The Ecology of Health During Middle-Childhood in Rural Akamba of Kenya

by

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Abstract

To the Akamba people of Kenya middle-childhood is well defined based on cultural expectations although it doesn't have a distinct name. These children are crucial to the survival of the Akamba, however, a combination of low mortality and cultural biases has contributed to their marginalization in both health studies and community based dialog participation. This study examines the ecology of middle-childhood health by assessing their nutritional status through anthropometry and contextualizing it in the Akamba culture. Cross-sectional, anthropometric data were collected for 472 school aged Akamba children in the semi-arid lowlands of Makueni County. The results show that 95.12% of the children are underweight with 69% classified as severely underweight with BMI values of less than 16 kg/m^2. The overall prevalence of stunting is 19% with the highest prevalence occurring in the 13 year olds at 40.35%. Water scarcity and the unreliable rain cycles have increased incidents of drought and food insecurity resulting in a more adverse environment. As the children enter middle-childhood and are given more responsibility, greater physical demands and inadequate caloric intake affect their growth and development. The provenance of solutions to health-related maladies may be stronger if education targets Akamba children in middle-childhood because of the physiology of growth in this life stage. Historically, survival has been predicated on the plasticity of the proximate variables of the Akamba culture giving supportive space for this dialog to have greater impact potential to the future landscape of Akamba health insofar as the children are included in culturally supported models.

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Introduction

To the Akamba people of Kenya middle-childhood is well defined based on cultural expectations although it doesn't have a distinct name. The noun used is "syana" (children), but it is only in name that children in middle-childhood are not distinguished from those in early childhood. In middle-childhood *syana* are expected to assume more responsibility than before, to endure more physical labor and show greater maturity in both their speech and conduct. Usually, they accompany their adolescent siblings or an adult when performing certain chores that may require them to travel several kilometers from the homestead, however, it is in this stage of life that individual tasks begin to be assigned. These responsibilities range from cooking, fetching water and firewood, herding cattle and assisting in the gardens. It is not unusual to see a female child in middle-childhood with an infant sibling strapped on her back walking beside her mother who is carrying a large container filled with water, and when the baby becomes a toddler and can hold mom's hand, both the older child and mother will have water containers on their backs. The environment of the traditional homeland of the Akamba people has specific challenges that necessitate the contribution from every able member of the family in order to survive. Responsibilities given to the children increase with age and parallel their physical growth and development.

In the context of life history theory, growth patterns reveal trade-offs made to growth and development when an individual experiences an insult significantly

diminishing or eliminating one or more resources. These concessions are a way of coping with an unfavorable condition; they do not lead to an adaptive trait. Unlike adaptation in which the resulting phenotype is beneficial to a population in a given environment (Ellison and Jansienska, 2007), these trade-offs can be, and often are, detrimental to individuals with the degree of deleteriousness varying from a treatable ailment to death. For this reason, some researchers refer to these trade-offs as maladaptive (Ellison and Jansienska, 2007). Although these environmental insults are experienced on an individual level, the results are reflected on the growth curves of the population because they affect individuals in a group in a similar way.

Growth curve references provide guidelines for how children are expected to progress (Gibson, 2011). Physical growth in middle-childhood is steady and predictable (Tanner, 1990); thus, variations in a population could be attributed to stressful conditions that alter their environment. Although individual genetics cause some variation in normal growth, the mean for a sample group should fall within the same ranges as the mean of the larger population with shared common environment and ancestry. When growth curves of a sample population are skewed, both physical and emotional environmental conditions have been shown to influence physical growth beyond the genetic blueprint (Cameron, 2007).

This study assesses the ecology of middle-childhood health among rural Akamba people of Makueni County in Kenya. Through the life history lens, insight may be gained into how the environment influences schedules of growth in Akamba children by noting the occurrence of transitional physiological markers. The

ecological perspective evaluates the relationship between humans, their culture and their environment. Utilizing anthropometric data to assess the nutritional status (Blossner and de Onis, 2005) in middle-childhood, inferences can be drawn regarding the nutritional environment of their early life (Bogin, 2001). Current anthropometric measurements reflect the long-term nutritional status in a complex feedback loop where growth outcomes point to cultural responses as proximal factors that are dictated by the environment conditions in which the Akamba inhabit.

Human Life History

Human life history examines strategies for survival and timeframes of growth and reproduction so as to optimize resources throughout a life course (Stearns, 1992; Claudell & Quinlan, 2012). As early as *in-utero,* a human's growth and development is dependent on the available resources and the cost to utilize them. If accessibility to a needed resource is lacking, especially during critical moments in development, the fetus does not survive. The same applies to reproduction. Reproduction is particularly costly to women and when faced with an insult, such as the contraction of a disease, trade-offs are made that can fundamentally shift resource allocation (Abrams and Miller, 2011; Griskevicius et.al, 2011). In children most of the energy goes toward growth and will eventually be used in reproduction as they reach maturity (Stearns, 1992). The body needs most of its energy for maintenance and ideally, only the excess is available for allocation

toward activity or production. However, the process is not ideal; factors such as the amount of nutrient intake and storage and the children's levels of physical activity affect how much energy is available for their growth and maintenance (Kramer and Greaves, 2011).

Middle-Childhood

Middle-childhood is defined as the period of human growth and development that falls between the ages of 6 -12 years (Bogin, 2001; Campbell, 2011). It is the third of the five categories of human life history articulated by Barry Bogin,[1] (1999) and is characterized by relatively low hormonal activity with no detectable difference in growth velocity between girls and boys (Tanner, 1990). M.A. Preece reports that on average, children in this period gain about 6 cm in height and 3-3.5 kg in weight per year (Warrell et al., 2003). This growth occurs in mini spurts over the course of the year with no sexual dimorphism (Warrell et al., 2003). There are two major physiological markers that bookend middle-childhood.

The major physiological marker that children have transitioned from middle-childhood into adolescence is the adolescent growth spurt. On average it occurs at the age of ten in girls and twelve in boys (Bogin, 1999). Middle-childhood is unique to human life history. It extends childhood after weaning in a way un-replicated in other primates and provides a critical phase when young humans begin to learn

[1] The other stages Bogin outlines are infancy, early childhood, adolescence and adulthood (1999)
[2] Makueni county has 982 primary schools but only 339 high schools (MCIDP, 2013)

aspects of culture and survival that prepare them for the complexities of adult society (Flinn et al., 2009).

The beginning of middle-childhood is marked by the maturation of the brain which is at approximately 90% of its adult weight and reaches full growth at a mean age of seven (Bogin, 2001). Though the brain will not change in size thereafter, in middle-childhood it begins the process of editing itself to equip the individual with the best chance of surviving his or her environment. At approximately age seven, the production of adrenal androgens dihydroepiandrosterone and dihydroepiandrosterone sulfate (DHEA/S) is greatly increased (Campbell, 2011). This increase in DHEA/S avails more glucose to the brain. It is in middle-childhood that the human brain utilizes the most glucose, almost 1.5 times more than during adulthood with peak usage of two times greater than adults at the age of eight (Chugani, 1998). The added glucose to the brain is necessary to fuel the maturation of the prefrontal cortex that is responsible for the development of normative stress responses and the formation of habits in middle-childhood. A sense of reason and a responsibility starts to solidify (Campbell, 2011).

Additionally, DHEA/S increase glucose transporters GLUT1 and GLUT4 that promote the uptake of circulatory glucose into adipose tissue (Campbell, 2011). Low circulatory glucose reduces the release of insulin, which decreases the uptake of glucose in the muscles, while facilitating its uptake in adipose cells with the added glucose transporters. Thus, the spike of DHEA/S in middle-childhood results in boosting adiposity (Campbell, 2011) in preparation for the adolescent growth spurt.

The Study Environment: Makueni County

This study was carried out in Makueni County, in the southeastern part of Kenya (Figure 1). Although there are a few hilly regions in the northern area of the county that reach altitudes of 1200 meters above sea level, most of Makueni lies at low altitudes, with its lowest terrain at 600 meters above sea level at the south-most end (Makueni County Integrated Development Plan-MCIDP, 2013). This study was done in the semi-arid lowlands where daily temperatures range from 11^0 C-17^0 C (51.8-62.6 ^{0} F) in the cooler months to 24^0 C-29^0 C (75.2-84.2 ^{0} F) in the dry season (KMD, 2015. Figure 2) when the highest daytime temperatures are recorded (MCIDP, 2013).

The average rainfall is between 550 – 850 millimeters per year (KFSSG, 2011). From 1998 to 2013, the area averaged 672 millimeters of rain per annum (KMD, 2015). Like the rest of the country, Makueni County has two rainy seasons. The short rains last for a few weeks intermittently in October-November/December (OND) and the heaviest rains are known as long rains and occur from March to May (MAM). In Makueni County, rainfall is unreliable and may be delayed by weeks, cease prematurely, fall below the normal ranges or fail completely (KFSSG, 2011). Drought occurs from failure or inadequacy of two or more consecutive rainy seasons.

Water is a scarce resource in the Makueni. The county does not have any lakes. It has one perennial river, the Athi River, and few tributaries and streams that are seasonal due to recurring droughts (MCIDP, 2013). To supplement water from

community boreholes and the few streams, most residents have some form of rain-catchment device making rainfall an essential source of water for the residents (KFSSG, 2011). These large barrels are expensive to install and most useful to families that have a guttered, corrugated metal roof as opposed to the traditional grass-thatched roofing. Even in such situations, the catchment system is only as valuable as the rains are reliable.

Unfortunately, the environment is rapidly becoming inadequate for the needs of the growing population. Erratic climate conditions and soil erosion as a consequence of high rates of deforestation for fuel, have resulted in low food production with several partial or total crop failures in the last decade (KFSSG, 2011).

The Residents of Makueni County: Population Demographics

The population of Makueni County is comprised mostly of Bantu-speaking Akamba people. Of the 47 counties in Kenya, Makueni County is one of the three counties located in *Ukambani*, the traditional homelands of the Akamba. The other two counties of *Ukambani* are Kitui to the east and Machakos that is sandwiched to the north between Makueni and Nairobi counties (Figure 1). *Ukambani* is approximately 45,000 km^2 of which 8,008.80 km^2 is Makueni county (Figure 1). However, not all of *Ukambani* land is legally available to the Akamba as it is set aside for national parks and wild life game reserves. A portion of Makueni County is part of Chyulu hills game reserve and Tsavo National Park (Figure 1), one of the world's

largest wildlife reserves, which opened in 1948 (MCIDP, 2013; www.tsavopark.com).

The most recent Kenyan national census conducted in 2009 reported that Makueni County had a population of 884,527 with 186,478 households (KNBS, 2014). However, in the four years since the census the county has experienced an annual population growth rate of about 1.4% (MCIDP, 2013). In 2012 the county government reported the population had increased to 922,183 individuals, with a male-female sex ratio of 100:105 (MCIDP, 2013). Population density is approximately 110 people per kilometer squared (KNBS, 2014).

Forty-four percent (43.7) of the population in the Makueni county is under the age of 15 (Figure 3) (KNBS, 2014). The abrupt decline in population after the age of 14 illustrates the outmigration of adults in search of employment, and enrollment of teenagers in out-of-county high schools, due to shortage of high schools in the county[2]. Almost 7% of the residents are over the age of 65 years and the largest demographic group is children between the ages of five and nine years who represent 15.1% of the population(KNBS, 2014).

Total fertility rate in the county is 5.1, higher than the national average of 4.6 (KDHS, 2010) while the mortality rate falls below the nation's. The 2009 census reported that the infant mortality rate (IMR) in Makueni County was 42 per 1000 live births, lower than the national rate of 52 per 1000 births. The under-five mortality rate (U5MR) was 51 per 1000 births where the national rate was 74 per 1000 births (KDHS, 2010). In the years since the census county records (Table 1)

[2] Makueni county has 982 primary schools but only 339 high schools (MCIDP, 2013)

have mortality rate increasing in both those categories with the IMR at 45/1000 and the U5MR at 84/1000 (MCIDP, 2013).

The Ecology of Health in Middle-childhood Among the Akamba

A Common Akamba Saying; "Noo ũũ thowa nthĩ (You are still buying Earth)"sums up the view of life during middle-childhood. Middle-childhood is perceived as the time when the dangers of infancy and early childhood have passed, the responsibilities are slightly less than those of adolescence and the struggles are minor compared to those of adulthood. Since this is a time of relatively low mortality, aches and pains experienced by children are usually met with this saying "noo ũũ thowa nthĩ" or the attitude it represents. It connotes that there are physical struggles we experience during growth and development that earn us the right to live on earth. They are either part of the natural growth process, such as the loss of baby teeth, or they are part of an arbitrary experience such as bruises inflicted during playtime, or the struggles are a part of necessary life activities such as doing household chores. I remember these words from my childhood years and not surprisingly I heard this phrase from parents while I was in *Ukambani* doing research for this study.

This adage is multi-dimensional in meaning; it is not limited to childhood. It reflects the relational aspect of the Akamba culture. To the Akamba people the older one gets, the deeper one is woven into the relational fabric of the community.

As a child grows, he/she learns through contributive interactions. Life challenges are faced with the support of others. An old man earns high value because of a lifetime of relationships such that when he dies the pain of his loss is greater to the community than the loss of a child (Lysaught et al., 2012). In his analysis of the Akamba worldview Jones Kaleli says in contrast to the Cartesian ideology of "I think therefore, I am," the Akamba people espouse, "I participate, therefore, I am" (1985). Indeed, in a life/death situation where one has to choose between saving a young man or an old man, to the Akamba, the old man would be the favored choice (Kilner, 1984).

Children learn early that their livelihood must be earned and the children in middle-childhood, the largest group of the the population, provide much needed labor as they learn how to do chores crucial to the survival of their families. For example, in Makueni where 64% of the population rely on water from scarce and unimproved sources such as ponds, dams, streams and wells (KNBS and SID, 2013; MIC, 2008), young girls help the women to fetch water as they enter middle-childhood years. They also assist in gathering firewood, the cooking fuel for 84.8% of the households (KNBS, 2013). Young boys learn to herd the cattle.

Makueni residents practice mixed marginal farming to produce the food they consume and to generate income (MCIDP, 2013; Speranza et al., 2008). Division of labor across the gender lines is learned early through observation. Although most of a family's income (more than 83%) is from the sale of crops and livestock, adult males will seek seasonal day-labor employment to supplement the income, leaving the females to tend to on-farm duties (Speranza et al., 2008). Wages from temporary

jobs are crucial to the survival of the whole family, and children learn by watching adult labor in the family and through participating in farming and livestock herding. This is all considered part of the "earning the right to live on earth" mentality.

A hallmark of the Akamba culture is its plasticity (Krapf, 1860; Oliver, 1965; Kaleli, 1985). To the Akamba culture change is welcomed if it better facilitates "earning the right to live on earth". This survial mechanism has preserved the Akamba people through historical challenges. For example, after resisting conscription during World War I (WWI) had fatal consequences, the years that followed showed a compliance of the Akamba men to join the colonial army, the King's African Rifles, allowing them to stay alive and provide for their families until opportunity to fight for freedom arose and they joined in the MAU MAU movement that led Kenya's independence from Britain (Parsons, 1999). Half a century before this, Christian missionaries saw the value in reaching the Akamba was their openess to change and their love for long distance travel that put them in contact with other cultures (Krapf, 1860). The spread of Christianity among the Akamba had beneficial results extending to children in middle-childhood with the decline of clitoridectomy among the girls[3] (Munro, 1975), and for the boys, as early as the 1950s many were being circumcised in hospitals and not in village ceremonies (Kaleli, 1985). Formal education was quickly adopted for middle-childhood. It is viewed as a necessary tool for survival in modern times with primary school enrollment at 83% and a retention rate of 93% (MCIDP, 2013).

[3] Today clitoridectomy is rarely performed among the Akamba. In my research the teachers at all three schools did not know of any cases in the region.

This relatively high primary school enrollment and retention rate is fundamentally due to the Akamba cultural plasticity and is expedited by the constitutional provisions of the Republic of Kenya that make it compulsory for both girls and boys between the ages of six and thirteen to attend school (Kenya Constitution, Article 53, 2010). County records show that about 70% of these students walk 5 km or more to the nearest school and the teacher student ratio is 1:37 (MCIDP, 2013). Children are expected to tend to their chores before and after school hours and during weekends and holidays. As they help their parents and grandparents through daily activities and fulfill their responsibilities at school, children learn how to respect the elders, how to survive in their environment and how to live in community with others all as part of the larger lesson of "*kuthowa nthĩ*" (buying the earth). Thus, in the Akamba ecosystem, the distal cultural philosophy has a proximal influence on behavioral expectations.

Nutritional Studies in *Ukambani*

Nutritional studies in *Ukambani* have so far focused on adults or the under-5 population and not middle-childhood. This could be because of the relatively low mortality rate in this period and cultural attitude that struggles encountered at this time are all part of earning the right to live. Data collection is costly and thus usually limited to patients at healthcare facilities. Unfortunately, with no free medical care in Kenya and transportation challenges in the rural counties, visits to clinics or other health facilities are limited. Usually people in Makueni County go to

the clinics only when they have to, for example, for childhood immunizations[4], acute illnesses, or pregnancy and childbirth complications..

Published nutritional studies among rural Akamba are confined to adults (Hansen et al., 2011; Njarui, et.al, 2011), pregnant women, infants, and under-five's (MIC, 2008; Ndiku, et.al, 2010; Ndiku, 2011; Steeenbergen et al., 1978). The few studies dealing with school-aged children have focused on the causes and effects of diseases such as malaria and bilharzia (Booth et al., 2004; Wilson, et.al, 2011). Studies on the under-five Akamba children show that 34% are moderately stunted and approximately 20% are moderately underweight (MIC, 2008). Data on the nutritional status of children after the age of five continues to be scarce and thus, the current study focuses on school-aged children between the age of six and the onset of puberty to assess whether these indicators of malnutrition in under five's persist into middle-childhood.

Materials and Methods

Study Sample

Cross-sectional, anthropometric data were collected for 472 children enrolled at three different primary schools in the northwestern area of Makueni County: Kikongooni, Kathungu and Kilombo Primary Schools (Figure 1). These schools provide a good representation of the children in marginal mixed-farming areas of Makueni County. One hundred and eighteen children were measured in

[4] Kenya's national rate of immunizations in 2012 ranged from 83-93% (UNICEF, 2013)

January 2014, and 354 in June and July. Each child was measured only once. All participants are local residents who commuted daily to school on foot and who identify themselves as ethnically Akamba. Table 2 shows the age and sex composition of the sample population.

The following anthropometric measurements were taken: head circumference, mid-upper arm circumference, weight, height, age and arm triceps skinfold. Age was recorded from school transcripts, which is based on the age listed on each child's clinical card. The schools' head-teachers reported that they check the children's clinical cards prior to school admission for immunization information and year of birth verification in accordance with the Kenyan Public Health Act (Cap 242. Sect 112.1) which requires vaccinations prior to school entry (Kenya Law Reports, 2004-2011). Thus, each child is also identified as having received some or all of the infant and child (birth-6 years) vaccine recommendation.

Children were weighed wearing light clothing and shoes on a Taylor lithium battery-powered, portable digital scale with a capacity of 160 kg x 0.1 kg. A wall-mounted stadiometer (Seca 206CM) was used to measure children's height in centimeters. Children stood with their backs and heels to the wall and were encouraged to stand tall. A non-elastic body tape from Elite Medical Instruments was used to measure both head and mid-upper arm circumferences to the nearest millimeter. Rosscraft Slim-guide calipers were used for measuring the triceps skinfold thickness and only the left arm was used (Tanner & Whitehouse, 1975; Moreno et al, 1998). Measurements were taken according to standardized protocol

described by Jelliffe (1966) and Lohman et al. (1988). BMI was calculated by dividing weight in kilograms (kg) by height in square meters (m^2) (CDC, 2000).

The primary investigator (Kaleli-Lee) took measurements on all the children. At each school, two teachers also were recruited to assist. One was assigned the role of record keeper and the other read the weight measurements on the digital scale. A certified nurse assistant was always present with the investigator. Measurements were all done in a designated evaluation room at each school. Class teachers escorted their group of students to the room. The students sat on benches and their teacher called them up one at a time to be measured.

The study protocol was approved by the IRB at the University of Kansas in Lawrence in December of 2013 and was conducted in conjunction with Kabarak University, Kenya, the in-country affiliate institution approved by Kenya Ministry of Education, Science and Technology.

Statistical Analysis

Descriptive statistics were calculated for continuous variables and anthropometric measurements were plotted using IBM SPSS version 22.0 (SPSS, Inc., Chicago, IL). EpiInfo7 was used to calculate z-scores and percentiles for comparison with the World Health Organization references (WHO, 2007). Z-scores were calculated for each of the 472 children: Height-for-Age (HAZ) and BMI (BMIZ) for all children, and Weight-for-Age (WAZ) for children less than 10 years of age. This is because WHO references for WAZ are only up to age 10. Z-scores were not calculated for the other anthropometric measurements of head circumference-for-

age, arm circumference-for-age and triceps skinfold-for-age, since the WHO standards (2005) are only available until the age of five in those categories. Thus, the USA's National Health And Nutritional Examination Survey (NHANES III) data from 1988-1994 was used as reference for triceps skinfold (CDC, 2009).

Results

The means and standard deviations of the taken measurements are presented in Tables 3 and 4. Height of Makueni children is compared with the multi-center growth references children from WHO 2007 in Figure 5. Both boys and girls in Makueni are below the 50th percentile in height. The adolescent growth spurt that occurs right after puberty seems to occur after the age of thirteen in both Makueni boys and girls.

WHO cutoffs categorize childhood stunting by z-scores of less than negative two (-2); those under negative three are classified as severely stunted. The height-for-age z-score of the Makueni sample indicated prevalence of stunting is 19%: 16.56% of the children are stunted and 2.34% are severely stunted (Table 5). A greater percent of boys experience stunting than girls. The lowest prevalence of stunting is in the six-year olds (2.78%), and the highest in thirteen-year olds (40.35%).

Weight-for-age z-scores (WAZ) for the Makueni County children between the ages of five and ten (ages 6-9; n=177; boys-88, girls-89) show that 9% of the boys are underweight (<-2 z-score) and less than 6% of the girls. Since WAZ scores are

only available for a portion of the children in middle-childhood, BMI is a more comprehensive tool of evaluating underweight prevalence.

Body mass index (BMI) indicates the children are very lean (Figure 6). All 472 children are below the 50th percentile for BMI with a marked increase in thinness at the age of 7 for boys and 8 for the girls. The males experiencing an additional drop in BMI at the age of eight. By the age of nine, the average girls' weight/height ratio falls below the 25th percentile where as the boys' does not, however the resulting difference in mean BMI between boys and girls is not statistically significant, $t(469)= -0.26$, $p=0.79$.

There is a high degree of correlation between the age of the children and how underweight they are based on the BMI mode per age. A simple linear regression was calculated to predict the BMI mode based on age. A significant regression equation was found ($F(1,8)=28.887$, $p< 0.001$), with a R^2 of 0.783. Participants predicted BMI mode is equal to 10.675 + 0.366 (age) kg/m^2 with age measured in years. The BMI mode of Makueni children in middle-childhood increased 0.366 for each year.

Of the sampled Makueni children, 95.12% are classified as underweight, with a BMI of less than 18.4kg/m^2 (WHO, 2007). Underweight BMI is further categorized in levels of chronic energy deficiency (CED) (Shetty and James, 1994). The results are shown in Table 6. Most (69%) of Makueni underweight children are in the most acute (worst) grade of CED (severely underweight) with BMI values of less than 16 kg/m^2.

Only two of the five anthropometric measurements taken show a statistically significant difference in averages between boys and girls: head circumference and triceps skinfold (Table 7). The girls have a smaller head circumference (50.68 cm +/- 1.85) compared to the boys (51.78 cm +/- 1.71), t(440) = 6.46, p= 0. Makueni boys have lower triceps skinfold means (5.82 mm +/-2.75) when compared to the girls (7.04cm +/- 2.87), t(441) = 4.58, p = 0. When charted against NHANES III data, the triceps skinfolds for both boys and girls are below the 15th percentile with the girls mean values more closely paralleling the reference than the boys (Figure 8).

Discussion

To the Akamba, 'earning the right to live on earth' is supported by the cultural assumption that good health is the human archetype. Our good health enables us to fulfill our life's responsibilities. In *Kikamba*, the language of the Akamba, there is no word for health, instead, positive phrases that speak to physical strength and ability are used. Some examples include "vinya wa mwĩĩ" (strength of body), "mwĩĩ mũseo" (good body), or "mavĩndĩ manou" (robust bones). Health is assumed to always be good; i.e. one either has good health or has a disease, but cannot have bad health. In the Akamba tradition, life is viewed as a spiritual journey punctuated by a single physical manifestation. As good health is assumed and the physical manifestation is derived from the spiritual, anything contrary to healthiness is presumed to have a spiritual causation. However, in contemporary

Akamba culture, attempts to separate the spiritual and the physical have made it harder to address non-fatal health concerns.

No culture is stagnant, and the Akamba historically have been open to adapting new systems that increase their ability to survive. Since change is a gradual process, the separation between the old and the new is porous, thus new perceptions are sprinkled with old beliefs that are built on a few ancient traditions. Holding on to the old premise that good health is the human norm, anomalies are seen as uncommon and rarely acknowledged unless the risk of death is obvious. This risk is highest as one nears the two transitional stages of life on earth, which are birth and old age. In traditional Akamba belief systems, birth was the earliest test of whether one would be afforded, by the spirits, the chance at life and contribute to society. Thus, infants were named four days postpartum; until then, they were still considered part of the spirit world (Krapf, 1860). In the other transitional stage, an old person would gain respect as with each passing year they came nearer the deity in both age and wisdom (Gehman, 1989).

In contemporary Akamba culture, vestiges of tradition linger concerning the beginning of a life. For example, pregnancy is rarely spoken of, even within families, and no references are made of a human until after they are born. There is no *Kikamba* noun for pregnancy; instead, when necessary, the phrases “ni muito” (she is heavy) or “ena ĩvu” (she has an abdomen) are substituted. This is because maternal and infant mortality rates are still a concern. Conversely, absent disease, any child during middle-childhood is viewed as healthy, thus making it challenging to address symptoms of malnutrition.

The high prevalence of underweight and stunting are indicators of malnutrition in Makueni children during middle-childhood. Malnutrition has a negative effect on growth and development. However, since most of the children move out of the community changing the environmental context of growth and development as early as the age of thirteen or fourteen (Figure 3), they may experience catch-up growth during adolescence as other studies have shown (Bogin, 2001; Kulin et al., 1982; Little and Gray, 1990). A comparative longitudinal study would be necessary to assess whether the children that stay in Makueni County and continue to experience nutrient scarcity, and those that leave the county exhibit similar growth patterns into adulthood.

To those that remain in Makueni County, the narrative of health needs to expand to include middle-childhood preventative healthcare and not be limited to occurrence of disease. One of the biggest challenges is the lack of the codification of malnutrition in *Kikamba*. It is possible that in ancient days, *Kikamba* words existed for different indicators of malnutrition. If so, these words have faded from common knowledge. Although the emphasis on western education promises benefits for a future generation's health outcome, currently it places a gap between the dominant caretakers, who in many cases are grandparents, and their understanding of middle-childhood health needs. To bridge this gap, the narrative of healthcare cannot simply address physical shortcomings, but must acknowledge the culture of the Akamba and the spiritual space within the current dominant context.

The Akamba's spiritual context has always been monotheistic. They believed in an unapproachable but benevolent Supreme God in a relationship mediated by

the spirits of the ancestors, however, many accepted Christianity as they understood that the Supreme God actually wanted to be in a personal relationship with mankind and had provided himself as the mediator (Krapf, 1860; Kaleli, 1985; Gehman, 1989). Thus currently, and mirroring the rest of Kenya, most Akamba are Christian (mix of both catholic and protestant). It is from the Christian spiritual perspective that stress-inducing hardships in *Ukambani* are made bearable. Insults such as food insecurity increase stress responses in the body stimulating the release of cortisol and suppressing the production of androgenic and gonadal steroids. Research shows that children in stressful situations, such as abusive environments and those suffering from post-traumatic stress disorder (PSTD) have lower DHEA/S levels in response to the high stress hormone cortisol (Kellner, 2010). The stress of living in a semi-arid, drought-prone, subsistent-farming community with high physical labor demands would similarly affect the hormonal balance. Children end up with high levels of cortisol that hinder the usual increase in middle-childhood DHEA/S production leading to decreased adiposity (Campbell, 2011). A low adiposity is noted in Makueni middle-childhood children as indicated by their low BMI. Culturally, the Akamba cope with stress through a strong sense of spiritual purpose as they engage in community with others. Coping mechanisms that diminish the awareness of stressful stimuli lower cortisol levels. Thus, the most effective healthcare narrative must marinade in the spiritual worldview of the Akamba.

The geographic area of this study is a relatively new habitat for the Akamba and most of the adults in the location can name different areas of Ukambani where their parents or grandparents immigrated from. Traditionally, the people of

Makueni and Machakos counties were very few in numbers and concentrated on the hilly regions that experience higher annual precipitation and slightly lower temperatures. The lowlands, with their rich savannah grasslands, were predominantly used as grazing grounds for their cattle and later confiscated by the British and converted to ranches. It wasn't until after Kenya's independence from Britain in 1963, and a growth in population that the people reclaimed their grazing lands and started settling the lowlands in large numbers. Where the hills have wild fruit trees and riverbeds gracing the adjoining valleys, cattle flourish in the savannah grasslands and when it rains, the plains produce an abundance of grain. However, unreliable rainfall results in adverse environmental conditions that affect the children's growth and development as noted by the elevated levels of malnutrition indicated by the high prevalence of stunting and low BMI levels across all the ages of middle-childhood. The semi-arid lowlands are now home to several generations of hundreds of thousands of Akamba people and traditional narratives of health that they may have had while occupying the northern hills are not applicable anymore. In order to achieve long term success, activities and conversations concerning preventative health should include Makueni's middle-childhood youth because of how the brain is remodeled during this stage of development.

It is in middle-childhood that habits begin to emerge and normative stress responses to their environment are shaped based on the increased androgenic hormones. Makueni children data show increased thinness marked by the decline in BMI at the age of eight that corresponds to increased brain glucose utilization, but

also due to the increase in physical activities tending to the family farms and an insufficient caloric intake to account for the added demand. These are crucial moments in Akamba cultural transformation. These children are more educated than any prior generations of Akamba people and have the advantage of experiencing some of the traditional ways through parents and grandparents. These years of habit formation provide opportunity to influence the future health narrative of the Akamba and address gender discrepancies.

Makueni girls are thinner than the boys: a difference that becomes greater during the middle-childhood years. Though all the children work on the farms; gardening, milking, caring for younger siblings etc., the introduction of additional, gendered chores contribute to great physical demand on the girls. High PAL coupled with low nutrient intake will affect the girls as they mature and cause complications in reproduction that lead to either maternal or infant mortality. In 2013 the maternal mortality rate in Kenya was 400 per 100,000 live births (WHO, 2013). Although out migration from the county may provide more options for girls it is not an ideal answer for the Akamba culture or for Kenya as a whole.

Superimposing healthcare ideas that may have worked in a different ecosystem has inherent weaknesses. A change in one or more variables cripples its chances for success. Honoring the culture by soliciting the wisdom of the elderly in combination with the ideas of resident youth can result in culturally sensitive solutions that have a better chance of taking root. As an Akamba proverb states, “Sya kunewa ni mutui iyusua ikumbi” (that which comes from the neighbor is insufficient to fill the silo) (Kaleli, 1985). When community members can participate in their

own solutions, they are empowered. It starts with the initiation of community dialog on how to approach a healthier lifestyle. This begins with a more culturally attuned redefinition of health, knowledge of current concerns and available choices and a better understanding of outcomes to the community. It is advantageous that middle-childhood children are eager to learn and the elders are willing to teach, but codification is necessary and the resources to execute, mandatory. The community does not have the resources for this initiative. However, the community's problem is a national problem.

These low BMI levels of Makueni children are at a critical status and should be cause for concern in Kenya's public health. Such low levels for almost all of the children (99.52% of the children have a low BMI<18.4) indicate that the children are not consuming enough nutrients to reach normal body energy levels (Shetty and James, 1994). Life history would support that to meet the energy demands of Makueni children living in a state of CED with daily subsistent activities and a communal culture that requires high physical participation, trade-offs are made in other areas.

The balance of energy allocation in the children's somatic growth and maintenance is affected by Makueni's adverse environmental conditions and the high amount of physical labor expenditures. As Gibson notes, the lack of adequate energy reserves leads to decreased productivity, compromised immune response and reduced memory retention (2005). These trade-offs not only affect the Makueni

children's at-home productivity and educational performance[5] but also have national effects.

The Kenya national nutrition survey ranks stunting in Makueni County as very high at 40.9 % (35.4%-46.7%) (UNOCHA, 2012). Though more research is necessary and certain variables need to be controlled for, preliminary analysis in this study of Makueni children delineated per age group shows a correlation with severity of drought and levels of stunting. In 2001, Kenya was experiencing a significant food crisis due to poor rains; 4.4 million people needed food assistance (UNOCHA, 2001). The Red Cross termed it as the worst drought in 37 years (Kenya Red Cross Society, 2010; Kanji, 2006). The 13-year olds in this sample, who were in utero and/or born that year, have the highest averages of stunting and underweight. Climatology data shows the years of major drought over the last decade were 2001, 2003, 2006, 2009 and 2011 (Venton et al., 2012). In Makueni County the prevalence of stunting seems to be higher when children were conceived or born in periods of substantial drought, but further research needs to be done to clarify this relationship (See Table 7). Other studies on the landscape of infancy and early childhood (less than five years old) show continued influence to a person's health status throughout his life span (Shonkoff, 2003; MIC, 2008; Ndiku et al 2011).

The relationship between maternal nutritional status during pregnancy and risk of underweight and stunting in their children becomes of increasing concern as incidents of drought in the region are becoming more prevalent (UNOCHA, 2006; Kenya Red Cross Society, 2010). Each generation of children born in Makueni

[5] The modern culture in Makueni emphasizes academic success as the hallmark and the children in this study viewed education as their ticket for a better future.

County is at the mercy of the climatic condition in the year they are born. This effect has been documented before in Europe. Babies conceived during the Dutch famine, a period of 6 months in World War II, had low birth weights and ended up being shorter than their parents (Kuzawa, 2007). According to Ellison and Jasienka, fetal growth and birth weight respond to the maternal metabolic environment of the womb (2007). Their research indicates that hormone levels are known to shift depending on energy expenditure; low energy results in decreased capacity that could constrain the uterus and hinder optimal growth or maternal pathology could result in a negative feedback. There is a potential that the fetal origin of adult diseases (Cameron, 2007) could be detected much earlier during middle-childhood and the risk mitigated.

The extent to which the maternal metabolic environment, the ratio of the maternal metabolic capacity and maternal metabolic load (Wells, 2010), influences the fetus and its health outlook is unknown and because so much of human growth and development must occur in the first year post birth (Schuppli et al., 2012), it could be that the environment experienced during the first year of infancy has a greater effect to the phenotypic adjustments than intrauterine conditions. In either case, fetuses and children in drought-prone ASAL environments, such as Makueni County are at increased exposure to environmental stresses that will affect their phenotype beyond their genotype.

As research continues into what has the highest impact on growth and development and at what stage of life history is the impact most deleterious, the current health outcomes of the Akamba can be drastically improved by the initiation

of these dialogs because this information parallels certain themes in traditional and contemporary Akamba beliefs and thus can be embedded in their health culture. For example, the belief that all life is spiritual and extends before birth and after death, may encourage proactive attention to prenatal care resulting in improved fetal health. Since the Akamba cultural definition of "health" conceptualizes vitality and physical strength and not the lack of disease, the emphasis in public health policies should be on preventative care and not disease cure. This will have a positive effect on the lives of middle-childhood children who, though are not plagued by diseases, are certainly experiencing various degrees of unhealthiness. Unfortunately, there is no quick solution to mitigate the adverse environmental conditions, however, the actions of individuals can be influenced toward healthier choices when an individual is empowered. In the context of the Akamba, the individual empowerment is as strong as the community support. This is the network into which Akamba life is born, growth is nurtured and health decisions are made. For the Akamba child, this is the socio-ecological context that is embedded in their biological makeup. It is this "socialized biology" (Levins and Lewontin, 1998 in Crooks et al., 2007) that can be traced in the allocation of finite energy reserves throughout the cycle of the human life history.

Conclusion

Further research is still being done on the variability of growth and development and the influence of the external and internal environments. Data from multiple studies continue to support the phenomenon of the plasticity of

phenotypic expression from such influences. Results from this study among rural Makueni Akamba children in a drought-prone environment add to this information. Though this study utilized BMI and stunting prevalence to assess malnutrition, a third useful indicator for malnutrition is wasting. To evaluate wasting, weight-for-height references are necessary, however, comprehensive references for middle-childhood in developing countries are yet to be developed even though the distinct pattern of human growth is predictable and homogenous in prepubescent children of a similar population and exposed to comparable environments. Thus, this study and other such studies in developing countries continue to provide data adding to the available reference material.

The correlation between years of major drought episodes in Makueni with a higher incidence of stunting in middle-childhood urges future studies in Makueni County to look at fetal programming as it relates to growth and development in drought-prone ASALs. Trade-offs between energy available for growth and that for maintenance are driven by several known factors and some that are yet to be discovered. In semi-arid Makueni County, trade-offs are mediated by low body energy reserves and regular high levels of physical exertion that are expected as part of survival and part of the culture. High activity demands in energy result in trade-offs to somatic growth and maintenance. The influence of these factors is not limited to the children but affects the whole community. With no reliable water supplies in Makueni, decreased rainfall and increased drought episodes adversely affect crop production and reduce food available for consumption. Declines in nutrient availability correlate with severity of drought and increase malnutrition in

children born during these periods. Thus, prenatal care interventions should be prioritized. The very idea that childhood growth is non-rigid could be a source of hope when uncontrollable conditions of stress are encountered, if intervention occurs before it's too late.

In the old days when the Akamba found themselves in an unfavorable environment, they migrated and found a more suitable area, capable of meeting their requirements for a healthier life. As a consequence of colonization and subsequent constraints of modern living some of the terms governing their ecosystem have changed. The majority of these once migratory people, known for their long distance trades that took them all over the continent, find themselves bound within a country and a county and subject to the unreliability of Africa's constantly-changing climatic conditions. Hope is scarce and needs to be redefined so that new ways of taking ownership of their health as a people can be effectively explored.

Figures and Illustrations

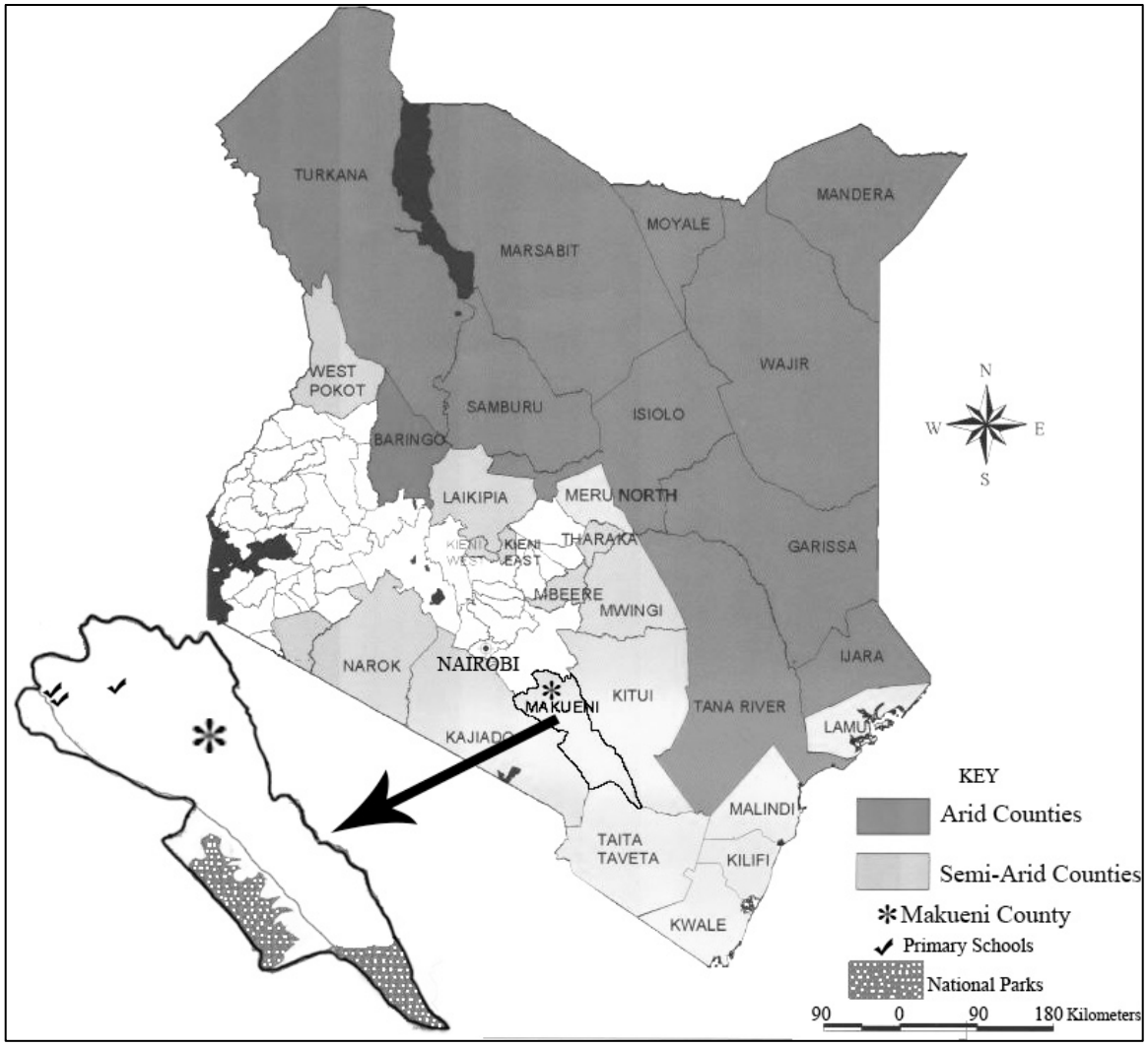

Figure 1: Map of Kenya Showing Arid and Semi-Arid Counties and Location of Makueni County

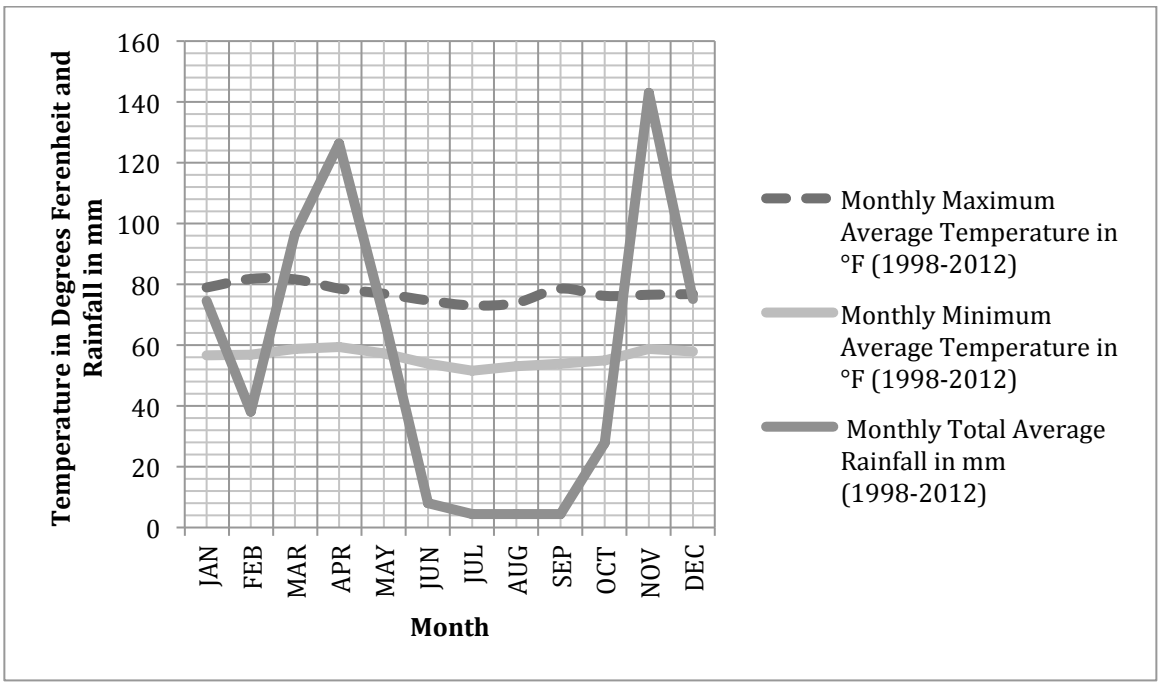

Figure 1: Makueni Area Average Monthly Minimum and Maximum Temperature and Average Rainfall from 1998 to 2012 (KMD, 2015).

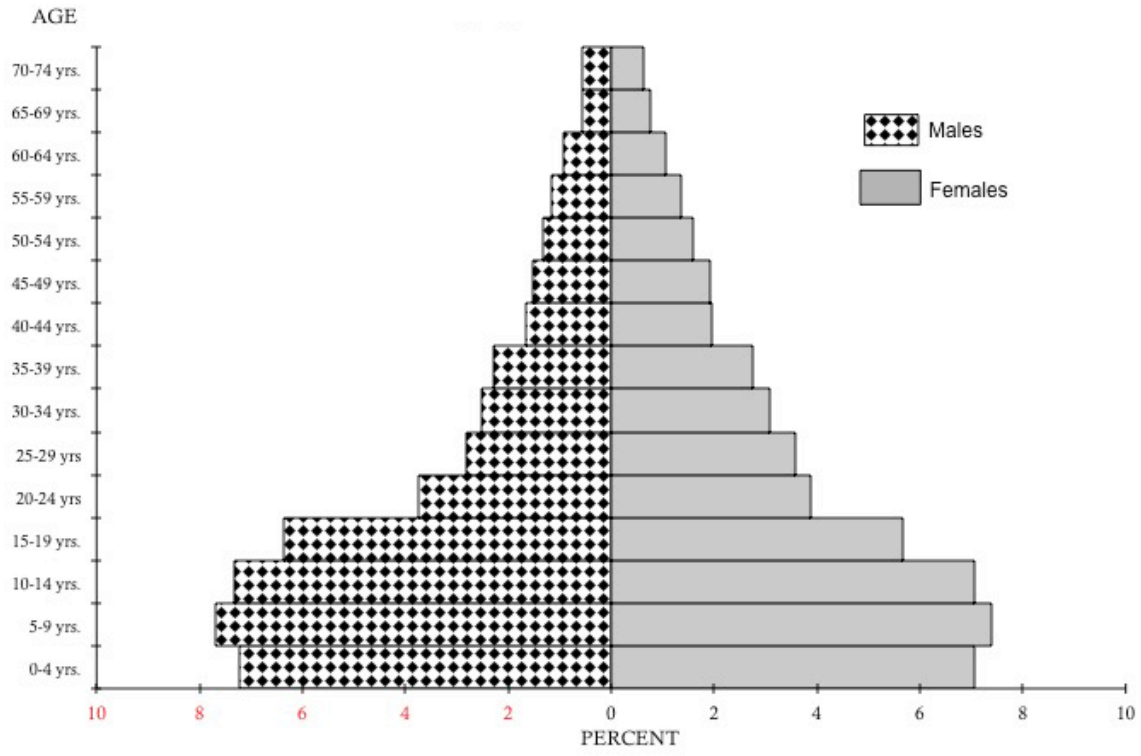

Figure 3: Makueni County Age-Sex Population Distribution based on 2009 National Census (KNBS, 2009)

Table 1: Makueni County Basic Demographic Indicators

Makueni County Basic demographic indicators		
Indicator	2005-2009 Makueni County	2012 Makueni County Report (MCIDP, 2013)
Population	884,527*	922,183
Density (pop./km2)	110*	203
Crude Birth Rate	44.7/1000[b]	44.7/1000
Crude Death Rate	7/1000[b]	13.9/1000
Total Fertility Rate	4.7[b]	5.1
Infant Mortality rate (IMR)	42/1000[a]	45/1000
Under five years Mortality rate (U5MR)	51/1000[a]	84/1000
Life Expectancy	68[b]	67
(*KNBS, 2014; [a] KDHS, 2010; [b] NCAPD, 2005)		

Table 2: Sample Size of Makueni Children per Age and Sex Distribution

	Total		**Boys**		**Girls**		**Ratio**
Age (years)	**no.**	**%**		**%**	**no.**	**%**	**Boy : Girl**
5	2	0.42	1	0.42	1	0.43	**1:1**
6	36	7.63	10	4.20	26	11.11	**0.28:1**
7	57	12.08	29	12.18	28	11.97	**1.04:1**
8	44	9.32	29	12.18	15	6.41	**1.93:1**
9	40	8.47	20	8.40	20	8.55	**1:1**
10	74	15.68	43	18.07	31	13.25	**1.39:1**
11	65	13.77	24	10.08	41	17.52	**0.59:1**
12	68	14.41	42	17.65	26	11.11	**1.62:1**
13	57	12.08	26	10.92	31	13.25	**0.84:1**
14	24	5.08	11	4.62	13	5.56	**0.85:1**
15	5	1.06	3	1.26	2	0.85	**1.5:1**
Total	**472**	**100**	**238**	**50.42**	**234**	**49.58**	**1.02:1**

Table 3: Means and standard deviations for selected anthropometric measurements of Akamba primary school girls in Makueni County, Kenya in 2014. The data are cross-sectional for girls aged five to fifteen years.

Age in years	Weight in cm		Height in Kg		MUAC in cm		Head Circumference (H.C.) in cm		Triceps Skinfold (T.S) in mm	
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
Girls										
5	15.10	N/A	102.40	N/A	13.90	N/A	50.50	N/A	7.00	N/A
6	18.38	1.97	112.14	3.87	14.84	1.49	49.85	1.31	6.58	2.44
7	19.94	2.22	116.51	6.29	15.11	1.29	49.24	1.82	6.18	2.23
8	22.55	3.12	121.17	6.44	15.62	1.15	49.99	2.14	6.80	1.78
9	24.79	2.88	127.41	5.21	16.88	1.55	50.51	1.66	6.40	1.98
10	26.69	3.87	133.16	5.88	16.78	1.69	50.76	1.60	7.10	3.24
11	28.49	4.38	136.20	6.62	16.92	1.79	50.86	2.01	7.07	3.37
12	31.27	4.03	141.34	5.60	17.99	1.61	51.92	0.97	7.73	3.13
13	33.81	4.98	144.15	5.77	23.27	1.34	51.70	1.63	8.06	3.08
14	41.72	5.75	153.15	6.15	19.69	1.66	52.32	1.51	9.54	3.18
15	47.55	1.77	157.85	11.10	20.60	1.56	52.15	0.21	5.50	0.71

Table 4: Means and standard deviations for selected anthropometric measurements of Akamba primary school boys in Makueni County, Kenya in 2014. The data are cross-sectional for girls aged five to fifteen years.

Age in years	Weight in cm		Height in Kg		MUAC in cm		Head Circumference (H.C.) in cm		Triceps Skinfold (T.S) in mm	
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
Boys										
5	15.10	N/A	102.80	N/A	15.20	N/A	48.10	N/A	4	N/A
6	19.09	1.89	114.45	3.41	14.89	1.03	50.77	1.56	5.20	2.30
7	21.50	4.30	117.46	5.65	15.34	2.23	50.82	1.32	6.28	3.45
8	22.06	2.60	120.32	5.78	15.52	1.44	51.35	1.69	6.24	3.26
9	23.51	2.81	125.78	5.10	15.82	1.63	51.55	1.61	5.05	1.88
10	26.51	2.98	131.45	5.38	16.21	1.62	51.67	1.96	6.37	2.93

11	28.40	3.98	134.6	6.35	17.26	1.70	52.20	1.52	5.17	2.55
12	30.41	3.81	140.16	5.63	17.22	1.66	52.35	1.53	5.21	2.23
13	32.73	3.63	143.66	6.37	17.47	1.20	52.74	1.50	6.31	2.41
14	39.07	3.82	151.83	6.39	19.76	1.09	53.10	1.92	5.18	1.17
15	45.20	6.61	161.33	10.70	19.70	1.35	53.90	2.29	5.67	2.89

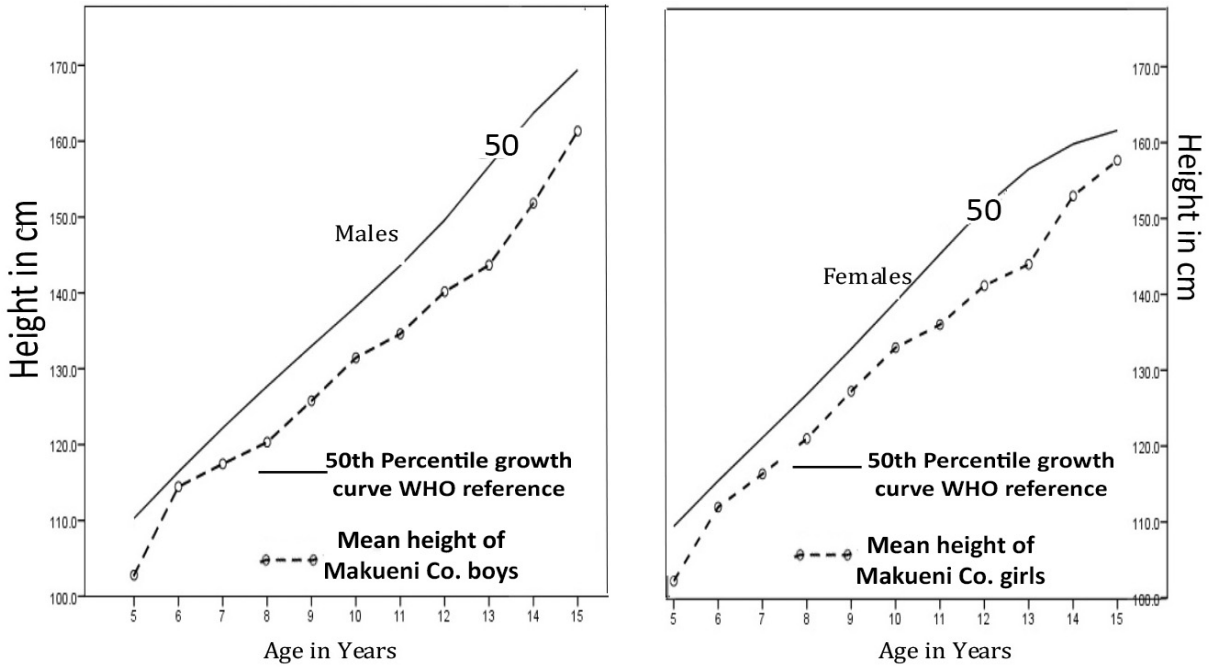

Figure 5: Mean Height of Makueni children compared with 50th percentile curves (WHO reference, 2007)

	All n = 471	**Boys** n = 238	**Girls** n = 233
Prevalence of stunting (<-2 z-score)	78 (16.56%) (95% C.I = 13.38-20.30)	43 (18.07%) (95% C.I = 13.39 – 23.55.)	35 (15.02%) (95% C.I = 10.69-20.27)
Prevalence of severe stunting (<-3 z-score)	11 (2.34%) (95% C.I = 1.23-4.27)	6 (2.52%) (95% C.I = 0.93 - 5.41)	5 (2.15%) (95% C.I = 0.70 - 4.94)
Total Prevalence	89 (18.9%)	49(20.59%)	40(17.17%)

Table 5 : Prevalence of stunting and severe stunting among Makueni boys and girls in 2014 based on height-for-age z-scores WHO 2007 References

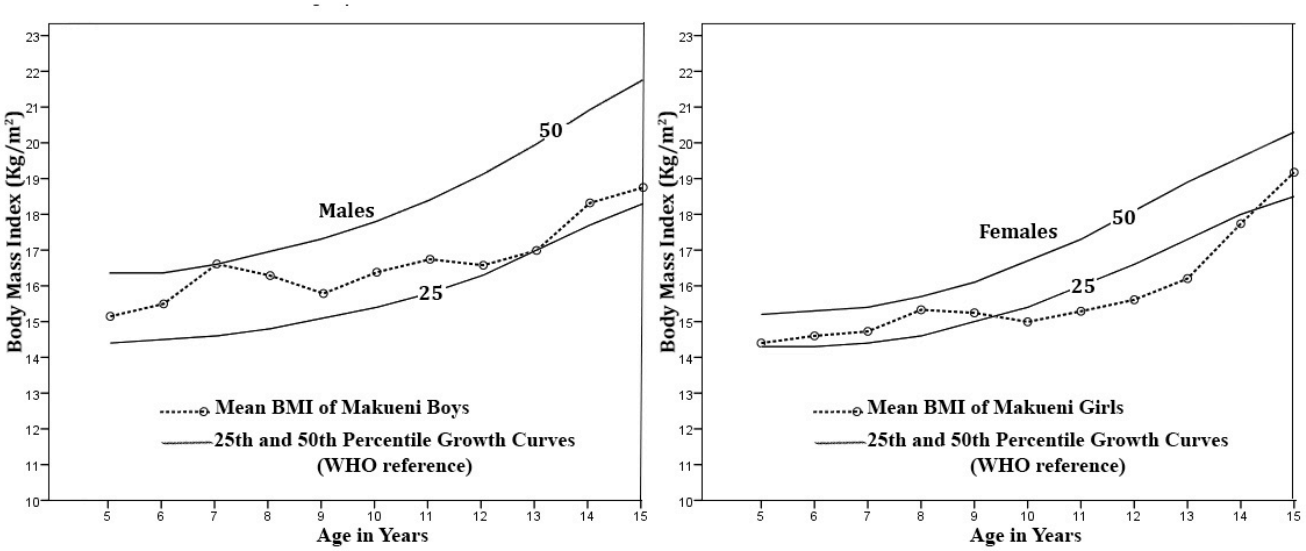

Figure 6: Mean BMI per age for Makueni County boys and girls in 2014 compared with 25th and 50th percentile curves (WHO reference 2007)

Table 6: Prevalence of Chronic Energy Deficiency in Makueni County Children in 2014.

BMI Grades of Chronic Energy Deficiency	Frequency	Percent
Normal (>18.5-24.99)	23	4.88 % (3.19 – 7.35 95% C.I.)
Grade I (17.0-18.4)	41	8.70 % (6.39 – 11.72 95% C.I.)
Grade II (16-16.9)	82	17.41 % (14.16 – 21.21 95% C.I.)
Grade III (<16.0 Severe underweight)	325	69.00 % (64.58 – 73.11 95% C.I.)
TOTAL	**471**	**100.00 %**

Table 7: Independent Samples Test between Makueni Middle-Childhood boys and girls (6-13 years old) comparing means of anthropometric measurements.

Anthropometric Measurement (Mean)	Boys Mean and S.D.	Girls Mean and S.D.	t–value	p–Value (α = 0.05)
Weight	26.33 kg +/- 5.33	26.30 kg +/- 6.26	t(440) =0.072	p= 0.943
Height	130.31 cm +/- 10.97	130.27 cm +/- 12.37	t(441) =0.037	p = 0.970
MUAC	16.36 cm +/- 1.83	17.36 cm +/- 11.09	t(441) = -1.305	p=0.193
Head Circumference	51.78 cm +/- 1.71	50.68 cm +/- 1.85	t(440) = 6.461	p= 0.000
Triceps Skinfold	5.82 mm +/-2.75	7.04cm +/- 2.87	t(441) = -4.582	p = 0.000

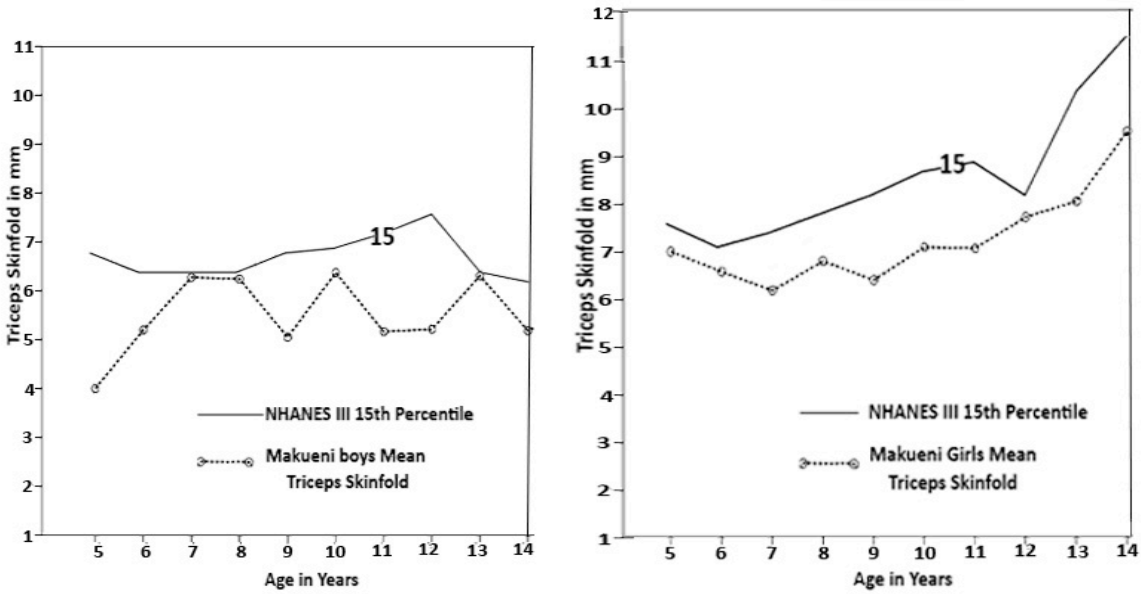

Figure 8: Triceps skinfold measurement of Makueni boys and girls compared to the 15th percentile of 1988-94 American Children (NHANES III)

Table 7: Major drought years reported by KFSSG, the severity of drought shown by the number of Kenyans affected and the prevalence of stunting in Makueni Children

Year	Number of People affected by drought (UNOCHA 2001; Grunewald et al., 2006)	Current Age of Study Children Born	Percentage of Stunted Makueni Children per Age-Group
2001(major drought)	4 million	13 year olds	***40.35%**
2002	-	12 year olds	13.24%
2003(major drought)	2.23 million	11 year olds	***21.54%**
2004	-	10 year olds	13.5%
2005	-	9 year olds	2.5%
2006 (major drought)	2.97 million	8 year olds	***22.73%**
2007	-	7 year olds	7.14%
2008	-	6 year olds	2.78%

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