctivae which is a sign of possible iron, folic acid, vitamin B₁₂, or copper deficiency and for Bitot's spots, a sign of vitamin
A deficiency. All participants were asked if they had any recent problems with "night blindness". No contact was made with the eye. The participant was asked to pull the eyelids up or down and to move the eyeballs up, down, to the left and to the right.

**Mouth, lips and tongue**

This exam was visual and no contact was made with the participants' saliva. The participant was asked to open the mouth and to stick out the tongue. The purpose of this exam was to look for angular stomitis (inflammation at corners of mouth) as a sign of riboflavin deficiency, cheilosis (reddened lips with fissures at angles) as a sign of riboflavin or vitamin B₆ deficiency, glossitis (inflammation of the tongue) as a sign of vitamin B₆, riboflavin, or niacin deficiency, magenta tongue as a sign of riboflavin deficiency, and edema of the tongue and tongue fissures as signs of niacin deficiency.

**Gums and teeth**

The participants were asked to bare their gums and teeth. Spongy, bleeding gums were noted as a sign of possible vitamin C deficiency. A brief look at the teeth was made to estimate overall dental health.

**Goiter**

Each participant was examined visually for any sign of a goiter, which would indicate an iodine deficiency.
Diarrhea, Malaria and Vaccinations

Each participant was asked to report any cases of diarrhea or malaria during the previous month. Participants were also asked if they had received any vaccinations.

Food Frequency Questionnaire

Each participant was interviewed orally about dietary intake for the month preceding the interview. Participants were asked the frequency (never, monthly, weekly, 2-4 times per week, 5-6 times per week or daily) that 89 food items were consumed during the month preceding the interview. This information was recorded by the observer on the Food Frequency Questionnaire (Appendix I). Participants were also asked to list their source of water, smoking/tobacco habits and foods that are forbidden by their culture or family unit. Mother's of breastfed infants were asked to list supplemental weaning foods on Appendix J.

Nutritional and Health Assessment

Adults

Temperature

Readings exceeding 37.3 °C were recorded as a fever on the adult anthropometric worksheet (Appendix F).

Systolic Blood Pressure

A systolic reading of <120 mm Hg was recorded as "optimal" on the adult nutritional/health risk assessment form (Appendix K). A reading of 120 to 129 mm Hg
was recorded as "normal"; 130 to 139 mm Hg as "high normal"; and ≥ 140 mm Hg as "high".

Diastolic blood pressure

A diastolic reading of < 80 mm Hg was recorded as "optimal" on the adult nutritional/health risk assessment form (Appendix K). A reading of 80 to 84 mm Hg was recorded as "normal"; 85 to 89 mm Hg as "high normal"; and ≥ 90 mm Hg as "high".

Pulse

A pulse reading of less than 60 beats per minute (bpm) was recorded on the anthropometric worksheet (Appendix F) as a low pulse. Sixty to 100 bpm was recorded as normal and over 100 bpm was noted as high.

Mid-Upper Arm Circumference

A mid-upper arm circumference of ≥ 230 mm for men and ≥ 220 mm for women was recorded as "no risk" on the adult health/nutritional assessment form. A measure of < 230 mm for men and < 220 mm for women was recorded as "low risk"; < 200 mm for men and < 190 mm for women was recorded as "medium risk"; and < 170 mm for men and < 160 mm for women was recorded as "high risk".

Body Mass Index

Body mass index (BMI) was calculated for all adult participants using Quetelet's Index. Weight in kilograms was divided by the square of the height (in meters). The
BMI was recorded on the adult anthropometric worksheet (Appendix F). A body mass index (BMI) of 18.5 to 19.9 was recorded as "underweight" on the adult anthropometric worksheet and on the adult nutritional/health risk assessment form. A BMI of 20 to 24.9 was recorded as "normal" on the respective forms. A BMI of 17 to 18.4 was noted as grade 1 protein energy malnutrition (PEM) on the adult anthropometric worksheet and on the adult nutritional/health risk assessment form. A BMI of 16 to 16.9 was recorded as grade 2 PEM on the respective forms. A BMI less than 16 was noted as grade 3 PEM on the adult anthropometric worksheet and on the risk assessment form. Grades of obesity were recorded on the adult anthropometric worksheet as follows: 25 to 29.9 (grade 1 obesity), 30 to 39.9 (grade 2 obesity), and ≥ 40 (grade 3 obesity). Obesity was also recorded on the adult nutritional/health risk assessment form.

Clinical Evaluation

Potential macro- and micro-nutrient deficiencies derived from the clinical evaluation were noted on the second page of the clinical evaluation form (Appendix H).

Dietary

Each participant's Food Frequency Questionnaire was examined for potential dietary deficiencies. Significant changes in the diet between the two study periods were noted.
Children

Temperature

Readings exceeding 37.3 °C were recorded as a fever on the child anthropometric worksheet (Appendix G).

Mid-Upper Arm Circumference

For children aged 1 to 5, a mid-upper arm circumference >135 mm was recorded on the child nutritional/health risk assessment form (Appendix K) as no risk; measurements between 125 mm and 134 mm were noted as mild malnutrition, and below 125 mm was recorded as moderate to severe malnutrition.

Weight-for-age

Each child's weight-for-age was plotted on a 2000 Center for Disease Control (CDC) growth chart. The percent of mean weight-for-age was computed for all children in the study by dividing the child's weight by the median weight for reference children of the same age. The child's growth percentile and percent of median were recorded on the child anthropometric worksheet (Appendix G). A mean percent weight-for-age greater than 80% was recorded as normal on the child health/nutritional risk assessment form (Appendix K); 60% to 79% was recorded as moderate malnutrition and less than 60% was noted as severe malnutrition.
Height-for-age

Each child's height-for-age was plotted on a 2000 CDC growth chart. The percent of mean height-for-age was computed for all children in the study by dividing the child's height by the median height for reference children of the same age. The child's growth percentile and percent of median were placed on the child anthropometric worksheet (Appendix G). A mean percent height-for-age of 95% to 105% was recorded as normal on the child health/nutritional risk assessment form (Appendix K); a recording of 90% to 94% was noted as mild stunting, 85% to 89% as moderate stunting, and less than 85% as severe stunting.

Weight-for-height

Weight-for-height for each child was plotted on a 2000 CDC growth chart. The percent of mean weight-for-height was calculated for all children in the study by dividing each child's weight by the median weight for reference children of the same height. Each child's percentiles and percent of median were placed on the child anthropometric worksheet (Appendix G). A percent of median weight-for-height of 90% to 110% was recorded as normal on the child health/nutritional risk assessment form (Appendix K); a percent of mean of 80% to 89% was noted as mild wasting, 70% to 79% as moderate wasting, and less than 70% as severe wasting.

Head circumference

Head circumference-for-age was plotted on a 2000 CDC growth chart for each child under the age of three. The percent of mean head circumference-for-age was
calculated by dividing the child's head circumference by the median head circumference for reference children of the same age. The child's percentile and percent of median were recorded on the child anthropometric worksheet (Appendix G). It was also noted on the child anthropometric worksheet whether the chest was larger than the head.

Body mass index and BMI-for-age

Body mass index (BMI) was calculated for all child participants over the age of 2 using Quetelet's Index. Weight in kilograms was divided by the square of the height (in meters). The BMI was recorded on the child anthropometric worksheet (Appendix G). BMI-for-age was plotted on a 2000 CDC growth chart. The percent of mean BMI-for-age was calculated by dividing the child's BMI by the median BMI for reference children of the same age. The child's percentile and percent of median were recorded on the child anthropometric worksheet (Appendix G).

For adolescents between the ages of 11 and 13, a body mass index of less than 15.0 was recorded on the child health/nutritional risk assessment form (Appendix K) as indicating the presence of protein energy malnutrition. For adolescents aged 14 to 17, a BMI of less than 16.5 was used as the cut-off for determining PEM.

Clinical evaluation

Potential macro- and micro-nutrient deficiencies determined from the clinical evaluation were noted on the second page of the clinical evaluation form (Appendix H).
Dietary

The data from each participant's Food Frequency Questionnaire was examined for potential dietary deficiencies. Significant changes in the diet between the two study periods were noted.

Limitations

1) Most of the age-based sub-populations did not have a large representation making it difficult to make comparisons within and between populations. There were also significantly more females (69%) than males (31%).

2) The interviews were conducted in a cross-cultural setting and it may have been possible that participants were reluctant to answer truthfully. Cultural etiquette also prohibited certain questions from being asked (such as the incidence of HIV).

3) Although the two seasons studied were representative of the extremes in conditions, it would have been interesting to collect the data throughout a complete 12-month period and perhaps even including two lean seasons on either side of a plentiful seasons.

4) It was not possible to collect biochemical data that would have aided in a more complete diagnosis of vitamin and mineral deficiencies.

5) Since this culture consumes its meals from a “common pot” with ingredients added throughout the day as needed, it was not possible to use a 24-hour recall in collecting dietary information. A food frequency questionnaire was used instead of a 24-hour recall and although this instrument provided interesting information
concerning the frequency of foods consumed, it, by nature, was not able to provide information concerning energy and nutrient intakes.

Statistical analysis

Statistical analyses of the data were performed by Mr. Eric Reinhardt, Division of Computing Services, University of North Florida. SAS Version 8.0 was used in the analyses. Correlations between each of the variables were calculated using Pearson’s Correlation Coefficient. A chi square test was performed to test for difference based on gender, age group and season. The General Linear Model or GLM was the analysis of variance test used in this study to determine the relationship between variables while controlling for gender, season, age group and the combined effect of gender and season. The significance level was set at p<0.05.
RESULTS

Population statistics

The total population in this study consisted of 100 participants. Each participant was interviewed twice. The population was made up of 31 males and 69 females. The participants came from 21 different households. There were seven sub-populations: neonates and infants (n=6), toddlers (n=4), preschoolers (n=8), prepubescents (n=13), adolescents (n=10), adults (n=51) and older adults (n=8). Table 1 shows the breakdowns of each sub-population by gender.

Of the adult participants, 15.3% were single, 63.6% were married, 2.5% were separated and 18.6% were widowed. Of married men, 16 had one wife, two had two wives and two had three wives. The majority of the population (66.2%) had no formal schooling. Another 19.5% had some primary education, 13% had completed primary and 1.3% had some secondary education. Among school-aged children, 33.3% did not attend school.

Weight and height

The mean weight was 36.4 kilograms for all female populations and 40.3 kg for all male populations (F=[4,195] 5.51, p=.02). The mean weight for the entire population during the lean season was 37.0 kg compared to 39.7 kg in the plentiful season (F=[4,195] 2.59, p=.11). Table 2 and Table 3 detail the mean weights for each gender by season.
Table 1
Sample population divided into age groups and genders

<table>
<thead>
<tr>
<th>Sub-population</th>
<th>Females</th>
<th>Males</th>
<th>Total for sub-population</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neonates and infants (birth to 12 months)</td>
<td>3</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>Toddlers (12 to 36 months)</td>
<td>2</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Preschoolers (37 to 59 months)</td>
<td>5</td>
<td>3</td>
<td>8</td>
</tr>
<tr>
<td>Prepubescents (5 to 10 years for females and 5 to 11½ years for males)</td>
<td>6</td>
<td>7</td>
<td>13</td>
</tr>
<tr>
<td>Adolescents (11 to 16 years for females and 11½ to 17 years for males)</td>
<td>6</td>
<td>4</td>
<td>10</td>
</tr>
<tr>
<td>Adults (17 to 59 years for females and 18 to 59 years for males)</td>
<td>42</td>
<td>9</td>
<td>51</td>
</tr>
<tr>
<td>Older adults (over 60 years)</td>
<td>5</td>
<td>3</td>
<td>8</td>
</tr>
<tr>
<td><strong>Total:</strong></td>
<td>69</td>
<td>31</td>
<td>100</td>
</tr>
</tbody>
</table>
Table 2
Mean weights of females in sample population by season and age group
Weights are in kilograms

<table>
<thead>
<tr>
<th>Sub-population</th>
<th>Lean season</th>
<th>Standard deviation</th>
<th>Plentiful season</th>
<th>Standard deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neonates and infants (birth to 12 months)</td>
<td>5.9</td>
<td>2.1</td>
<td>9.2</td>
<td>1.0</td>
</tr>
<tr>
<td>Toddlers (12 to 36 months)</td>
<td>9.5</td>
<td>2.5</td>
<td>9.8</td>
<td>1.8</td>
</tr>
<tr>
<td>Preschoolers (37 to 59 months)</td>
<td>12.4</td>
<td>1.1</td>
<td>13.8</td>
<td>1.1</td>
</tr>
<tr>
<td>Prepubescents (5 to 10 years for females and 5 to 11½ years for males)</td>
<td>15.8</td>
<td>4.1</td>
<td>16.3</td>
<td>2.2</td>
</tr>
<tr>
<td>Adolescents (11 to 16 years for females and 11½ to 17 years for males)</td>
<td>27.2</td>
<td>11.2</td>
<td>31.5</td>
<td>9.3</td>
</tr>
<tr>
<td>Adults (17 to 59 years for females and 18 to 59 years for males)</td>
<td>47.4</td>
<td>8.4</td>
<td>51.7</td>
<td>6.8</td>
</tr>
<tr>
<td>Older adults (over 60 years)</td>
<td>42.4</td>
<td>6.5</td>
<td>45.8</td>
<td>2.7</td>
</tr>
</tbody>
</table>

Table 3
Mean weights of males in sample population by season and age group
Weights are in kilograms

<table>
<thead>
<tr>
<th>Sub-population</th>
<th>Lean season</th>
<th>Standard deviation</th>
<th>Plentiful season</th>
<th>Standard deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neonates and infants (birth to 12 months)</td>
<td>6.3</td>
<td>0.8</td>
<td>8.3</td>
<td>1.2</td>
</tr>
<tr>
<td>Toddlers (12 to 36 months)</td>
<td>9.6</td>
<td>0.8</td>
<td>10.3</td>
<td>1.8</td>
</tr>
<tr>
<td>Preschoolers (37 to 59 months)</td>
<td>12.7</td>
<td>2.1</td>
<td>15.7</td>
<td>2.9</td>
</tr>
<tr>
<td>Prepubescents (5 to 10 years for females and 5 to 11½ years for males)</td>
<td>16.9</td>
<td>6.4</td>
<td>19.1</td>
<td>3.5</td>
</tr>
<tr>
<td>Adolescents (11 to 16 years for females and 11½ to 17 years for males)</td>
<td>39.8</td>
<td>18.2</td>
<td>37.8</td>
<td>13.5</td>
</tr>
<tr>
<td>Adults (17 to 59 years for females and 18 to 59 years for males)</td>
<td>61.4</td>
<td>14.8</td>
<td>62.8</td>
<td>14.3</td>
</tr>
<tr>
<td>Older adults (over 60 years)</td>
<td>49.7</td>
<td>3.5</td>
<td>55.0</td>
<td>1.0</td>
</tr>
</tbody>
</table>

F=(4,195) 5.51, p=.02 for gender differences and F=(4,195) 2.59, p=.11 for seasonal differences (combined populations).
The mean height for all female populations was 138.2 cm and 144.4 cm for all male populations \((F=[4,195] 12.96, p=.0004)\). The average height of the entire population only varied by 1.4 cm between the two seasons \((F=[4,195] .69, p=.41)\).

**Weight-for-age**

The body weight for each child participant was divided by the body weight of the median child of the reference population (from the 2000 Centers for Disease Control-CDC- weight-for-age growth chart) to obtain a percent of median body weight-for-age. The percent of median body weight-for-age was not dependent on gender \((F=[4,77] 1.99, p=.16)\) or season \((F=[4,77] 2.70, p=.10)\). There were significant differences in percent of median body weight-for-age when age group was considered \((F=[4,77] 16.65, p=.0001)\) with higher percentages among the younger age groups \((r=-.41, p=.0001)\).

**Weight-for-age risk**

The percent of median body weight-for-age for each child was categorized into three risk levels. A percent of median greater than 80% was assigned to the “no risk” category. Sixty percent to 79% was categorized as “mild risk” and less than 60% as severe risk for malnutrition. There were no statistical differences in weight-for-age risk when gender alone (chi square = .30, \(p=.86, \text{df}=2\)) and age group alone (chi square = 12.79, \(p=.12, \text{df}=8\)) were considered. Season alone (chi square = 5.78, \(p=.06, \text{df}=2\)) was the only factor to approach statistical significance concerning differences in weight-for-age risk. **Figure 1** shows the classifications of weight-for-age risk by season.
Figure 1
Weight-for-age risk by season
Determined by the percent of median body weight-for-age*
(Totals for both genders)

* The child's body weight was divided by the body weight of the median child of the reference population (2000 CDC growth chart median) to obtain a percent of median for body weight-for-age.
Weight-for-height

The body weight for each child was plotted on a 2000 CDC weight-for-height chart. The weight-for-height percentile from the growth chart showed statistically significant differences when divided by age group (chi square = 40.34, p=.02, df=24) with prepubescent children having a tendency toward the lower percentiles. Table 4 shows the breakdown of weight-for-height percentile for each age group.

The child’s body weight was divided by the body weight of the median child of the reference population to obtain a percent of median body weight-for-height. There were statistically significant differences in percent of median body weight-for-height in each season (F=[4,51] 8.56, p=.005) but not gender (F=[4,51] 1.70, p=.20). The mean percent of median body weight-for-height was 85.2% for the lean season and 94.6% for the plentiful season.

Wasting

The degree of wasting was determined from the percent of median weight-for-height. A percent of median weight-for-height of 90% to 110% was categorized as “normal”. Eighty percent to 89% was assigned to the mild wasting category, 70% to 79% to the moderate wasting category and less than 79% to the severe wasting category. Gender alone (chi square = 4.37, p=.22, df=3), season alone (chi square = 5.54, p=.14, df=3) and age group alone (chi square = 10.83, p=.29, df=9) did not show statistically significant differences in risk of wasting. The effect of gender on wasting, however, did approach statistical significance when the following variables were considered: birth order (F=[5,50] 3.11, p=.08), number of children birthed to the child’s
Table 4
Sample population by age group and growth percentile
Percentiles taken from the 2000 CDC weight-for-height chart

<table>
<thead>
<tr>
<th>Subpopulation</th>
<th>3&lt;sup&gt;rd&lt;/sup&gt;</th>
<th>5&lt;sup&gt;th&lt;/sup&gt;</th>
<th>10th</th>
<th>25th</th>
<th>50&lt;sup&gt;th&lt;/sup&gt;</th>
<th>75&lt;sup&gt;th&lt;/sup&gt;</th>
<th>90&lt;sup&gt;th&lt;/sup&gt;</th>
<th>95&lt;sup&gt;th&lt;/sup&gt;</th>
<th>97&lt;sup&gt;th&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neonates and infants</td>
<td>25% (n=3)</td>
<td>8.3% (n=1)</td>
<td>16.7% (n=2)</td>
<td>8.3% (n=1)</td>
<td>0% (n=0)</td>
<td>16.7% (n=2)</td>
<td>8.3% (n=1)</td>
<td>16.7% (n=2)</td>
<td>0% (n=0)</td>
</tr>
<tr>
<td>Toddlers</td>
<td>37.5% (n=3)</td>
<td>0% (n=0)</td>
<td>12.5% (n=1)</td>
<td>0% (n=0)</td>
<td>25% (n=2)</td>
<td>12.5% (n=1)</td>
<td>12.5% (n=1)</td>
<td>0% (n=0)</td>
<td>0% (n=0)</td>
</tr>
<tr>
<td>Preschoolers</td>
<td>25% (n=4)</td>
<td>31.25% (n=5)</td>
<td>6.25% (n=1)</td>
<td>0% (n=0)</td>
<td>25% (n=4)</td>
<td>6.25% (n=1)</td>
<td>0% (n=0)</td>
<td>0% (n=0)</td>
<td>6.25% (n=1)</td>
</tr>
<tr>
<td>Prepubescents</td>
<td>60% (n=12)</td>
<td>0% (n=0)</td>
<td>10% (n=2)</td>
<td>20% (n=4)</td>
<td>0% (n=0)</td>
<td>5% (n=1)</td>
<td>0% (n=0)</td>
<td>0% (n=0)</td>
<td>5% (n=1)</td>
</tr>
</tbody>
</table>

Chi square = 40.34, p=.02, df=24
mother ($F=[5,50] 3.02, p=.09$), number of adults on the compound ($F=[5,50] 2.97$, $p=.09$), paternal educational level ($F=[5,50] 2.97, p=.09$) and the number of child deaths for the mother ($F=[5,50] 2.98, p=.09$). When these variables were considered, females had a lower risk of wasting than males.

Of all children participating, 44.6% presented no risk for wasting and 33.9% presented only with a mild risk for wasting. The remaining 21.5% were divided between the moderate risk category (16.1%) and severe wasting category (5.4%).

**Height-for-age**

The height of each child was plotted on a 2000 CDC height-for-age growth chart. All of the children were at or below the 50th percentile for both seasons. Height-for-age did not differ significantly in either season (chi square = 2.67, $p=.61$, df=4) or between age groups (chi square = 15.45, $p=.49$, df=16) on height-for-age. Gender (chi square = 15.02, $p=.005$, df=4) produced statistically significant differences in height-for-age with males more likely to be short for their age. **Figure 2** shows the percentages of males and females in each of the percentile categories.

The relationship between nursing status and height-for-age percentile approached statistical significance with nursed infants and toddlers being in greater height-for-age percentiles than non-nursed infants and toddlers ($r=.40$, $p=.08$). Height-for-age was also correlated with the number of children under the age of five on the compound ($r = -.26$, $p=.02$). The fewer the children under the age of five on the compound, the higher the height-for-age percentile for the index child.
Figure 2
Height-for-age percentiles by gender
From the 2000 CDC height-for-age growth charts
(Totals for both seasons)

Chi square = 15.02, p=.005, df=4
n=82

Males (n=38)
Females (n=44)
Stunting

The child’s height was divided by the height of the median child of the reference population (from the 2000 CDC height-for-age growth chart) to obtain a percent of median height-for-age for the index child. The degree of stunting was determined from the percent of median height-for-age. A percent of median height-for-age between 95% and 105% was categorized as “normal”. Ninety percent to 94% was assigned to the mild stunting category, 85% to 89% to the moderate stunting category and less than 85% to the severe stunting category.

When examined alone, gender (chi square = 4.23, p=.24, df=3), season (chi square = .36, p=.95, df=3) and age group (chi square = 15.18, p=.23, df=12) did not show statistically significant differences in risk of stunting. Females, however, tended to be less stunted than males. The majority of children (52.4%) were not categorized as stunted. Another 39% were mildly stunted while only 4.9% and 3.7% were moderately or severely stunted (respectively).

Body Mass Index

Body mass index (BMI) differed based on the season (F=[4,177] 4.77, p=.03) but not gender (F=[4,177] .04, p=.83). Mean BMI for all sub-populations was 16.9 in the lean season and 17.9 in the plentiful season. Figure 3 shows the seasonal differences in each category of BMI classification. The classification of adults into different categories of under- and over-nutrition was not statistically related to age group (r=.10, p=.29). BMI classification did, however, differ significantly with season (chi square = 15.79, p=.008, df=5). BMI was negatively correlated with the number of live births per female
Figure 3
BMI classification by season
(Totals for both genders)

Chi square = 15.79, p=.008, df=5
n=113

*PEM=Protein Energy Malnutrition
BMI=Body Mass Index – weight (kg)/height (m)^2

<table>
<thead>
<tr>
<th>PEM 3</th>
<th>BMI below 16.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>PEM 2</td>
<td>BMI of 16.0 to 16.9</td>
</tr>
<tr>
<td>PEM 1</td>
<td>BMI of 17.0 to 18.4</td>
</tr>
<tr>
<td>Underweight</td>
<td>BMI of 18.5 to 19.9</td>
</tr>
<tr>
<td>Normal</td>
<td>BMI of 20.0 to 24.9</td>
</tr>
<tr>
<td>OBESITY</td>
<td>BMI 25.0 to 29.9</td>
</tr>
</tbody>
</table>
Women with fewer live births tended to have higher BMIs. Oil consumption (F=[5,107] 4.82, p=.03) was also significantly related to BMI with BMI increasing as the frequency of oil consumption increased.

**BMI-for-age**

BMI was also calculated for children and plotted on a 2000 CDC BMI-for-age growth chart. When examined alone, gender (chi square = 8.78, p=.36, df=8), season (chi square = 6.14, p=.63, df=8) and age group (chi square = 29.89, p=.19, df=24) revealed no significant differences in BMI-for-age. The number of children birthed to the child’s mother was correlated with BMI-for-age with children from smaller families having higher BMI-for-age percentiles (r = -.25, p=.05).

**Mid-upper arm circumference**

Mean mid-upper arm circumference (MUAC) was 215.4 mm for all female populations and 212.3 mm for all male populations (F=[4,182] .41, p=.52). The difference in mean MUAC between the lean and plentiful seasons was only 1 mm (F=[4,182] .04, p=.84). MUAC in adults differed statistically between the genders (F=[5,107] 6.52, p=.01) with males having a larger mean MUAC. MUAC remained gender specific when corrected for by the BMI class of the individual. This measure also differed significantly with the body mass index of the individual (F=[5,107] 8.93, p=.004); MUAC increased as BMI increased.
Head circumference

The head circumference of child participants under the age of three was divided by the head circumference of the median child of the reference population (from the 2000 CDC head circumference-for-age growth chart) to obtain a percent of median head circumference-for-age for the index child. This percentage approached statistical significance when gender was considered ($F=[4,15] 9.44, p=.08$) with females having a higher percent of median head circumference-for-age. This measure did not differ statistically when season ($F=[4,15] .04, p=.85$) or age group ($F=[4,15] 2.40, p=.14$) were considered.

Cardiovascular health

Systolic blood pressure

Systolic blood pressure was measured for all adults in the study. Mean systolic pressure for the adult population was 117 mm Hg. Mean systolic pressure was dependent on age group ($F=[4,113] 33.15, p<.0001$) with older adults having higher systolic pressures. The relationship between systolic pressure and age group remained constant when oil consumption ($F=[5,112] 33.67, p<.0001$) and type of oil consumed ($F=[5,112] 31.34, p<.0001$) were taken into consideration. Figure 4 shows the percentage of adults and older adults in each systolic blood pressure range.

Systolic pressure increased with increased beer ($F=[12,105] 1.98, p=.09$) and tobacco ($F=[12,105] 3.28, p=.07$) consumption, although this relationship was not statistically significant. Systolic pressure was also positively correlated with diastolic pressure ($r=.66, p<.0001$) and kola nut consumption ($r=.49, p<.0001$). Neither gender
Figure 4
Systolic blood pressure by age group
(Totals for both seasons and genders)

F=\[4,113\] 33.15, p<.0001
n=118
(chi square = 5.77, p=.12, df=3) nor season (chi square = .58, p=.90, df=3) produced statistically significant differences in systolic blood pressure range.

**Diastolic blood pressure**

Mean diastolic pressure for the entire adult population was 73.7 mm Hg. Diastolic pressure did not differ statistically between age groups (F=[4,113] 2.44, p=.12) but approached statistical significance when oil consumption was controlled for (F=[5,112] 2.84, p=.09). Beer consumption showed a positive statistical correlation with diastolic pressure (F=[12,105] 3.27, p=.009). There was also combined positive statistical correlation between beer and kola nut consumption and diastolic pressure (F=[12,105] 3.94, p=.01). Diastolic pressure increased with greater consumption of beer and kola nuts. Increased weight also approached statistical significance when correlated with an increase in diastolic blood pressure (r=.15, p=.10).

**Heart rate**

Resting heart rate was also measured for each adult participant. Mean heart rate for the entire adult population was 89.8 beats per minute. Differences in resting heart rate were statistically significant between the genders (F=[4,112] 10.02, p=.002) with females (mean = 91.6 bpm) having higher rates than males (mean = 82.9 bpm). This positive statistical correlation continued when oil consumption (F=[5,111] 9.93, p=.002) and type of oil consumed (F=[5,111] 11.73, p=.0009) were accounted for. **Figure 5** shows the percentage of males and females in each pulse range. The differences in pulse
Figure 5
Pulse range by gender
(Totals for both seasons)

Chi square = 8.20, p=.004, df=1
n=117

Males (n=24)
Females (n=93)
range (low, normal or high pulse) were statistically significant by gender (chi square = 8.20, p=.004, df=1) with females tending to have higher heart rates than males.

**Reproductive history**

The youngest age at first birth was 16 and the oldest age at first birth was 25 with the majority of women having their first child between the ages of 18 and 21. Four of the women in the study were pregnant and 22.3% were nursing. The average number of births per adult female was 3.7. The range was 0 to 11 with a standard deviation of 3.2. There was an average of 3.4 years between births with a minimum of 2 years and a maximum of 6 years (standard deviation is 1.1 years).

**Total number of live births**

The number of live births for a female did not differ statistically based on age at first birth (F=[2,71] .06, p=.81). Age group had a positive statistical correlation with the number of live births with females in the older age group having more children (F=[2,91] 27.47, p<.0001). The educational level of the female had a negative statistical correlation with the number of live births (F=[2,91] 11.79, p=.001). Women with a lower educational level birthed a greater number of children (r=-.34, p=.001). The total number of live births had an inverse relationship with BMI class that approached statistical significance (F=[5,83] 2.17, p=.07).
Total number of still births

Most of the women had not had any still births (87.2%). Another 10.6% had one still birth each and one woman had four still births. The differences in number of still births per female approached statistical significance when age at first birth ($F=[2,71] \, 2.99, \, p=.09$) was considered. Age group affected the number of still births with women in the older age group having significantly more still births per female ($F=[2,91] \, 10.96, \, p=.001$).

Total number of deceased children

The majority of women in the study, 57.5%, did not have any children die before the age of five. Nine women had one child to die before the age of five, five women had two deaths, three women had three deaths, one woman had 4 deaths, one had 6 deaths and one had 8 deaths.

The number of children who were deceased before the age of five did not differ statistically based on the mother’s age at first birth ($F=[2,71] \, 1.66, \, p=.20$). There was a statistically negative correlation between the educational level of the female and the number of deaths of children under the age of five ($F=[2,91] \, 4.12, \, p=.05$) with females with a lower educational level experiencing more deaths of their children younger than five ($r=-.21, \, p=.04$).

The majority of women did not have any children die after the age of five (93.6%). There were no statistically significant differences in the number of children deceased after the age of five when the mother’s age at first birth was considered ($F=[2,71] \, .61, \, p=.44$). It did, however, differ based on the age group of the mother, with
women in the older age group having more children die after the age of five ($F=2.91, 31.70, p<.0001$).

**General health**

**Bitot’s spots**

Forty-nine percent of the population did not show any symptoms of Bitot’s spots while 15.5% had them in either eye and 35.5% had them in both eyes. A chi square analysis showed a statistically positive correlation between Bitot’s spots and age group with the occurrence of Bitot’s spots increasing for each age group (chi square = 119.41, $p<.0001$, df=18). The relationship between gender and the incidence of Bitot’s spots approached statistical significance with females being more likely to show symptoms (chi square = 6.63, $p=.09$, df=3).

**Pale conjunctivae**

Most of the population did not have pale conjunctivae (75%). Eighteen percent had slightly pale conjunctivae and 7% were classified as having pale conjunctivae. The differences between the genders in the incidence of pale conjunctivae approached statistical significance with females more likely to show symptoms than males ($r=-.12$, $p=.08$). There was also a relationship between pale conjunctivae and age group (chi square = 22.77, $p=.03$, df=12) and pale conjunctivae and season (chi square = 6.69, $p=.04$, df=2). There were more cases of slightly pale and pale conjunctivae in the lean season than in the plentiful season. Toddlers were the most likely to show symptoms
followed by preschoolers, older adults and adults. Pale conjunctivae were not related to reported malaria status ($r = -0.04, p = 0.95$).

**Malaria**

Malaria affected a relatively large percentage of the population with 28.5% of the population reporting a case of malaria during the study period. The prevalence of malaria did not differ based on gender alone (chi square = 0.05, $p = 0.82$, df = 1) or age group alone (chi square = 7.82, $p = 0.25$, df = 6). Season alone, however, did show statistically significant differences in the prevalence of malaria (chi square = 23.58, $p < 0.0001$, df = 1) with higher reported prevalences during the lean season. Self-reported cases of malaria within the 30 days prior to data collection were not correlated with actual fever status ($r = 0.11$, $p = 0.12$).

**Incidence of diarrhea**

Nine percent of the population reported having diarrhea during the study period. A chi square analysis showed that the incidence of diarrhea did not differ between gender (chi square = 1.67, $p = 0.20$, df = 1) or season (chi square = 0.98, $p = 0.32$, df = 1). Age group, however, exhibited a statistically significant difference in the incidence of diarrhea (chi square = 23.73, $p = 0.001$, df = 6) with diarrhea being more common in the younger age groups (birth to 5 years).
Consumption of foods

Figure 6 shows the frequency of consumption of foods for each season. Corn was consumed more in the lean season than in the plentiful season (chi square = 153.36, p<.0001, df=5). Nuts were also consumed more frequently in the lean season (chi square = 13.86, p=.02, df=5). Oil consumption decreased in the plentiful season (chi square = 53.71, p<.0001, df=4).

There was a statistically positive correlation between age group and tobacco (r=.42, p<.0001), beer (r=.57, p<.0001) and kola nut (r=.36, p<.0001) consumption with those in the older adult age group having higher consumption rates.
Figure 6
Frequency of foods consumed in the lean/plentiful season
The rows contain each of the food items consumed by the sample population. The columns represent the frequency of consumption for each food item. The number to the left of the slash in each column represents the number of participants consuming the food item for the listed frequency during the pre-harvest season. The number to the right of the slash represents the post-harvest season.

<table>
<thead>
<tr>
<th>Frequency</th>
<th>NEVER</th>
<th>MONTHLY</th>
<th>WEEKLY</th>
<th>2-4 WEEK</th>
<th>5-6 WEEK</th>
<th>DAILY</th>
</tr>
</thead>
<tbody>
<tr>
<td>FRUITS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Banana</td>
<td>89/93</td>
<td>8/1</td>
<td>1/1</td>
<td>2/3</td>
<td>0/0</td>
<td>0/2</td>
</tr>
<tr>
<td>Fried plaintain</td>
<td>100/99</td>
<td>0/0</td>
<td>0/0</td>
<td>0/1</td>
<td>0/0</td>
<td>0/0</td>
</tr>
<tr>
<td>Orange/juice</td>
<td>90/91</td>
<td>10/5</td>
<td>0/3</td>
<td>0/1</td>
<td>0/0</td>
<td>0/0</td>
</tr>
<tr>
<td>Lemon/juice</td>
<td>94/89</td>
<td>6/1</td>
<td>0/0</td>
<td>0/10</td>
<td>0/0</td>
<td>0/0</td>
</tr>
<tr>
<td>Watermelon</td>
<td>100/84</td>
<td>0/1</td>
<td>0/5</td>
<td>0/10</td>
<td>0/0</td>
<td>0/0</td>
</tr>
<tr>
<td>Shea fruit</td>
<td>90/100</td>
<td>8/0</td>
<td>1/0</td>
<td>0/0</td>
<td>0/0</td>
<td>1/0</td>
</tr>
<tr>
<td>Baobab fruit</td>
<td>97/80</td>
<td>3/3</td>
<td>0/6</td>
<td>0/11</td>
<td>0/0</td>
<td>0/0</td>
</tr>
<tr>
<td>Powder from locust bean pods</td>
<td>81/76</td>
<td>5/5</td>
<td>0/0</td>
<td>10/19</td>
<td>0/0</td>
<td>4/0</td>
</tr>
<tr>
<td>Detar</td>
<td>97/97</td>
<td>3/3</td>
<td>0/0</td>
<td>0/0</td>
<td>0/0</td>
<td>0/0</td>
</tr>
<tr>
<td>Mango</td>
<td>88/98</td>
<td>10/2</td>
<td>0/0</td>
<td>2/0</td>
<td>0/0</td>
<td>0/0</td>
</tr>
<tr>
<td>Papaya</td>
<td>100/97</td>
<td>0/0</td>
<td>0/2</td>
<td>0/1</td>
<td>0/0</td>
<td>0/0</td>
</tr>
<tr>
<td>Guava</td>
<td>85/90</td>
<td>14/0</td>
<td>1/0</td>
<td>0/10</td>
<td>0/0</td>
<td>0/0</td>
</tr>
<tr>
<td>Tamarind juice</td>
<td>94/100</td>
<td>3/0</td>
<td>1/0</td>
<td>0/0</td>
<td>0/0</td>
<td>2/0</td>
</tr>
<tr>
<td>VEGETABLES</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tomatoes</td>
<td>24/22</td>
<td>1/1</td>
<td>15/9</td>
<td>28/47</td>
<td>0/1</td>
<td>32/20</td>
</tr>
<tr>
<td>Tomato sauce</td>
<td>96/91</td>
<td>3/2</td>
<td>0/0</td>
<td>1/6</td>
<td>0/0</td>
<td>0/1</td>
</tr>
<tr>
<td>Cabbage</td>
<td>95/58</td>
<td>4/3</td>
<td>0/12</td>
<td>0/27</td>
<td>0/0</td>
<td>1/0</td>
</tr>
<tr>
<td>Carrots</td>
<td>100/93</td>
<td>0/1</td>
<td>0/2</td>
<td>0/3</td>
<td>0/0</td>
<td>0/1</td>
</tr>
<tr>
<td>Corn</td>
<td>11/88</td>
<td>1/1</td>
<td>13/0</td>
<td>28/1</td>
<td>3/0</td>
<td>44/0</td>
</tr>
<tr>
<td>Beans or lentils</td>
<td>16/21</td>
<td>8/4</td>
<td>9/33</td>
<td>49/30</td>
<td>1/1</td>
<td>17/11</td>
</tr>
<tr>
<td>Pumpkin</td>
<td>99/99</td>
<td>0/0</td>
<td>0/0</td>
<td>1/0</td>
<td>0/0</td>
<td>0/1</td>
</tr>
<tr>
<td>Local eggplant (&quot;kumba&quot;)</td>
<td>40/95</td>
<td>24/4</td>
<td>9/0</td>
<td>17/1</td>
<td>0/0</td>
<td>10/0</td>
</tr>
<tr>
<td>Yams or sweet potatoes</td>
<td>84/86</td>
<td>8/0</td>
<td>2/11</td>
<td>6/3</td>
<td>0/0</td>
<td>0/0</td>
</tr>
<tr>
<td>Spinach</td>
<td>98/95</td>
<td>0/4</td>
<td>0/0</td>
<td>1/0</td>
<td>0/0</td>
<td>1/1</td>
</tr>
<tr>
<td>Lettuce</td>
<td>100/98</td>
<td>0/1</td>
<td>0/1</td>
<td>0/0</td>
<td>0/0</td>
<td>0/0</td>
</tr>
<tr>
<td>Leaves, fresh</td>
<td>30/84</td>
<td>12/1</td>
<td>16/13</td>
<td>31/2</td>
<td>0/0</td>
<td>11/0</td>
</tr>
<tr>
<td>Leaves, dried</td>
<td>26/17</td>
<td>9/7</td>
<td>11/4</td>
<td>39/49</td>
<td>4/0</td>
<td>11/23</td>
</tr>
<tr>
<td>Okra, dried or fresh</td>
<td>11/7</td>
<td>0/0</td>
<td>0/0</td>
<td>13/13</td>
<td>5/0</td>
<td>71/80</td>
</tr>
</tbody>
</table>
**Figure 6 continued**

<table>
<thead>
<tr>
<th>Frequency →</th>
<th>N U M B E R</th>
<th>M O N T H L Y</th>
<th>W E E K L Y</th>
<th>2-4 W E E K</th>
<th>5-6 W E E K</th>
<th>D A Y L Y</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>EGGS, MEATS, ETC</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eggs</td>
<td>95/99</td>
<td>3/1</td>
<td>1/0</td>
<td>1/0</td>
<td>0/0</td>
<td>0/0</td>
</tr>
<tr>
<td>Chicken or guinea</td>
<td>93/92</td>
<td>5/2</td>
<td>0/4</td>
<td>1/2</td>
<td>0/0</td>
<td>1/0</td>
</tr>
<tr>
<td>Liver</td>
<td>100/98</td>
<td>0/0</td>
<td>0/2</td>
<td>0/0</td>
<td>0/0</td>
<td>0/0</td>
</tr>
<tr>
<td>Beef, pork, lamb, goat</td>
<td>61/67</td>
<td>20/17</td>
<td>6/2</td>
<td>13/14</td>
<td>0/0</td>
<td>0/0</td>
</tr>
<tr>
<td>Fish</td>
<td>11/7</td>
<td>0/2</td>
<td>1/1</td>
<td>20/6</td>
<td>0/4</td>
<td>68/80</td>
</tr>
<tr>
<td>Dog</td>
<td>98/100</td>
<td>2/0</td>
<td>0/0</td>
<td>0/0</td>
<td>0/0</td>
<td>0/0</td>
</tr>
<tr>
<td><strong>BREADS, CEREALS, STARCHES</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&quot;Beere&quot; (breakfast &quot;mush&quot; from millet, corn, rice or fonio)</td>
<td>74/59</td>
<td>13/5</td>
<td>8/5</td>
<td>4/13</td>
<td>0/0</td>
<td>1/18</td>
</tr>
<tr>
<td>&quot;Sagbo&quot; (Staple - can be made from corn, white sorghum, red sorghum in time of famine or millet.)</td>
<td>10/7</td>
<td>0/0</td>
<td>0/0</td>
<td>1/1</td>
<td>0/0</td>
<td>89/92</td>
</tr>
<tr>
<td>&quot;Fura&quot; (made from &quot;petit mil&quot;). Thicker than &quot;sagbo&quot; and is spicy. Can be eaten plain or mixed with flour, milk and sugar.</td>
<td>99/98</td>
<td>1/0</td>
<td>0/2</td>
<td>0/0</td>
<td>0/0</td>
<td>0/0</td>
</tr>
<tr>
<td>&quot;Zom kom&quot; (beverage made from millet)</td>
<td>66/66</td>
<td>17/9</td>
<td>5/9</td>
<td>12/12</td>
<td>0/0</td>
<td>0/4</td>
</tr>
<tr>
<td>Bean paste or leaf paste</td>
<td>31/27</td>
<td>16/11</td>
<td>29/24</td>
<td>19/28</td>
<td>0/0</td>
<td>5/10</td>
</tr>
<tr>
<td>&quot;Babenda&quot;</td>
<td>29/73</td>
<td>17/7</td>
<td>30/3</td>
<td>20/17</td>
<td>0/0</td>
<td>4/0</td>
</tr>
<tr>
<td>&quot;Samsa&quot; (fried) (made from bean flour)</td>
<td>73/65</td>
<td>14/14</td>
<td>2/14</td>
<td>11/6</td>
<td>0/0</td>
<td>0/1</td>
</tr>
<tr>
<td>&quot;Massa&quot; (fried) (pancake made from millet flour)</td>
<td>96/89</td>
<td>1/2</td>
<td>0/8</td>
<td>3/1</td>
<td>0/0</td>
<td>0/0</td>
</tr>
<tr>
<td>&quot;Buri massa&quot; (fried) (made from wheat flour)</td>
<td>79/86</td>
<td>12/6</td>
<td>3/1</td>
<td>5/7</td>
<td>0/0</td>
<td>1/0</td>
</tr>
<tr>
<td>Bread</td>
<td>52/56</td>
<td>10/14</td>
<td>18/5</td>
<td>19/21</td>
<td>0/1</td>
<td>1/3</td>
</tr>
<tr>
<td>White rice</td>
<td>28/17</td>
<td>11/13</td>
<td>21/20</td>
<td>30/40</td>
<td>0/1</td>
<td>10/9</td>
</tr>
<tr>
<td>Pasta (spaghetti, macaroni)</td>
<td>88/78</td>
<td>4/9</td>
<td>3/3</td>
<td>1/5</td>
<td>0/0</td>
<td>4/5</td>
</tr>
<tr>
<td>Couscous</td>
<td>97/97</td>
<td>1/0</td>
<td>1/1</td>
<td>1/2</td>
<td>0/0</td>
<td>0/0</td>
</tr>
<tr>
<td>&quot;Dége&quot; (snack made from yogourt and couscous)</td>
<td>99/100</td>
<td>0/0</td>
<td>1/0</td>
<td>0/0</td>
<td>0/0</td>
<td>0/0</td>
</tr>
<tr>
<td>Igname</td>
<td>94/89</td>
<td>3/1</td>
<td>1/3</td>
<td>1/3</td>
<td>1/0</td>
<td>0/4</td>
</tr>
<tr>
<td>Cassava</td>
<td>94/100</td>
<td>3/0</td>
<td>2/0</td>
<td>1/0</td>
<td>0/0</td>
<td>0/0</td>
</tr>
</tbody>
</table>
**Figure 6 continued**

<table>
<thead>
<tr>
<th><strong>BEVERAGES</strong></th>
<th><strong>BEVERAGES</strong></th>
<th><strong>BEVERAGES</strong></th>
<th><strong>BEVERAGES</strong></th>
<th><strong>BEVERAGES</strong></th>
<th><strong>BEVERAGES</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Coke, Fanta, Sprite, Bullvit (seltzer water)</td>
<td>96/99</td>
<td>4/0</td>
<td>0/1</td>
<td>0/0</td>
<td>0/0</td>
</tr>
<tr>
<td>Bissap (made from the hibiscus flower)</td>
<td>93/90</td>
<td>4/0</td>
<td>1/1</td>
<td>1/8</td>
<td>0/0</td>
</tr>
<tr>
<td>Milk</td>
<td>91/92</td>
<td>2/0</td>
<td>3/1</td>
<td>4/6</td>
<td>0/0</td>
</tr>
<tr>
<td>Coffee</td>
<td>98/97</td>
<td>1/0</td>
<td>0/0</td>
<td>1/2</td>
<td>0/0</td>
</tr>
<tr>
<td>Homemade beer</td>
<td>57/54</td>
<td>10/4</td>
<td>7/2</td>
<td>9/17</td>
<td>0/1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>SWEETS, BAKED GOODS, MISC</strong></th>
<th><strong>SWEETS, BAKED GOODS, MISC</strong></th>
<th><strong>SWEETS, BAKED GOODS, MISC</strong></th>
<th><strong>SWEETS, BAKED GOODS, MISC</strong></th>
<th><strong>SWEETS, BAKED GOODS, MISC</strong></th>
<th><strong>SWEETS, BAKED GOODS, MISC</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Candies/chewing gum</td>
<td>79/72</td>
<td>2/2</td>
<td>3/7</td>
<td>13/19</td>
<td>1/0</td>
</tr>
<tr>
<td>Cookies</td>
<td>80/78</td>
<td>2/0</td>
<td>2/2</td>
<td>11/18</td>
<td>2/0</td>
</tr>
<tr>
<td>Cake</td>
<td>87/72</td>
<td>2/3</td>
<td>0/4</td>
<td>3/14</td>
<td>0/0</td>
</tr>
<tr>
<td>Honey</td>
<td>97/100</td>
<td>1/0</td>
<td>0/0</td>
<td>1/0</td>
<td>1/0</td>
</tr>
<tr>
<td>Peanut butter</td>
<td>41/40</td>
<td>6/9</td>
<td>16/12</td>
<td>30/35</td>
<td>1/0</td>
</tr>
<tr>
<td>Peanut butter rings (&quot;kula kula&quot;)</td>
<td>59/58</td>
<td>12/0</td>
<td>9/17</td>
<td>15/24</td>
<td>1/0</td>
</tr>
<tr>
<td>Nuts</td>
<td>21/37</td>
<td>3/1</td>
<td>14/14</td>
<td>27/32</td>
<td>6/1</td>
</tr>
<tr>
<td>Kola nuts</td>
<td>84/84</td>
<td>1/0</td>
<td>0/0</td>
<td>1/1</td>
<td>0/0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>SAUCE INGREDIENTS</strong></th>
<th><strong>SAUCE INGREDIENTS</strong></th>
<th><strong>SAUCE INGREDIENTS</strong></th>
<th><strong>SAUCE INGREDIENTS</strong></th>
<th><strong>SAUCE INGREDIENTS</strong></th>
<th><strong>SAUCE INGREDIENTS</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Soumbala (&quot;kolgo&quot;) (pungent black ball made from fermented locust bean seeds)</td>
<td>10/7</td>
<td>0/0</td>
<td>0/1</td>
<td>5/6</td>
<td>0/0</td>
</tr>
<tr>
<td>Zem and Zem Moaga (pot ash)</td>
<td>11/7</td>
<td>0/0</td>
<td>0/0</td>
<td>0/0</td>
<td>0/0</td>
</tr>
<tr>
<td>&quot;Rabile&quot; (Brewer’s yeast)</td>
<td>15/7</td>
<td>0/0</td>
<td>0/0</td>
<td>0/1</td>
<td>0/0</td>
</tr>
<tr>
<td>Salt</td>
<td>10/7</td>
<td>0/0</td>
<td>0/0</td>
<td>0/0</td>
<td>0/0</td>
</tr>
<tr>
<td>Hot pepper</td>
<td>32/45</td>
<td>1/0</td>
<td>2/0</td>
<td>11/2</td>
<td>3/0</td>
</tr>
<tr>
<td>Oil</td>
<td>11/35</td>
<td>2/2</td>
<td>0/0</td>
<td>7/33</td>
<td>5/0</td>
</tr>
<tr>
<td>Meat</td>
<td>62/37</td>
<td>20/8</td>
<td>5/29</td>
<td>12/24</td>
<td>0/0</td>
</tr>
<tr>
<td>Onion</td>
<td>69/32</td>
<td>4/1</td>
<td>2/3</td>
<td>8/9</td>
<td>0/0</td>
</tr>
<tr>
<td>Garlic</td>
<td>81/91</td>
<td>4/1</td>
<td>0/0</td>
<td>7/6</td>
<td>0/0</td>
</tr>
<tr>
<td>Tomato</td>
<td>31/17</td>
<td>2/1</td>
<td>10/13</td>
<td>24/15</td>
<td>0/0</td>
</tr>
</tbody>
</table>
ACCEPTANCE OF HYPOTHESES

**H1)** The prevalence of protein energy malnutrition in rural Mossi adults and wasting in rural Mossi children will be higher than that of persons in the United States.

The mean body mass index for all adults in the study population for both seasons was 19.1. If this BMI represents the median adult in the population, then the “normal” Mossi adult would have a BMI that falls in the underweight category. Based on unpublished NHANES III data, the average height for an American male is 69.1 inches with an average weight of 180 pounds (64). The average American male would therefore have a BMI of 27.0. For American women, the average height is 63.7 inches with an average weight of 152 pounds (64). Based on this height and weight, the body mass index of the average American female would be 26.0. These mean BMIs would place the average adult American male and female in the slightly obese category. Although the data appear to support this hypothesis, it cannot be accepted without statistical analysis.

Seventy percent of all children were below the 50th percentile of weight-for-height on the 2000 CDC growth charts, 39.3% of the same population were at or below the 3rd percentile. Therefore the sample population of children in this study were significantly lighter for their height than the average American child of the same age. Although the data appear to support this hypothesis, it cannot be accepted without statistical analysis.
H2) The prevalence of protein energy malnutrition in rural Mossi adults and wasting in rural Mossi children will decrease during the post-harvest season as compared with the pre-harvest season.

The body mass index for adults differed statistically between the seasons, with higher BMIs in the plentiful season ("post-harvest") (F=[4,177] 4.77, p=.03). The hypothesis is ACCEPTED for adults.

The percent of median body weight-for-height, an indicator of wasting status in children, also differed statistically between seasons (F=[4,51] 8.56, p=.005). The plentiful season showed a higher mean percent of median body weight-for-height. The hypothesis is ACCEPTED for children.

H3) The prevalence of protein energy malnutrition in rural Mossi adults and wasting in rural Mossi children will be greater in females than in males.

Body mass index in adults did not differ statistically based on gender (F=[4,177] .04, p=.83). The hypothesis is REJECTED for adults. Wasting status in children did not differ statistically based on gender alone (chi square = 4.37, p=.22, df=3). When other factors were controlled for, differences in wasting status between the genders approached statistical significance, with females being less likely to be wasted. The hypothesis is also REJECTED for children.
H4) The prevalence of protein energy malnutrition in rural Mossi will be greater in older adults than in adults under the age of 60. The prevalence of wasting in rural Mossi children will be greater in the under-five population than in other sub-populations of children.

Body mass index classification in adults did not differ statistically based on age group (r=.10, p=.29). The hypothesis is REJECTED for adults. Weight-for-height percentile in children did differ statistically between the age groups (chi square = 40.34, p=.02, df=24); however, the prevalence of low percentiles was greater in the prepubescent age group than in the under-five population. Therefore, the hypothesis is REJECTED for children.
DISCUSSION

Synopsis of findings

The results of this study indicate that this rural population of Mossi people is less well-nourished than their American counterpart and that their nutritional status depends on season and not gender or age group.

Population

Although there are no population statistics available for the Mossi ethnic group, females in Burkina Faso as a whole slightly outnumber males. Forty-seven percent of the population is under the age of 15. There was an over-representation of females in the study population and some of the sub-populations had a relatively small number of participants. Although the study population did not represent the entire Burkinabé population, it did represent the village of Songnkom where the study was undertaken. Many young men have migrated to the capital to look for work while the young women have moved to the village of their spouse. Married men do not tend to stay in the village during the daytime and were therefore unavailable for study. Since this study was conducted with a “convenience sample”, the villagers that were the most accessible were the married women, widows, the elderly and children. The outcome of the study might have been affected had the study population more closely represented the overall population of Burkina Faso.
Protein Energy Malnutrition

Protein energy malnutrition, or PEM, is commonly referred to simply as "malnutrition". In adults, the body mass index (BMI) is used to classify individuals into different categories of under- and over-nutrition. Adults in this study (both genders and seasons) had an average BMI of 19.1 which would classify the adult population as "underweight" as a whole. The lowest adult BMI was 12.9 and the highest was 27.8. Of the adult population, 2.7% were slightly obese, 30.1% were "normal", 30.1% were classified as underweight, 16.8% as grade 1 PEM, 11.5% as grade 2 PEM and 8.8% as grade 3 PEM. These findings are similar to those of Ferro-Luzzi et al. in Ethiopia where women had an average BMI of 19.0 and 16% of all the women were classifiable as second or third degree PEM based on their BMI (38).

Body mass index for this population differed statistically based on season but not gender. The population showed a higher BMI during the post-harvest season than during the pre-harvest season. There is a greater availability of nutrients in the plentiful season but there is also a lessened workload. All of the cultivating and harvesting of food for the year is done during the lean season. The combination of increased food consumption and decreased activity is the most likely explanation for the increase in BMI in the post-harvest season for this population. In Ethiopia, Ferro-Luzzi et al. found lower weights during the lean season than before the harvest. The observed changes in body weight seen by Ferro-Luzzi confirmed the existence of a disturbance in the energy balance of the community brought about by depletion of domestic food availability and possibly aggravated by a simultaneous increase in energy expenditure (38).
There are three main defense mechanisms for dealing with a decrease in food availability: 1) decreased physical activity, 2) reduction in basal metabolic rate and 3) loss of weight leading to a decrease in body mass index. There was no evidence that women in the study population decreased their physical activity during the pre-harvest season. It was not possible to study the basal metabolic rate of this population, but Schutlink et al. did not find a significant seasonal change in basal metabolic rate in women in Benin (a country to the south of Burkina Faso) (51). The most likely coping strategy for the reduction in food availability in the study population was a loss of weight. There was as much as a 15 kilogram weight change between the pre- and post-harvest seasons in some women, while other women experienced no improvement during the post-harvest season. One possible explanation is that the poorer, leaner women live a marginally hungry existence year round.

Although body mass index was not age group specific or gender specific, older adult females had the lowest mean BMI during the lean season (16.8), followed by older adult males (18.2), adult females (18.3) and adult males (20.1). During the plentiful season, the mean BMI for older adult females increased to 18.2, followed by adult females (20.0), older adult males (20.2) and adult males (20.6).

Body mass index in adults and older adults was also related to oil consumption (p=.0303). Higher BMIs were correlated with an increased frequency of oil consumption. This, of course, is not an unusual finding. Oil consumption, however, was also affected by season (chi square = 53.71, p<.0001, df=4) with greater oil consumption occurring during the pre-harvest season. At first it would appear that perhaps more oil was consumed in the lean season as a way to ensure greater caloric intake but the most
likely explanation for change in oil consumption patterns between seasons is that the oil
of preference is a home-made “butter” made from the oil of the shea nut. The shea nut is
available during the pre-harvest season, but not the post-harvest season. Therefore, the
relationship between oil consumption and body mass index is also a seasonal
relationship.

In children, three indices are often used to determine malnutrition: weight-for-age,
weight-for-height and height-for-age. Risk levels for malnutrition are determined by
comparing the index child to a reference population. In this study, the 2000 Centers for
Disease Control growth charts were used. The practice of using American references to
study populations from the developing world has been debated. Undoubtedly, the best
solution would be to use reference data from the target population, but, most often, these
data are not available. In that case, the American standards are the ones most commonly
accepted. There were no standards available for the Mossi people group nor for any other
closely related ethnic group in Burkina Faso; therefore, the American reference data were
used in this study.

Weight-for-age is a good indicator for malnutrition among children under the age
of three, but after that age it becomes less specific. This is due in large part because the
body of a growing child compensates for lack of protein and energy intake by slowing
down longitudinal growth. In other words, the child becomes stunted. A large
percentage of children in this study showed either no risk (42.7%) or mild risk (47.6%) of
malnutrition based on weight-for-age. Only 9.8% of the children showed severe risk for
malnutrition based on this index. Season approached statistical significance on this
measure (chi square = 5.79 p=.06, df=2) with there being a larger percentage of low
weight-for-age values in the lean season. This is logical due to the greater availability of food in the plentiful season as well as a reduction in individual work load.

Weight-for-height is an indication of current malnutrition, or wasting. Anderson concluded that this measure is the single best indicator of current malnutrition in children over the age of one (14). Just over one-third of the child population in this study was under the 3rd percentile for weight-for-height and 70% were below the 50th percentile. To determine wasting status from weight-for-height, the body weight for each child was divided by the body weight of the median child in the reference population from the growth chart. The mean percent of median body weight-for-height in the lean season was 85.2% indicating that the average child was mildly wasted in the lean season. The mean percent of median body weight-for-height for the plentiful season rose to 94.6% indicating that the population was “normal” in regards to wasting status during this season. Again, the change in wasting status was expected between seasons with an increase in food availability and a decrease in work load during the plentiful season.

Although gender alone did not have a statistically significant effect on differences in wasting status, it did play a slight but not statistically significant role when several other factors were considered. When birth order, number of children birthed to the mother, number of adults on the compound, paternal education and the number of child deaths for the mother were controlled for, females were less likely to be wasted than males. Although this is contrary to the hypothesis of the study, it can be explained. Female children in the Mossi culture, although they have a higher workload than male children, are possibly taken better care of in order to assure a higher bride price in the future. Once the female is married, this respect for the female gender is lessened.
Anderson also found a lessening of the gender differential in his study of five developing countries with there being little difference in weight-for-height between male and female children (14).

The weight-for-height percentile on the growth chart differed statistically based on age group with prepubescent children having significantly lower percentiles than other sub-populations of children (chi square = 40.34, p=.02, df=24). This was contrary to the hypothesis that the under-five populations would have lower percentiles. The contrary effect of age on this index could be due in part to the pre-teen changes in the prepubescent child in addition to the greater expectations for a child of this age to perform more household duties such as farming which would increase their caloric expenditures. Children in this age group also start attending school. In the case of the sample population, this was a walk of several miles that increased energy expenditure.

Height-for-age is an indicator of past malnutrition, or stunting. Stunting is a "defense mechanism" of the body to cope with a lack of adequate intake of protein and calories. The relationship between height-for-age and stunting is like that of weight-for-height and wasting. To determine the level of stunting, the height of the index child was divided by the height of the median child in the reference population from the growth chart. This percent of median height-for-age was then used to determine the degree of stunting. In this study, 52.4% of the children were of normal height for their age. Another 39% were only mildly stunted while 4.9% were moderately stunted and 3.7% were severely stunted. This is similar to estimates that 43% of under-five year olds in developing countries are stunted (12). Season, age group and gender did not have statistically significant effects on differences in stunting status, but females tended to be
less stunted than males. The reason for this may again be a tendency to take better care of female children to obtain a higher bride price.

The Centers for Disease Control released new growth charts the year this study was completed (2000). One of the new developments was a body mass index-for-age growth chart for children aged 2 to 20. BMI-for-age for children in this study was plotted on the 2000 CDC growth chart. Cut-offs have not yet been established for developing countries to determine the risk of malnutrition based on BMI-for-age; however, 54.7% of the 2 year olds through adolescents were at the 3rd percentile or below for this measure and only about 21% were at or above the 50th percentile. Differences in BMI-for-age did not differ statistically based on gender, age group or season. Family size, however, did exhibit an effect on differences in this measure with children from smaller families having higher BMI-for-age percentiles ($r=-.25, p=.05$). This finding is contrary to the findings of Pelto et al. in Mexico where children from larger households were heavier and shorter for their ages (thus having a higher body mass index) than children from smaller households (63). The findings in this study were more logical for the sample population in that smaller households would have a greater availability of food and therefore the incidence of wasting would be lessened, thus increasing BMI.

Mid-upper arm circumference (MUAC) has also been used in adult and under-five populations as a replacement or supplement for body mass index. There were no statistically significant effects of gender, age group or season on differences in MUAC in this study. There was, however, a relationship between MUAC and BMI with MUAC increasing with an increase in body mass index. This may indicate that MUAC could be used instead of BMI to determine the degree of under- or over-nutrition in this
population. Cut-off values would have to be determined before this practice could be established. Although MUAC in this study was measured on the weaker arm (left arm), the values for MUAC were relatively high and the existing cut-offs developed by Ferro-Luzzi and James to determine malnutrition were not appropriate in this culture (42). The most probable reason is that although the left arm is the weaker arm, it is used when pounding millet (a strenuous and daily activity) thus giving females a relatively large muscle mass in both arms. Skinfold measurements were not taken so it was not possible to determine the percentage of fat and lean mass.

Protein energy malnutrition can sometimes be determined from a physical examination of the individual. In this population, the physical signs of PEM were not often evident. The vast majority of the population had no signs of dyspigmented (72%) or lackluster (97%) hair. Only one individual showed signs of a mild case of marasmus and one showed signs of kwashiorkor. This is not unusual since the prevalence of severe malnutrition was low in this population.

**Vitamin A deficiency**

Vitamin A deficiency is often a major problem in developing countries causing blindness and even death in the under-five population. Vitamin A deficiency can often be determined through a physical exam but even a sub-clinical deficiency can cause death in young children; therefore, a biochemical exam for retinol levels may be the best way to test for true deficiency.

Forty-nine percent of the sample population did not show any symptoms of Bitot’s spots, a common indication of vitamin A deficiency. The remainder of the
population had Bitot’s spots in either eye (15.5%) or both eyes (35.5%); however, most of those with Bitot’s spots were older children and adults and it is not certain that Bitot’s spots in those populations are related to a past vitamin A deficiency or perhaps not related at all. Another eye sign of vitamin A deficiency is night blindness. The vast majority, 96.5%, indicated no symptoms of night blindness during either season. Only 3.5% ever experienced night blindness. Hyperkeratosis and plaques around the hair follicles are both signs of vitamin A deficiency that occur in the skin. There were no cases among the study population of either hyperkeratosis or plaques around the hair follicles. Perhaps this population was deficient in vitamin A at a sub-clinical level or perhaps they absorbed enough vitamin A from the red pepper, kumba (native eggplant) and fresh and dried leaves that they consumed to meet the body’s requirements for the vitamin.

**Iron deficiency anemia**

Anemia, together with malnutrition, is among the major causes of disease and death in children in developing countries. The physical symptoms of iron deficiency anemia are varied and may also be caused by other conditions; therefore, the only good indication of a true iron deficiency is a biochemical analysis of the blood to test hemoglobin levels. It was not possible in this study to perform biochemical analyses. Each individual was examined for the presence of pale conjunctivae. The majority of the population had normal conjunctivae (75%). Eighteen percent had slightly pale conjunctivae and the remaining 7% had pale conjunctivae. There was no relationship between pale conjunctivae and age group or season. The incidence of pale conjunctivae
was not related to whether or not the individual had malaria (a possible confounding factor). In addition to a possible iron deficiency, pale conjunctivae can also indicate a folic acid, vitamin B\textsubscript{12} and/or copper deficiency. In the absence of a laboratory analysis, it was not possible to state the source of the pale conjunctivae in this population. There were several good sources of iron in the diet of the sample population: millet, soumbala (also known as kolgo – used in sauce preparation), brewer’s yeast, fresh and dried leaves, black-eyed peas and nuts.

**Goiter**

Iodine deficiency disorders, exhibited primarily in the form of goiter, affects an estimated 86 million people in Africa. Iodine deficiency disorder has an effect on growth and development, particularly in the fetal, neonatal and infancy stage. It has also shown a negative effect on school performance (10). Goiter, or enlarged thyroid, is the primary physical sign of an iodine deficiency but the diagnosis can be confirmed by testing urine iodine excretion and the level of serum thyroxine. The incidence of goiter in this population was very low with only two young adult females showing the early stages of an enlarged thyroid. Both of these cases were noted during the plentiful season but because the enlargement of the thyroid was slight, it is possible that the two cases were overlooked during the pre-harvest data collection. The relatively low incidence of goiter in the sample population may be due in part to their diet. Although they consume no iodized salt, they do frequently eat the following sources of iodine: fish, nuts and green leafy vegetables.
Cardiovascular health

Systolic and diastolic blood pressure were measured for adults in the sample population. The mean systolic (117 mm Hg) and diastolic (73.7 mm Hg) pressures for this population were in the optimal ranges. The range of systolic pressures was 87 mm Hg to 171 mm Hg. The vast majority of the population had a systolic pressure in the optimal category (63.6%). Another 17.8% had a systolic pressure in the normal range while only 11% were in the “high normal” category and 7.6% would classify as high blood pressure. Systolic pressure differed statistically based on age group with older adults having higher systolic pressures. It also increased with beer, tobacco and kola nut consumption. These findings are consistent with the American Heart Association’s warnings that blood pressure is known to increase with age, alcohol consumption, tobacco use and caffeine consumption (65).

For diastolic pressure, 75.5% of the population were in the optimal range. Another 7.6% were in the normal range, 5.9% were in the high normal range and the remaining 11% were in the high range of diastolic pressure. Diastolic pressure did not differ statistically based on age group (F=[4, 113] 2.44, p=.12). Age group approached statistical significance on this measure when oil consumption was controlled for (F=5,112] 2.84, p=.09). As with systolic pressure, beer and kola nut consumption had an effect on diastolic pressure. Diastolic pressure increased with weight which is also consistent with the warnings of the American Heart Association (65).

Beer, tobacco and kola nut consumption all seem to be a “rite of passage” for older adults in the Mossi culture. In addition to being in a higher risk category due to age, older adults in the sample population also participated in three controllable activities
that, if altered, could reduce their risk of heart disease. It is unlikely that any of the adults in this population would be willing to reduce their risk of heart disease by curtailing beer, tobacco and kola nut consumption. Also unknown is whether the African population has the same tendency toward high blood pressure as the African-American population in the United States. This is doubtful, however, considering the overall “lean” nature of the sample population and the amount of physical activity required to perform daily routines.

**Dietary practices**

The method of dietary analysis used in this study was a food frequency questionnaire. Since the sample population consumed their meals from a “common pot”, adding ingredients throughout the day as necessary, and since they were not familiar with international units of measure, it was not possible to use a 24-hour recall or food diary in the study. The best alternative would have been an observed food record but this would have been time and labor intensive. The only other viable option was a food frequency questionnaire. Although a non-quantitative food frequency questionnaire cannot provide information concerning daily intake of energy and nutrients, it did provide some interesting information concerning the dietary practices of the sample population.

As a whole, the sample population consumed very few fruits during the two study periods despite the fact that there were mango and baobab trees in the village. Meats were also consumed infrequently with the exception of fish, which, for the most part, was a daily part of the diet. Animals such as pigs, goats, sheep, chickens and cattle were seen by the researcher throughout the village, but these were most likely reserved for special occasions such as a festival or perhaps to have on hand to sell in case income was needed.
Beverages other than water and homemade beer were very rarely consumed, including milk.

The daily diet consisted of a millet-based “paste” with a sauce. Sauce ingredients included primarily tomatoes, okra or fresh/dried leaves, dried fish, soumbala (made from locust bean pods), potash, rabile (brewer’s yeast), salt, hot peppers and oil. The diet was not varied with little change from day-to-day, individual-to-individual or season-to-season. Only food items that were season-dependent changed with respect to consumption. In lean season, fresh leaves were consumed whereas in the plentiful season, dried leaves were consumed. Corn was harvested in the pre-harvest season and although it was dried for future consumption, not enough was grown to last the year. Millet, beans, okra and corn were dried for storage and future consumption. Fruits, which were eaten dried, were not stored for later in the year; they were consumed only while in season. The changes that would be recommended to the sample population would be to consume more fruits when they are available and to store them for future consumption, to add meats and eggs to their diet on occasion and to consume milk or other dairy products. The village grows its own food for the year and a change in dietary habits would be difficult particularly if foods had to be purchased or if animals were consumed rather than sold. However, if the sample population were to change its dietary habits, it might be possible to obtain a longer, healthier life.
APPENDIX A

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Deficiency Symptoms or Clinical Signs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protein</td>
<td>Hair easily pluckable/dyspigmented/lackluster; Moon face/thin muscles with fat/edema</td>
</tr>
<tr>
<td></td>
<td>Old man's face/thin muscles, thin fat</td>
</tr>
<tr>
<td>Vitamin A</td>
<td>Hyperkeratosis; plaques around hair follicles; Bitot's spots; night blindness</td>
</tr>
<tr>
<td>Iodine</td>
<td>Goiter (enlarged thyroid)</td>
</tr>
<tr>
<td>Fatty Acid</td>
<td>Xerosis and dry scaling of the skin</td>
</tr>
<tr>
<td>Vitamin K</td>
<td>Ecchymoses; petechiae</td>
</tr>
<tr>
<td>Vitamin C</td>
<td>Ecchymoses; petechiae; spongy, bleeding gums</td>
</tr>
<tr>
<td>Iron</td>
<td>Pale conjunctivae</td>
</tr>
<tr>
<td>Folic Acid</td>
<td>Pale conjunctivae</td>
</tr>
<tr>
<td>Vitamin B₁₂</td>
<td>Pale conjunctivae; smooth/beefy-colored tongue</td>
</tr>
<tr>
<td>Vitamin B₆</td>
<td>Cheilosis; glossitis</td>
</tr>
<tr>
<td>Riboflavin</td>
<td>Angular stomatitis; cheilosis; glossitis; magenta tongue</td>
</tr>
<tr>
<td>Niacin</td>
<td>Glossitis; edema of the tongue; tongue fissures; smooth beefy-colored tongue</td>
</tr>
<tr>
<td>Copper</td>
<td>Pale conjunctivae</td>
</tr>
</tbody>
</table>
APPENDIX B

STATEMENT OF INFORMED CONSENT (ASSENT)/PARENTAL CONSENT
(English)

The purpose of this project is to determine the health status of the Mossi people. Participants will be examined and interviewed twice: once before the harvest and once again about six months later. Each of the interviews should take about 45 minutes to one hour per participant. Participants will be asked basic background information such as age, occupation, and number of children. They will be measured to obtain information about their height, weight, blood pressure, etc. and will have a brief physical examination of the hair, eyes, skin, mouth, tongue, gums, lips and teeth. They will also be interviewed to obtain information about the food they eat.

Participants will not be put in any danger or experience any discomfort.

If you choose to participate in this project, your questions will be welcomed throughout the interview and examination process. The contact person for this project is Tamara Wood. She can be reached through the office of the Mission Baptiste in Ouagadougou. The office is located in the center of town and the address is: BP 580.

Information provided by you (including the results of all measurements and dietary data) will be kept confidential. At the end of the project, your name will be removed from all documents so that you cannot be identified as a participant. You are free to withdraw your consent and discontinue participation at any point.

There will be no monetary reward for participating in this project.

I have read (or been read) the above statement of informed consent and understand the procedures described above. I agree to participate in the project and indicate so by placing either my signature or fingerprint below. If at any point I feel that I should no longer continue in this project, I realize that I have the right to end the interview. I have received a copy of this description.

OR

I have read (or been read) the above statement of informed consent and understand the procedures described above. I agree to allow my minor child to participate in the project and indicate so by placing either my signature or fingerprint below. If at any point I feel that my child should no longer continue in this project, I realize that I have the right to end the interview. I have received a copy of this description. I realize that my child (aged 7 to 17) also has the right to accept or refuse to participate. His signature or fingerprint placed below indicates his willingness to participate. He will also be given a copy of this description.

Signatures (or fingerprints):

_____________________________ Date _______________________________ Date
Participant

_____________________________ Date
Parent of minor child

_____________________________ Date
Witness
DECLARATION DE CONSENTEMENT (ASSENTIMENT) INFORME/DES PARENTS (French informed consent)

Le but de ce projet est de déterminer la situation de santé du peuple Mossi. Les participants seront examinés et questionnés deux fois: une fois juste avant la récolte et une fois encore à peu près 6 mois plus tard. Chaque enquête doit prendre entre 45 minutes et une heure par personne. Les participants seront questionnés pour obtenir des informations de base selon leur âge, profession et nombre d'enfants. Ils seront mesurés pour connaître d'information sur: leur taille, poids, tension, etc. et auront un bref examen médical des cheveux, yeux, peau, bouche, langue, gencives, lèvres et dents. Ils seront aussi questionnés pour obtenir d'information sur la nourriture qu'ils mangent.

Les participants ne seront pas mis en danger.

Si vous décidez de participer dans ce projet, vos questions seront toujours accueillies pendant le procès d'interview et d'examen. La personne de contacte pour ce projet est Mme WOOD Tamara. Elle peut être contactée par le bureau de La Mission Baptiste de Ouagadougou. Le bureau est situé en centre ville et l'adresse est B.P. 580.

Toute information donnée par vous (y inclus les résultats de toutes mesures et informations diététiques) sera gardée confidentielle. À la fin de ce projet, votre nom sera oblitéré de toute affiche à fin que vous ne soyez pas identifié comme participant. Vous êtes toujours libre de retirer votre consentement à tout moment.

Il n'y aura pas de bénéfice financier pour participer dans ce projet.

J'ai lu (ou on m'a lu) la déclaration de consentement (assentiment) ci-dessus et je comprends les procès y décrits. Je consente à participer dans ce projet et j'y indique en mettant soi ma signature ou mon empreinte digitale ci-dessous. Si à tel moment je sens que je ne veux plus participer dans ce projet, je comprends que j'ai le droit d'arrêter l'interview. J'ai reçu une copie de cette déclaration.

OU

J'ai lu (ou on m'a lu) la déclaration de consentement ci-dessus et je comprends les procès y décrits. Je consente de permettre mon enfant de moins de 18 ans de participer dans ce projet et j'y indique en mettant soi ma signature ou mon empreinte digitale ci-dessous. Si à tel moment je sens que mon enfant ne doit plus continuer dans ce projet, je comprends que j'ai le droit d'arrêter l'interview. J'ai reçu une copie de cette déclaration. Je comprends aussi que mon enfant (âgé 7 à 17 ans) a le droit aussi d'accepter ou refuser d'y participer. Sa signature ou empreinte digitale placée ci-dessous indique sa volonté d'y participer. Il a été donné une copie de cette déclaration.

Signatures (ou empreinte digitale):

<table>
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<tr>
<th>Sujet</th>
<th>Date</th>
<th>Témoin</th>
<th>Date</th>
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<tbody>
<tr>
<td>Parent de l'enfant</td>
<td>Date</td>
<td></td>
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</tbody>
</table>
SAKRE SEBRE
(Mooré informed consent)

Tuumb kânga yaa sën dat n bâng Mossa laafi yelle. Neb niss sën na sak d ba n maan tuumâ, eb na visit-eb-lame, la b sokse ba nor a yiibu yuumdâ pugê, masâ la kiuug yoobe yasa. Visite ne soksgo na dika wakat pisnasse la nu. Ed na soka yuumâ, nugu tuumde, ne kamba sônre. Ed na maka a soaba woglem ne zislem la ed na gesa tension. La ed na gesa a zobdâ, a nina, a yînga gaongo, a nôra, a zilemde, a lida, a no-binga ne a yêna. La ed na bânga a sên dit bûmb ninga.

Neb niss sën na sak d ba ka sên na këse ba yel pugê ye. Ned fâa sân n tara sokre a sên ka mi a têe n sokame. Yâmb sân tara sokr a to yâmb têe n wa yê Mme WOOD Tamara. Bûmb be Mission Baptiste sên be tênga suka (a ka zara ne zabre dag ye). Adresse yaa B.P. 580.

Bûmb fâa neba sên na togsa na n pa ne tond ne tab bala. Tuumdâ wâ sân sa tond yêsda yuura sebra zugu. Neb niss sên sak n kô eb menga tuumdâ pugê eb sân le wa rat n base eb toëme.

Neb niss sên na n sak ed tuumâ ka tara yaod ye.

Mam wuma tuumdâ vöore, mam sakdame mam na ninga m nugu. Mam wumame ti m sân ka rat mam têe n basame. Mam paama sebra kânga buudu.

BI

Mam wuma tuumdâ vöore, mam sakdame ti mam biigâ na n maana tuumdâ, mam na ninga m nugu. Mam sân mik ti m biigâ pa na n tôge n maan tuumdâ mam na yiss-a-lame. Mam paama sebra kânga buudu. Mam bângame ti m biigâ me têe n sakame bi a têe n zâksame a sân data. A têe ninga a nugu. A paama sebra kânga buudu.

Signatures (ou empreinte digitale):

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<th>Témoin</th>
<th>Date</th>
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| Parent de l’enfant | Date |
APPENDIX C

ADULT FEMALE DEMOGRAPHIC INFORMATION

Date: ________________ Code: ________________

Last name: ____________________________
First name: ____________________________
Age: ____________________________
Maternal Tribe: ____________ Paternal Tribe: ____________

# Of years in a Mossi village: ________________

Marital status: Single ______ Married _____ Separated ______
Divorced ______ Widowed _____

Number of co-wives: ______

Educational level: No formal schooling ______ Some primary ______
Completed primary ______ Some secondary ______
Completed secondary ______

Occupation: Unemployed ______ Farmer ______
House help ______ Commerce ______
Housewife ______ Student ______

Animal Ownership: None ______ Chickens/other poultry ______
Pigs ______ Sheep/goats ______
Cattle ______ Donkeys ______

Salary (if applicable for previous month): ____________________________

Age at first birth: ____________

Pregnant? Yes ______ No _____ Don’t know ______
Breast-feeding? Yes ______ No ______

Total live births: 

Number alive under 5 years: ______
Number alive 5 years and over: ______
Number died before 5 years: ______
Number died between 5 and 18 years: ______
## APPENDIX D

### ADULT MALE DEMOGRAPHIC INFORMATION

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<th># Of years in a Mossi village:</th>
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<th>Marital status: Single</th>
<th>Married</th>
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<tr>
<td>Divorced</td>
<td>Widowed</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Number of wives:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Educational level:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>No formal schooling</td>
<td>Some primary</td>
</tr>
<tr>
<td>Completed primary</td>
<td>Some secondary</td>
</tr>
<tr>
<td>Completed secondary</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Occupation: Unemployed</th>
<th>Farmer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Guardian</td>
<td>House help</td>
</tr>
<tr>
<td>Commerce</td>
<td>Manual Labor</td>
</tr>
<tr>
<td>Student</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Animal Ownership: None</th>
<th>Chickens/other poultry</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pigs</td>
<td>Sheep/goats</td>
</tr>
<tr>
<td>Cattle</td>
<td>Donkeys</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---
APPENDIX E

CHILD DEMOGRAPHIC INFORMATION

Date: _______________   Code: _______________

Last name: __________________________
First name: __________________________

Gender: ____________________________

Age: ___________ (years and months)

Maternal Tribe: ___________   Paternal Tribe: ___________

# Of years in a Mossi village: ___________

Currently attending school? ___________

Educational level:  
- No formal schooling ______
-Completed primary ______
- Completed secondary ______

Some primary ______
Some secondary ______

Rank in mother's living children: ______ out of ______

Is child a twin?  Yes ______  No ______

Is child breastfeeding?  Yes ______  No ______

Spacing between child and next oldest sibling: __________ (years and months)

Who looks after child when mother is gone:

Father _______  Grandparent _______  Aunt _______

Uncle _______  Older sibling _______  Neighbor _______

No one _______  Other relative _______  Write-in: _______

CHILD DEMOGRAPHIC INFORMATION (continued)

INFORMATION ON HOUSEHOLD

# Of Adults/children in compound:  A_____  C_____

Total number of children under 5 on compound:  

Maternal marital status:  
Paternal marital status:  
Number of wives:  

Maternal education:  
Paternal education:  

Maternal occupation:  
Paternal occupation:  

Mother's age:  
Father's age:  

Is mother pregnant:  Yes  
No  

Is mother lactating:  Yes  
No  

Total number of births for mother:  

Ratio of deaths to births (for mother):  

## APPENDIX F

### ADULT ANTHROPOMETRY

<table>
<thead>
<tr>
<th>Date:</th>
<th>Code:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight:</td>
<td>kgs</td>
</tr>
<tr>
<td>Height:</td>
<td>cm</td>
</tr>
<tr>
<td>Upper arm circumference:</td>
<td>cm</td>
</tr>
<tr>
<td>Blood pressure:</td>
<td>mm Hg</td>
</tr>
<tr>
<td>Pulse:</td>
<td>bpm</td>
</tr>
<tr>
<td>Temperature:</td>
<td>° C</td>
</tr>
</tbody>
</table>

### CALCULATIONS

<table>
<thead>
<tr>
<th>BMI (kg / m²)</th>
<th></th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Fever:</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
# APPENDIX G

## CHILD ANTHROPOMETRY

<table>
<thead>
<tr>
<th>Date:</th>
<th>Code:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight:</td>
<td>kgs</td>
</tr>
<tr>
<td>OR: Weight of adult +child kgs minus weight of adult alone kgs = kgs</td>
<td></td>
</tr>
<tr>
<td>Height/length:</td>
<td>cm</td>
</tr>
<tr>
<td>Head circumference:</td>
<td>cm (for children under 36 months)</td>
</tr>
<tr>
<td>Chest circumference:</td>
<td>cm (for children under 36 months)</td>
</tr>
<tr>
<td>Arm circumference:</td>
<td>cm (for children over 12 months)</td>
</tr>
<tr>
<td>Temperature:</td>
<td>°C</td>
</tr>
</tbody>
</table>

## FROM GROWTH CHARTS

<table>
<thead>
<tr>
<th>Weight for age percentile</th>
<th>% of the median weight (weight/median weight)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Height for age percentile</td>
<td>% of the median height (height/median height)</td>
</tr>
<tr>
<td>Weight for Height percentile</td>
<td>% of the median height (height/median height)</td>
</tr>
<tr>
<td>Head circumference for age percentile</td>
<td>% of the median circ (circ/median circ) (for children under 36 months)</td>
</tr>
<tr>
<td>Body mass index for age percentile</td>
<td>% of the median BMI (BMI/median BMI) (for children ages 2 to 20)</td>
</tr>
<tr>
<td>BMI calculation (kg / m²)</td>
<td></td>
</tr>
<tr>
<td>Fever?:</td>
<td>Yes</td>
</tr>
<tr>
<td>Chest larger than head?:</td>
<td>Yes</td>
</tr>
</tbody>
</table>
APPENDIX H

CLINICAL EVALUATION

Date: _______________  Code: _______________

Hair:  easily pluckable? ______  dyspl pigmented?______
      lackluster?__________

Other signs of Protein Energy Malnutrition:

Kwashiorkor:  Moon face? ______  Thin muscles/fat present? ______
              Edema? __________

Marasmus: "Old man's face"? ______  Thin muscles, thin fat? _____

Skin:  Xerosis, dry scaling?______  Hyperkeratosis, plaques around hair follicles?______
       Ecchymoses, petechiae?__________

Eyes:  Pale conjunctivae?______  Bitot's spots?______
       Subject reports night blindness? __________

Teeth:

Mouth, lips and tongue:  Angular stomatitis?________
                        Cheilosis?_____Glossitis?_____  Magenta tongue?________
                        Edema/fissures of tongue? ______
                        Smooth, red, swollen tongue? ______  Small tongue?_______

Gums:  Spongy, bleeding?______

Goiter present?:  Yes _________  No __________

Diarrhea:  Subject reports recent diarrhea? __________

Malaria:  Subject reports recent case of malaria? __________

Participant?: Yes _________  No __________

Other comments:
**Deficiency worksheet/risk rating**

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Possible Deficiency (yes/no)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protein Energy</td>
<td>Yes ____  No ____</td>
</tr>
<tr>
<td>Vitamin A</td>
<td>Yes ____  No ____</td>
</tr>
<tr>
<td>Iodine</td>
<td>Yes ____  No ____</td>
</tr>
<tr>
<td>Fatty Acid</td>
<td>Yes ____  No ____</td>
</tr>
<tr>
<td>Vitamin K</td>
<td>Yes ____  No ____</td>
</tr>
<tr>
<td>Vitamin C</td>
<td>Yes ____  No ____</td>
</tr>
<tr>
<td>Iron</td>
<td>Yes ____  No ____</td>
</tr>
<tr>
<td>Folic Acid</td>
<td>Yes ____  No ____</td>
</tr>
<tr>
<td>Vitamin B₁₂</td>
<td>Yes ____  No ____</td>
</tr>
<tr>
<td>Vitamin B₆</td>
<td>Yes ____  No ____</td>
</tr>
<tr>
<td>Riboflavin</td>
<td>Yes ____  No ____</td>
</tr>
<tr>
<td>Niacin</td>
<td>Yes ____  No ____</td>
</tr>
<tr>
<td>Copper</td>
<td>Yes ____  No ____</td>
</tr>
</tbody>
</table>

A check in the "yes" column indicates that a deficiency is POSSIBLE. A "no" indicates that there were no clinical symptoms of a deficiency.

**Other clinical information:**

<table>
<thead>
<tr>
<th></th>
<th>Yes ____  No ____</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diarrhea:</td>
<td></td>
</tr>
<tr>
<td>Malaria:</td>
<td></td>
</tr>
<tr>
<td>Vaccinated:</td>
<td></td>
</tr>
</tbody>
</table>
## APPENDIX I

### FOOD FREQUENCY QUESTIONNAIRE

**Date:** ______________  
**Code:** ______________

<table>
<thead>
<tr>
<th>FRUITS</th>
<th>NEVER</th>
<th>MONTHLY</th>
<th>WEEKLY</th>
<th>2-4 PER WEEK</th>
<th>3-6 PER WEEK</th>
<th>DAILY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Avocado (&quot;avocat&quot;)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Banana (&quot;banane&quot;)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fried plantain (&quot;alloco&quot;)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Orange / juice (&quot;Jus d'orange&quot;)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lemon (&quot;citron&quot;) / juice (&quot;Jus de citron&quot;)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Canteloupe (&quot;melon&quot;)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Watermelon (&quot;pasteque&quot;)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wild grapes (&quot;sibi&quot;)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shea fruit (&quot;tama&quot;)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Baobab fruit (&quot;tuedo&quot;)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Powder from locust bean pods (&quot;rondo&quot;)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Detar (&quot;kaga&quot;) (light green pulpy fruit)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mango (&quot;mangue&quot;)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Papaya (&quot;papaye&quot;)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Guava (&quot;goyave&quot;)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tamarind juice (&quot;pus kom&quot;)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>VEGETABLES</th>
<th>NEVER</th>
<th>MONTHLY</th>
<th>WEEKLY</th>
<th>2-4 PER WEEK</th>
<th>3-6 PER WEEK</th>
<th>DAILY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tomatoes (&quot;tomates&quot;)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tomato sauce (&quot;sauce tomate&quot;)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cabbage (&quot;chou&quot;)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carrots (&quot;carroti&quot;)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corn (&quot;kamana&quot;)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Beans or lentils, dried (&quot;benga&quot;)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pumpkin (&quot;courge&quot; - &quot;nyogre&quot;)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eggplant (&quot;aubergine&quot;), zucchini (&quot;courgette&quot;) or local eggplant (&quot;kumba&quot;)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yams or sweet potatoes (&quot;nayui nodo&quot;)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spinach (&quot;epinards&quot;)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lettuce (&quot;salade&quot;)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Food Item</td>
<td>Frequency</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-----------</td>
<td>-----------</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leaves, fresh - peanut (&quot;nanguri vado&quot;), potato (&quot;pomme de terre vado&quot;), celery (&quot;celeri vado&quot;), parsley (&quot;persil vado&quot;), onion (&quot;jaba vado&quot;), bean plant leaves (&quot;beng vado&quot;), local eggplant leaves (&quot;kumb vado&quot;), &quot;keynedbo&quot;</td>
<td>Weekly</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leaves, dried - Roselle (&quot;bit kuenga&quot;), jute (&quot;bulvanka&quot;), kapok (&quot;vaag kuenga&quot;), baobab leaves (&quot;tuega&quot;)</td>
<td>Weekly</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Okra, dried or fresh (&quot;manna&quot;)</td>
<td>Weekly</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**EGGS, MEATS, ETC**

- Eggs ("gella")
- Chicken ("noag nemdo") or guinea ("kaongo")
- Liver ("saore")
- Beef ("naaf nemdo"), pork ("kurikuri nemdo"), lamb ("pesg nemdo"), goat ("bug nemdo") (in sauce or sandwich)
- Fish ("zima")
- Duck ("lade")
- Snake ("waafo")
- Horse ("wedmoaga")
- Donkey ("boanga")
- Dog ("baaga")
- Rabbit ("soamba")
- Cat ("yunga")
- Vulture ("yibrongo")
- Frog ("pondre")
- Snails ("garanweongo")
- Inch worms ("zazuri")
- Grasshoppers ("suure") or ants ("chenilles")
- Termites ("yu")

**BREADS, CEREALS, STARCHES**

- "Beere" (breakfast "mush" from millet, corn, rice or fonio)
- "Sagbo" (Staple - can be made from corn, white sorghum, red sorghum in time of famine or millet.)
- "Fura" (made from "petit mil"). Thicker than "sagbo" and is spicy. Can be eaten plain or mixed with flour, milk and sugar.
- "Zom kom" (beverage made from millet)
- Bean paste ("gaore") or leaf paste ("yao")
- "Babenda"
"Samsa" (fried) (made from bean flour)  
"Massa" (fried) (pancake made from millet flour)  
"Buri massa" (fried) (made from wheat flour)  
Bread ("buri" or "dupain")  
White rice ("mui")  
Pasta (spaghetti, macaroni)  
Couscous  
"Dégé" (snack made from yogourt and couscous  
Potatoes ("pommes de terre")  
Igname ("busa", "ku")  
Cassava ("bandaku")/"atièké"

**BEVERAGES**

Coke, Fanta, Sprite, Bullvit (seltzer water)  
Bissap ("wegd kom") (made from the hibiscus flower)  
Milk ("bisem")/"Bis kom" (nonfermented)  
Coffee ("café")  
Tea ("thé")  
Homemade beer ("ram moaga")

**SWEETS, BAKED GOODS, MISC**

Candies ("bonbons")/chewing gum  
Cookies ("biscuit damba")  
Cake ("gateau")  
Honey ("sido")  
Peanut butter (tégédégé")  
Peanut butter rings ("kula kula")  
Nuts ("nanguri", "suma", "sinli")  
Kola nuts ("gure")

**SAUCE INGREDIENTS**

Soumbala ("kolgo") (pungent black ball made from fermented locust bean seeds)  
Zem and Zem Moaga (potash)  
"Rabile" (crust from "dollo")  
"Yamsem" (salt)  
"Kipare" (hot pepper)  
"Kam" (oil) Kind most used ...........................................  
"Nemdo" (meat)
Are there any other foods that you eat regularly?  
("Ya dib yaasa yamb sen di wakat-wakate?")

Do you smoke or chew tobacco?  
("Yamb yu cigari bii?")

What is your water source?  
("Yamb yaka kom ye?")

Does your family have any forbidden foods?  
("Yamb budu tara dib sen kisa bii?")
APPENDIX J

Dietary Information for breastfed and weaning infants

Code:

Date:

Is baby strictly breastfed? YES NO

List supplemental / weaning foods:

Is baby given yamdé? YES NO

(Yamdé is a traditional drink made from tree bark given to infants during first year)
### ADULT NUTRITIONAL/HEALTH RISK ASSESSMENT

Date: ________________  
Code: ________________  

<table>
<thead>
<tr>
<th>Assessment factor</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upper arm circumference</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BMI</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Systolic blood pressure</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diastolic blood pressure</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### CHILD NUTRITIONAL/HEALTH RISK ASSESSMENT

Date: ________________  
Code: ________________  

<table>
<thead>
<tr>
<th>Assessment factor</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight for height (for all)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weight for age (for all)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Height for age (for all)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Upper arm circumference (1 to 5 year olds)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Adolescent protein energy malnutrition? Yes_______  No_______
REFERENCES


22. Nardone DA, Roth KM, Mazur DJ, McAfee JII. Usefulness of physical examination in detecting the presence or absence of anemia. Arch Intern Med 1990;150(1),201-204.


VITA

Tamara Wood was born in Pensacola, Florida. She grew up in Jacksonville, Florida and graduated from Edward H. White High School in 1986. After high school, Mrs. Wood attended the University of North Florida where she received a Bachelor of Arts degree in biology with a minor in psychology. Upon graduation from UNF in 1988, Mrs. Wood worked as a forensic serologist for the Florida Department of Law Enforcement in the Jacksonville Regional Crime Laboratory.

While working for FDLE, Mrs. Wood began taking classes toward a Master of Science in Health (Nutrition) degree in light of future service as a missionary in a developing country. Mrs. Wood’s studies were interrupted in 1993 when she resigned her post at FDLE to make final preparations for going overseas.

In March of 1994, Mrs. Wood and her husband David left the United States for French language school in Tours, France. At the end of that same year, she went to Niamey, Niger in West Africa. At the end of her first tour as a missionary, Mrs. Wood decided to completer her Master’s degree program at the University of North Florida. During her 8 months in the United States, she was able to complete all of the remaining course work toward her Master’s degree (with the exception of this project). In January of 1999, Mrs. Wood and her husband returned to West Africa to live and serve in Ouagadougou, Burkina Faso where she completed this study.