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The Prevalence of Essential Hypertension in Kasigau, Kenya

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THE PREVALENCE OF ESSENTIAL HYPERTENSION IN KASIGAU, KENYA

A Capstone Experience/Thesis Project

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Honors College Graduate Distinction at Western Kentucky University

By

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ABSTRACT

Hypertension is the leading cause of cardiovascular disease worldwide. Cardiovascular disease (CVD) is a widespread chronic non-communicable disease (NCD) which is on the rise in developing countries. Evidence based on extensive research studies on risk factors for NCDs suggests that they could be easily significantly decreased by simply controlling their risk factors. Although high blood pressure has been recognized as a leading risk factor for CVD, little research has been done to document the prevalence and incidence of essential hypertension (EH) in lower socioeconomic developing countries. One such country is Kenya. It was found in our research study that Kasigau has an extremely high prevalence of EH. Sixty seven percent of the population had stage 1 or stage 2 hypertension. No known risk factors showed a significant correlation with systolic blood pressure, and therefore it was determined that the high prevalence of EH in Kasigau could be contributed to ulterior causation; possibly a genetic mutation that causes salt hypersensitivity.

Keywords: essential hypertension, cardiovascular disease, Kenya, Kasigau, non-communicable disease, blood pressure

Dedicated to the people of Kasigau and my family and friends

ACKNOWLEDGEMENTS

There are so many people that deserve credit for the success of this project. First and foremost, I would like to thank my Lord and Savior Jesus Christ for blessing me beyond compare, and putting the right people in my path and having me exactly where He wants me so that His plans for me can succeed.

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I would like to thank the entire University for supporting me in many ways but especially monetarily, and placing such an emphasis on research and providing the funding for incredible learning opportunities such as Medicine in Kenya and the research component that goes along with it.

I would be remiss to not thank my parents for also supporting me in virtually every endeavor I set my sights on, and instilling in me a thirst for not only knowledge, but helping others. Mom, thank you for letting me go to Kenya, even in the dangerous times.

A special thanks also to my friends who stuck with me, even though I spent a majority of my time spring 2012 in the library.

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CHAPTER 1

INTRODUCTION

The World Health Organization (WHO) estimates that 36 million of the 57 million deaths that occurred worldwide in 2008 were due to non-communicable diseases (NCD) making this the leading cause of death with a 63% mortality rate [1]. Non-communicable diseases include cardiovascular disease, stroke, cancer, chronic respiratory disease, and diabetes. They are termed non-communicable, because, unlike infectious diseases such as HIV, malaria, and tuberculosis, they cannot be passed from individual to individual. One of the major effects of NCD is premature death *i.e*. death before the age of 60 with 29% of these deaths occurring in low and middle-income countries in 2008 [2]. Fortunately, according to WHO data, 80% of deaths due to NCD such as cardiovascular disease (CVD), stroke, and diabetes could be prevented by simply controlling the risk factors. Known risk factors for NCD include alcohol and tobacco use, obesity, physical inactivity, unhealthy diet, high blood pressure, high blood glucose levels, and high cholesterol [2].

The increase of NCD mortality is of particular significance in developing countries. The WHO estimates that in 10 years global NCD deaths will increase by 17%. This number is even greater in developing African nations (27% increase), among them, Kenya [3]. The leading causes of NCD mortality globally were CVD, cancers, and

respiratory diseases. CVD comprised 21% of these deaths with a total of 17 million deaths in 2008. Eighty percent of the NCD deaths due to either diabetes or CVD occurred in developing countries [2].

Kenya, a sub-Saharan country in east Africa, has a population of approximately 39 million people. Less than one fourth of the population lives in urban centers; the majority of Kenyans reside in rural areas and exist on less than $1 per day [4]. Kenya boarders the Indian Ocean and is located on the equator in a mostly arid or semi-arid

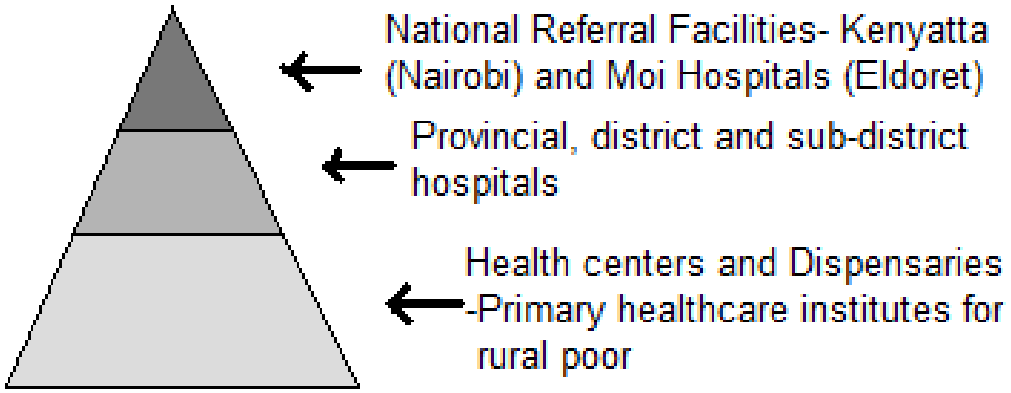

Figure 1. Healthcare infrastructure in Kenya

environment. The Kenyan healthcare system is a pyramid-like structure, with only two national referral hospitals, Jomo Kenyatta Hospital and Moi Hospital, which form the apex of the system. The rest of the country is divided into districts which have a few district-level hospitals and provincial clinics (Figure 1). Most of the care, however, is provided by the rural health centers and dispensaries. This pyramidal system is government run by both the Ministry of Medical Services and the Ministry of Public Health & Sanitation. Kenya averages 15 doctors per 100,000 people, with a concentration of physicians in the urban areas of Nairobi and Mombasa [4]. As shown in

Figure 2, infant, child, and adult mortality rates are significantly higher in Africa and Kenya as compared to the rest of the world [5].

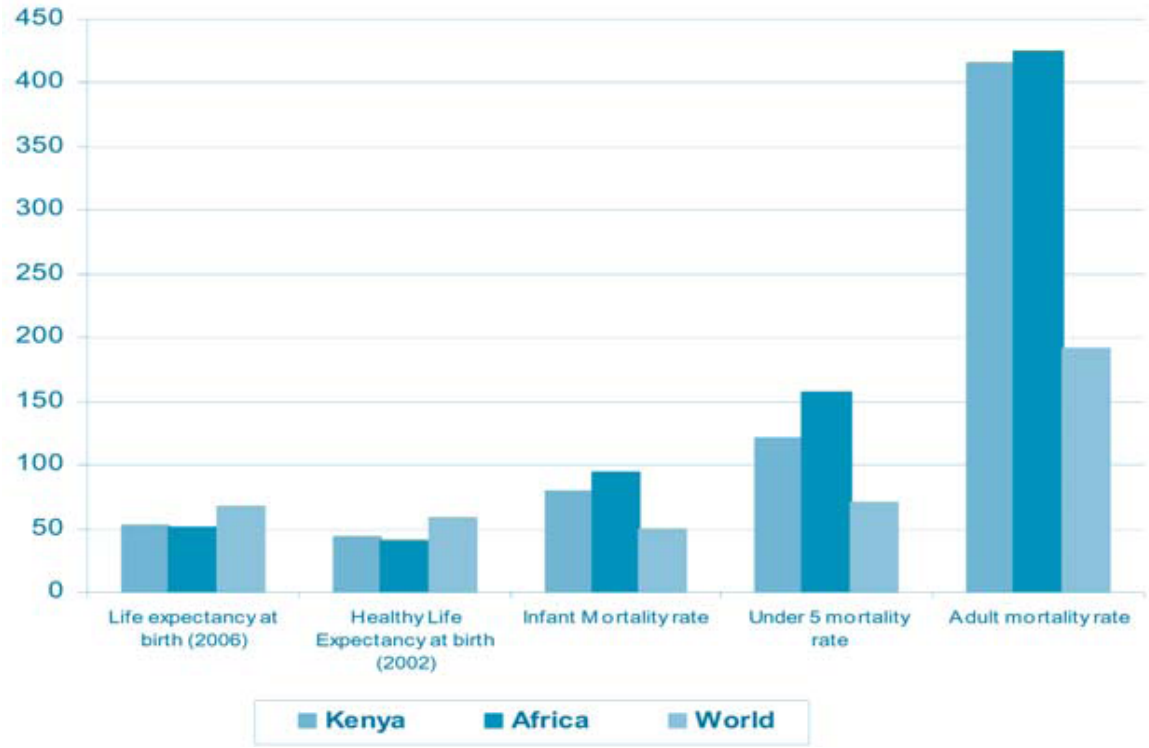

Figure 2. Health impact in Kenya, compared to Africa and the rest of the world. Kenya and Africa are compared to the rest of the world for general population health indicators such as life expectancy, infant mortality rates and adult mortality rates. The adult mortality rates for Kenya and Africa increase dramatically compared to the rest of the globe.

As previously mentioned, one of the key risk factors in development of NCD, and in particular CVD is chronic high blood pressure or hypertension [6]. There are two categories of hypertension; essential hypertension (EH) is high blood pressure without a diagnosable cause, and secondary hypertension is high blood pressure that occurs as a result of another systemic disease. The majority of hypertension cases are primary or EH.

Blood pressure evaluation consists of a systolic (resulting from ventricular contraction) measurement and a diastolic (ventricular relaxation) measurement, both

expressed in mmHg. Normal blood pressure is considered 120/80 mmHg. Pre-hypertensive is characterized by 120-139 systolic and 80-89 diastolic pressures. This stage is optimally treated with medication. Stage 1 hypertensive is characterized by 140-159 systolic and 90-99 diastolic pressures. Levels above the stage 1 range qualify as Stage 2 hypertensive, and medications are required to avoid a cardiac emergency [7]. Cardiovascular disease has become a pandemic in developing countries that lack the simple infrastructure, support, and resources to fight NCDs. The WHO and the United Nations have placed significant importance on the reduction of CVD through combating its risk factors, including EH. In spite of this, little research has been conducted in these third world countries with regard to EH prevalence.

The region of Kasigau is located in the Taita-Taveta District of Southern Kenya. The Taita-Taveta District covers a 17,128 km^2 area of land and is subdivided into 7 sections with the most prominent division being that of Voi [8]. According to the 2009 census, Kasigau has a population of 13,696 people comprising 2,742 households [9]. Kasigau can be further divided into 3 sub-locations and 7 total villages. Sub-location Rukanga contains 29% of the population spread across 4 villages (Rukanga, Jora, Ngambenyi, and Bungule). Sub-location Makwasinyi makes up 21% of the total population and is comprised of 3 villages (Makwasinyi, Kisimenyi, and Kiteghe). Finally, the sub-location Buguta is home to 50% of the Kasigau population [9]. East and West Tsavo National Parks make up 62% of the land mass in this District with Kasigau essentially situated between the parks. As a result, residents struggle with wildlife interaction and conflict as a wide variety of native species, mainly elephants, inhabit and

migrate through this biologically diverse ecosystem in the shadow of Mt. Kasigau. However, the local economy in Kasigau is bolstered due to the proximity of the parks and the resulting tourism industry [8].

Figure 3. Map of Kenya showing the Taita Hills with respect to Nairobi, Kenya's capitol city, and Mombasa, their coastal city [10].

The residents of Kasigau are predominately part of the Taita tribe and are subsistence farmers. The villages are situated in the Eastern Arc Mountains, one third of the distance between the Taita Hills and the Indian Ocean (Figure 3). The closest city, Voi, is located 60 km from Kasigau. Voi is home to the nearest provincial hospital, although Kasigau residents rely primarily on their local health center (Rukanga) and

dispensaries (Buguta and Makwasinyi), as transportation to Voi is unaffordable to most. The regional farming, and thus livelihood of the Kasigau people, is constantly vulnerable because of drought and crop destruction by way of elephant migration [8].

"Partners in Caring: Medicine in Kenya" is a service learning program constructed on the relationships that have been forged between Western Kentucky University's Department of Biology, the Kasigau region, and the University of Nairobi. Medicine in Kenya is a January-term course offered through Western Kentucky University in which a team of ~18 people (3 doctors, 12 students, 1 faculty member, and 2 volunteers) travel to Kenya for 2 weeks. The 2012 visit was the fourth trip by this program within the last five years. The goals of "Partners in Caring" include increasing the promotion of health and disease prevention with sustainable techniques and community oriented work while providing a valuable, substantive global experience for premedical undergraduate students. The participating students garner an increased appreciation and awareness of, not only Kenyan culture, but developing third-world countries in general and the epidemiological issues with which they are confronted. Partners in Caring attempts to not only identify the needs of the Kasigau community and act on those needs through engaging activities that promote the local quality of life, but also to generate a sense of social responsibility in the participating pre-professional students.

During the seven day clinical portion of the mission, the physicians and students conduct patient examinations in the local healthcare facilities with the help of the local Ministry of Public Health and Sanitation healthcare practitioners. Numerous patients (typically over 1,000) travel from the surrounding villages to be examined by the team.

An additional research component was added to the program in 2012. The goal of the research component was to quantify the prevalence of hypertension in the Kasigau area in order to provide a foundation for further research investigating its cause.

This research will be some of the first of its kind in the field of evolving third world epidemiology. Even though high priority has been placed on managing NCD risk factors, including hypertension, by organizations such as the WHO, few reported studies exist. Long term studies will also investigate the genetic basis of high blood pressure, hypothesizing that the people have a high prevalence of hypertension that is a result of polymorphic and/or epigenetic changes in the renin-angiotensin gene system. Therefore, in this work we will determine if indeed there is an abnormal prevalence of EH in this region and the anthropometric factors tied to the EH. Follow-up studies will be conducted to determine if any environmental or behavioral risk factors can be correlated to the occurrence of EH. Collectively these studies will provide key epidemiological and genetic information that will help formulate approaches to prevent, treat, and/or control hypertension leading to higher quality of life, decreased risk of developing a non-communicable disease such as CVD, and a lessened burden of NCD upon Kenya and similar countries.

CHAPTER 2

METHODS

The purpose of this study was to acquire initial data on EH occurrence in Kasigau, Kenya, in order to provide a foundation for future research on EH and other NCD risk factors in this area with the ultimate objective of lowering CVD in this area. A long-term goal of this study is to inform the Kenyan Ministry of Health of the results and assist them in developing a cost-effective plan for EH management in Kasigau. In order to accomplish this, I evaluated the frequency of common risk factors associated with EH including high body mass index (BMI), high waist to hip ratio (WHR), and high cholesterol levels. A secondary study is also underway which analyzes the more intangible risk factors that are based on socio-economic parameters such as income, stress levels, job, education, diet, etc. Future research that will follow this preliminary study will be conducted with the goal of providing genetic evidence for the elevated incidence of EH in Kasigau, Kenya.

The prevalence of hypertension was assessed using a survey based approach in connection with diagnostic testing in a community-based participatory context. According to the Centre for Community Based Research, this style of research is "community situated, collaborative, and action-oriented" [11]. The study site was Kasigau, Kenya and community members served as both participants and research

assistants in this collaboration. Hypertension is a significant health problem identified by the community. As a characteristic of the community based research method, the study participants had an active part in dictating the direction and the success of the research through their input, thus they are empowered and invested in the study.

Participant Selection

Residents of the 7 Kasigau villages (Jora, Rukanga, Makwasinyi, Bungule, Kiteghe, Ngambenyi, and Buguta) were invited to participate in our research study. The 7 villages were chosen because: 1) they are the most populous 2) 3 of them have government supported health centers and 3) they are very accessible. A 2009 population census dictated the formation of a stratified random sample by the natural population representation of the 3 sub-locations (29% Rukanga, 21% Makwasinyi, 50% Buguta) [9]. Participants in the study were 45 years of age or older, with 50% males and 50% females included in the study. Four hundred individuals were recruited to take part in the study, although only ~200 individuals finally participated in the study. Participants were required to go to a health assessment interview held in their respective village in December 2011/January 2012. This study was approved by WKU's Human Subjects Review Board and the Taita District Health Officer in Kenya, as well as the village chiefs/elders (Appendix 1). All investigators completed the CITI Program Training Modules before any research on human subjects was conducted, and the Human Subjects Review Board (HSRB) provided an Informed Consent Document to be read to and agreed upon by all survey participants (Appendix 2).

Data Collected

For each participant, the following data were collected: height measured to the nearest cm; weight measured to the nearest kg in the absence of footwear or heavy garments; the average of 3 blood pressure readings taken after 5 minutes of sitting; umbilical waist circumference to the nearest cm and hip circumference to the nearest cm; blood cholesterol levels determined by a hand held meter (Accutrend plus).

Raw data were analyzed to determine body mass index (BMI), (the percent body fat of a person), waist/hip circumference ratio (WHR), and cholesterol levels. BMI was calculated by weight in kg divided by the square of the individual's height (kg/m^2). For waist to hip ratio data, the waist circumference value was simply placed in the numerator above the hip circumference. The statistical One-way ANOVA and Pearson Correlation analyses were performed using the statistical processing package, SigmaPlot (version 3.5). When normality was not achieved a Dunn's method One-way ANOVA was used to determine variance.

CHAPTER 3

RESULTS

To quantify the prevalence of EH in the community of Kasigau and correlate the amount of hypertension to known risk factors including obesity, high BMI, high cholesterol levels and high WHR, 161 individuals were assessed from 3 sub-locations in Kasigau; Buguta, Makwasinyi, and Rukanga [6]. The total number of participants from each sub-location was as follows: Buguta *n*=67, Makwasinyi *n*=31, and Rukanga *n*=63.

Differences in means were analyzed via ANOVA statistical tests, and correlations between blood pressure and other anthropometric values were determined by Pearson correlations using SigmaPlot 3.5. This allowed us to look at differences in EH across village sub-locations, and whether these risk factors significantly contributing to the EH seen in the region.

EH was defined based on the value given by the Joint National Committee (JNC) as a blood pressure of 140/90 mmHg or higher [12].

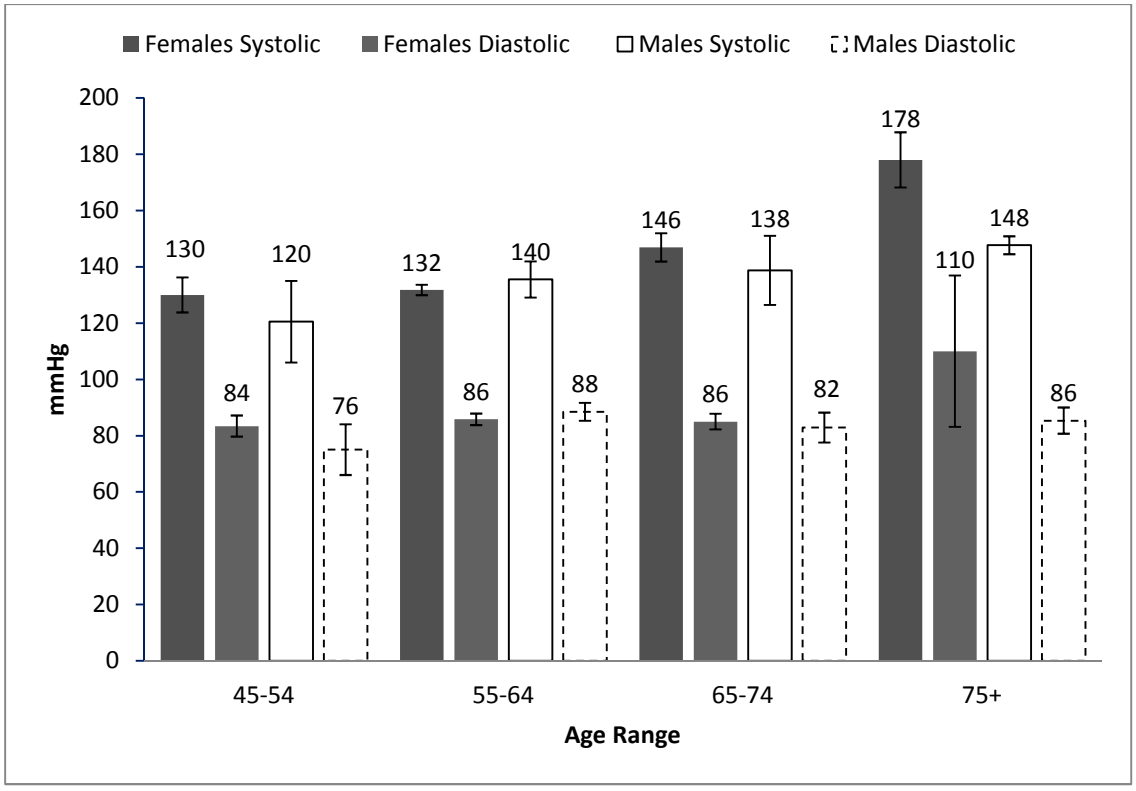

Figure 4a. Buguta Blood Pressure- The average blood pressure of participants from Buguta based on age and gender. *n*=67; Error bars represent standard error.

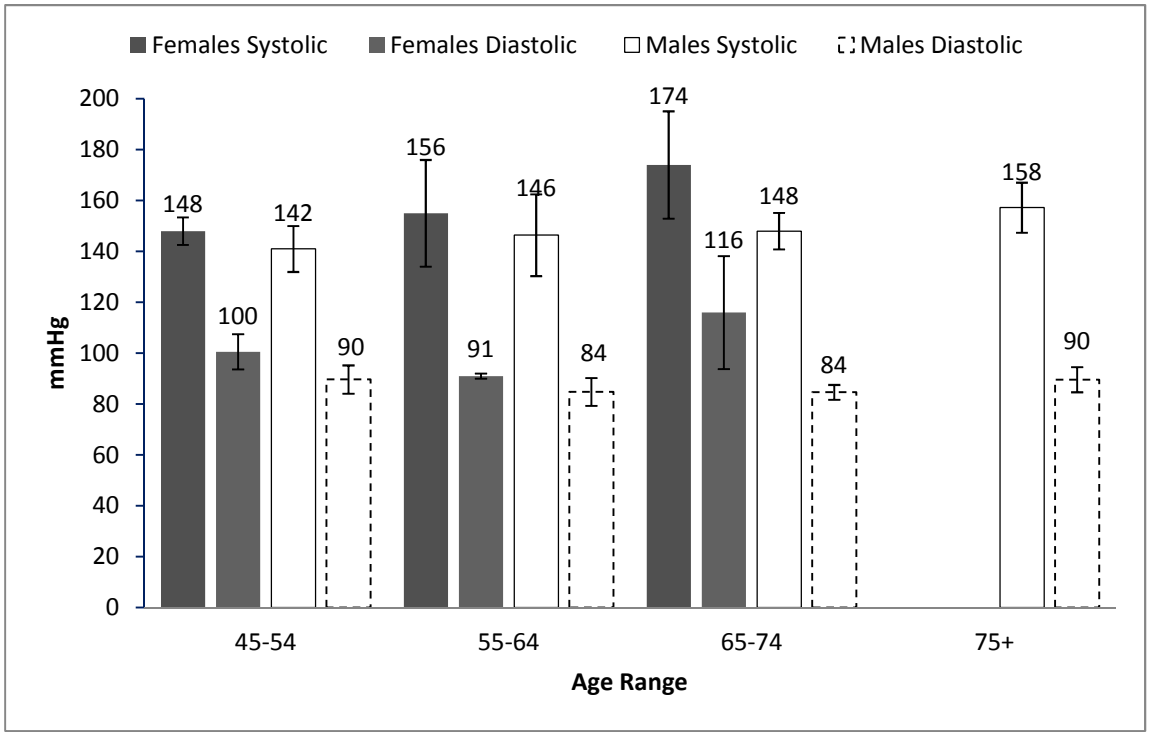

Figure 4b. Makwasinyi Blood Pressure- The average blood pressure of participants from Makwasinyi based on age and gender. *n*=31; but no females in the 75+ category. Error bars represent standard error.

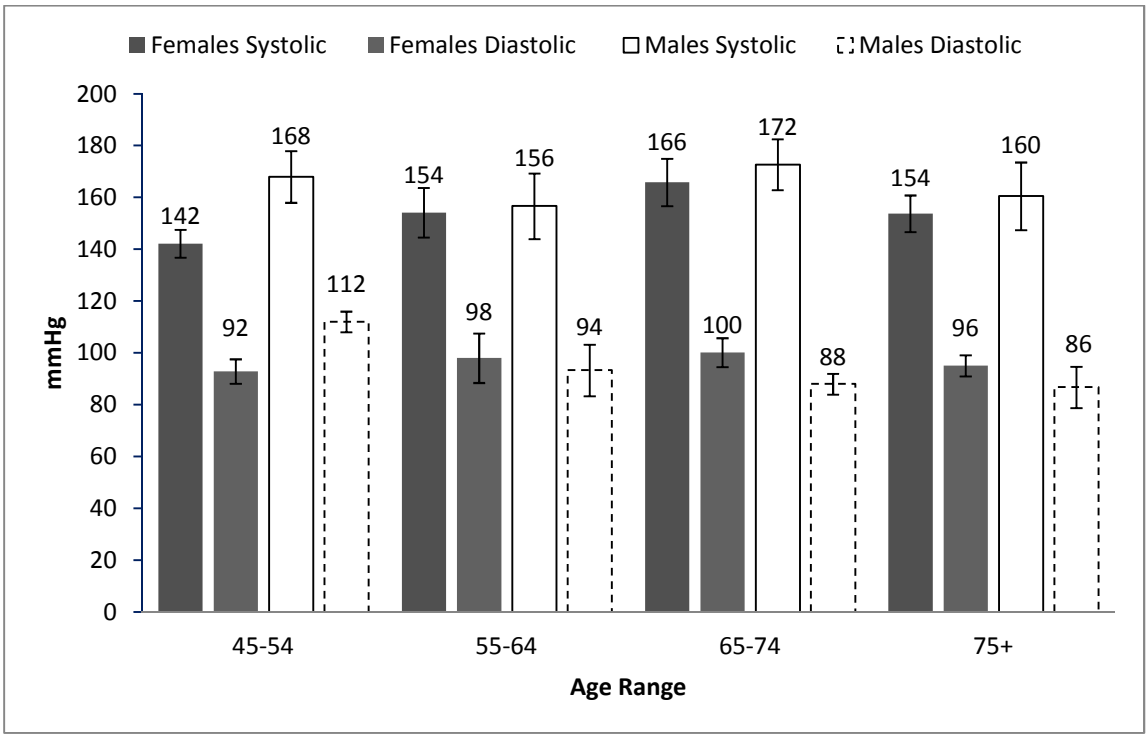

Figure 4c. Rukanga Blood Pressure- The average blood pressure of participants from Rukanga based on age and gender. *n*=63; error bars represent standard error.

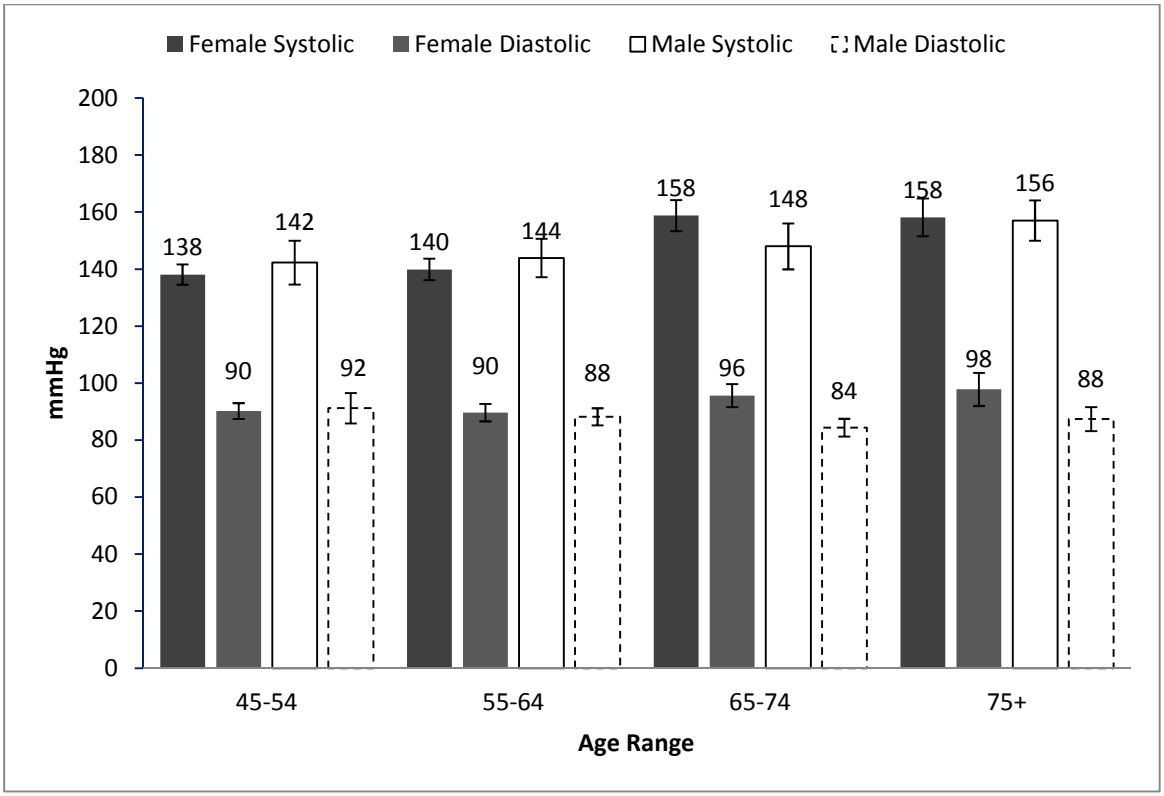

Figure 4d. Kasigau Blood Pressure.-The average blood pressure of the entire Kasigau region based on age and gender. *n*=161 error bars represent standard error.

When analyzed based upon sub-location, all female age groups and most male age groups in our study from Buguta had blood pressures above 120/80 mmHg with the exception of males between 45-54 years old (120/76mmHg) (Figure 4a). In Makwasinyi, all averages for each gender and each age range were above the healthy range for blood pressure. The lowest average was 142/90 mmHg which occurred in the males 45-54 years old (Figure 4b). Rukanga shows a similar trend, with neither gender nor age range of participant having a healthy blood pressure average (Figure 4c). The lowest average blood pressure in Rukanga was 142/92 mmHg for the females age 45-54. Figure 4d shows the averages for the entire community of Kasigau. Their lowest average blood pressure was 138/90 mmHg for the 45-54 year old females, which is still well over the healthy blood pressure 120/80 mmHg. Collectively from this work we can determine that the people of Kasigau do have EH in ranges greater than 140/90 mmHg, also considered stage 1. The absolute values are higher in older persons as would be expected (Figure 4d).

Moreover, based upon One-way ANOVA analyses, males in Rukanga have a statistically significant variance from males in Buguta when comparing systolic blood pressures (Table 1). The ANOVA also revealed variance in systolic blood pressure when comparing Rukanga to Buguta and Makwasinyi to Buguta regardless of gender (Table 2). The average systolic blood pressure in Buguta was 136 mmHg, while the average systolic blood pressure for Makwasinyi and Rukanga was 150 mmHg and 156 mmHg, respectively. Thus, Buguta had a significantly lower blood pressure than the other two

sub-locations regardless of gender. When diastolic blood pressure was compared in Table 1, Rukanga versus Buguta sub-locations as a whole demonstrated variance, as well as females in Makwasinyi compared to females in Buguta, and females in Rukanga compared to Buguta ($p<0.05$).

Factor	Comparison	Diff of Ranks	Q	p <0.05
Systolic	M Ruk vs M Bug	46.064	2.948	Yes
	F Mak vs F Bug	45.203	3.035	Yes
	F Ruk vs F Bug	28.538	2.988	Yes
	M Ruk vs M Mak	24.012	1.537	No
	M Ruk vs F Ruk	18.428	1.379	No
	F Mak vs F Bug	35.886	2.410	No
	F Mak vs M Mak	12.980	0.765	No
	F Mak vs F Ruk	7.397	0.496	No
	F Ruk vs F Bug	28.489	2.983	No
	M Mak vs M Bug	22.053	1.476	No
	M Bug vs F Bug	0.853	0.0681	No
	M Ruk vs M Mak	24.012	1.537	No
	M Ruk vs F Ruk	18.428	1.379	No
Diastolic	Rukanga vs Buguta	24.429	3.000	Yes
	F Mak vs M Mak	36.064	2.124	No
	F Mak vs F Ruk	16.665	1.117	No
	F Ruk vs M Ruk	14.887	1.114	No
	M Ruk vs M Bug	12.722	0.814	No
	M Ruk vs M Mak	4.512	0.289	No
	M Mak vs M Bug	8.211	0.550	No
	M Bug vs F Bug	0.929	0.0742	No

Table 1. Analysis of Variance in Blood Pressure based upon Gender and Sub-location- The data show a comparison of systolic blood pressure and diastolic blood pressure using a One Way ANOVA across the various parameters. Data that did show significant variance ($p<0.05$) is listed first. The other comparisons made were not significant ($p>0.05$).

Factor	Comparison	Diff of Means	t	Unadjusted p	Critical Level
Systolic BP	Rukanga vs Buguta	18.374	4.221	.0000412	.017
	Makwasinyi vs Buguta	14.036	2.619	.00969	.025
	Rukanga vs Makwasinyi	4.339	0.801	0.424	0.050

Table 2. Analysis of Variance in Blood Pressure based upon Sub-location- A comparison of systolic blood pressure across the Kasigau sub-locations determined significant by the Critical Level values obtained from One-way ANOVA test of variance using the Holm-Sidak method. The data in table 2 was determined to be significant if the critical level was greater than 0.050. A significant critical level meant that data varied enough that difference in compared groups was unlikely just by chance. Rukanga compared with Makwasinyi was non-significant.

The healthy, normal range of blood pressure (120/80 mmHg) requires no medication. Within the pre-hypertensive range (120/80 mmHg-140/90 mmHg) it is up to the health care provider's discretion whether drugs to aid in lowing blood pressure are prescribed, but typically behavior modifications are suggested. In western medicine in particular, Stage 1 hypertension (140/90 mmHg-160/100 mmHg) is the typical range in which medication administration begins, and a great increase in CVD risk occurs [13]. If an individual's blood pressure exceeds this, they fall into the Stage 2 hypertension category (160/100 mmHg +), and medication is necessary to prevent an imminent cardiac event or other complication [6].

Overall, of the 159 study participants, 88 had systolic blood pressure above 140 mmHg which is the stage 1 or stage 2 hypertensive range (55.3%) and 74 had diastolic blood pressure greater than 90 mmHg which is the stage 1 or stage 2 hypertensive range (46.5%) (Figure 5). Many individuals fell within the pre-hypertensive range (120-140 systolic/80-90 diastolic) and only 22 individuals (13.8%) were within the healthy

range for systolic blood pressure. Only 40 individuals (25.2%) had a healthy diastolic blood pressure. Systolic blood pressure is a more accurate predictor for cardiovascular problems than diastolic blood pressure among older populations especially, so systolic value will be the primary comparison tool that will be used in this study [6].

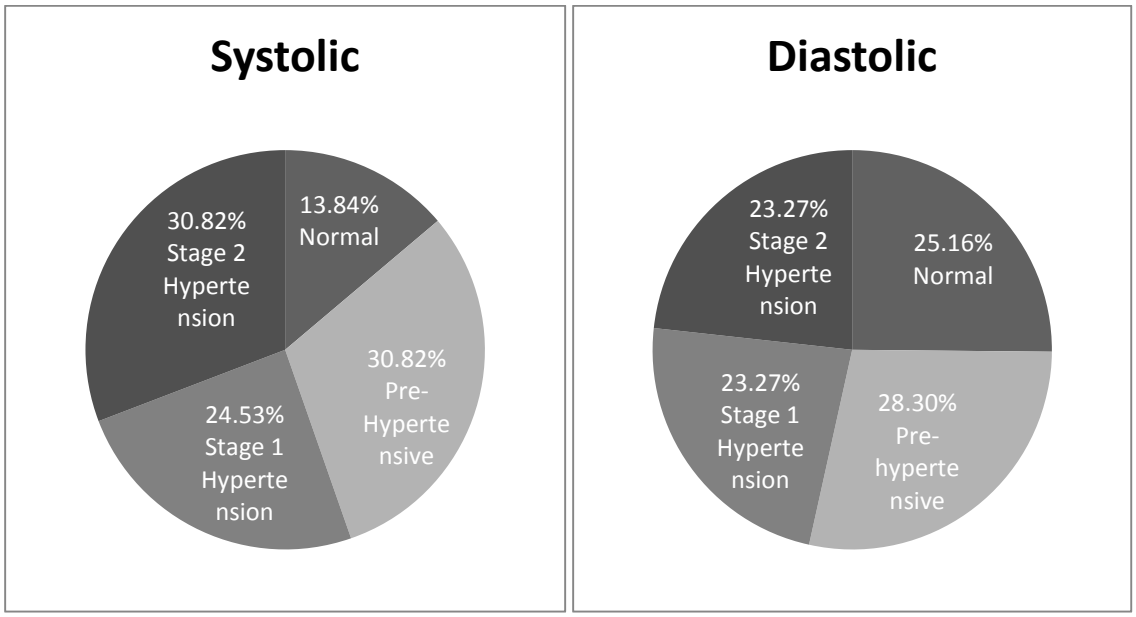

Figure 5. EH Distribution in Kasigau, Kenya- Pie graphs depicting the percent of the entire Kasigau population that walls within the given ranges of blood pressure. The pie graph on the left shows the values for systolic blood pressure, and the pie graph on the right shows the values for diastolic blood pressure. Those categories are normal, pre-hypertensive, stage 1 hypertension, and stage 2 hypertension. Their respective values are 120/80 mmHg and below, 121/81-139/89 mmHg, 140/90-159/99, and greater that 160/100 mmHg.

It is known that the risk of hypertension increases with age [14]. Therefore, to determine if age was a contributing factor for EH in Kasigau, normotensive and hypertensive values were subdivided based upon the following age groups 45-54, 55-64, 65-74, and 75+ years old and sub-location (Figure 6).

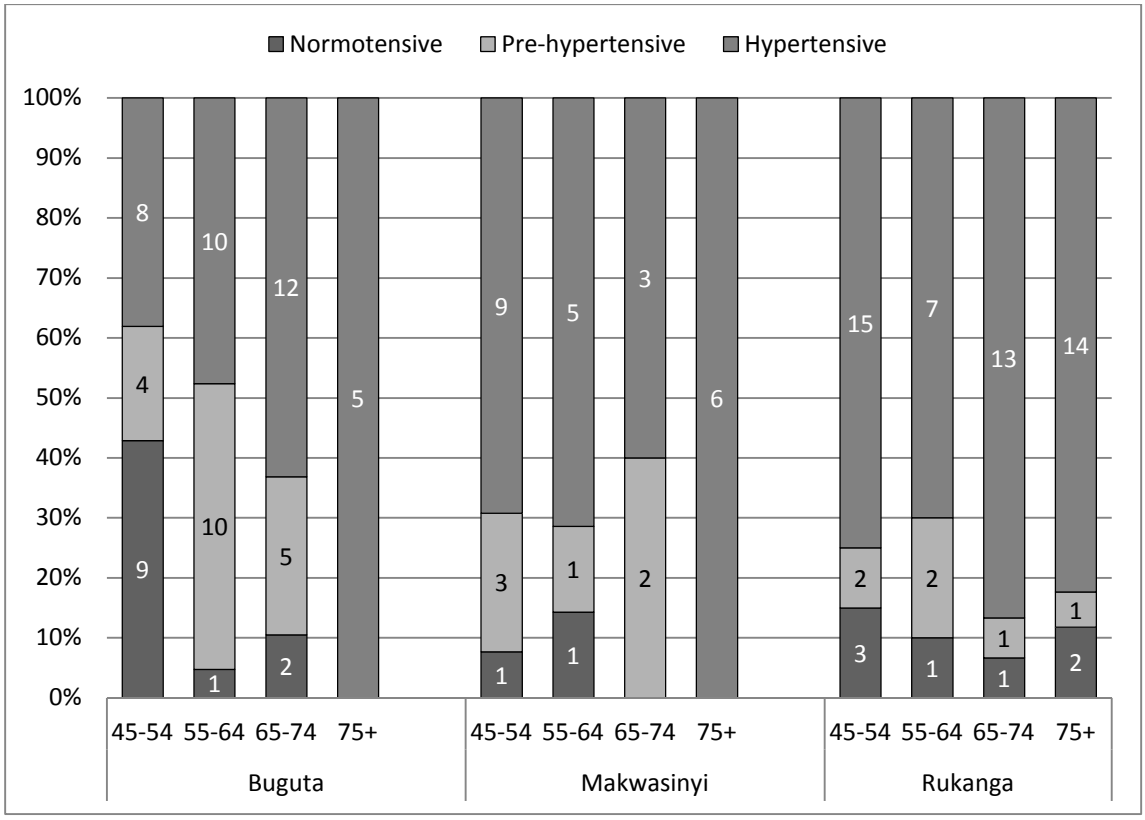

Figure 6. The Percent Prevalence of EH in Kasigau, Kenya by age and sub-location- Shows the percents of the total number of individuals in that particular population sub-category that fall within the normotensive (120/80 mmHg or below) range, pre-hypertensive (120/80 mmHg – 140/90 mmHg) range, or hypertensive range of blood pressure, with hypertension defined as any pressure value that was above the pre-hypertensive range (greater than 140/90 mmHg). The age ranges and sub-locations are shown along the x-axis, and the bars are represented as parts per 100, although the actual value is shown within each bar itself.

There was a statistically significant correlation between age and systolic blood pressure ($p<0.05$) but not between age and diastolic pressure for the Kasigau region as a whole (data not shown). The sub-location of Buguta showed a significant correlation between age and systolic blood pressure ($p<0.05$), although this was not observed in either Rukanga or Makwasinyi.

Overall, our study indicates that 67% of the Kasigau population had at least one of their blood pressure readings greater than 140/90 mmHg and thus, this region of Kenya does indeed have a high prevalence of EH.

Risk Factor Assessment of Kasigau

In addition to blood pressure, other anthropometric measurements were also analyzed since in developed countries high values are known to contribute to hypertension. These include body mass index (BMI), waist to hip ratio (WHR), and cholesterol levels. BMI was calculated using the formula BMI= weight (kg) / height $(m)^2$. Normal BMI ranges from 18.5-25% body fat, and anything 30% or more is considered obese (Figure 7).

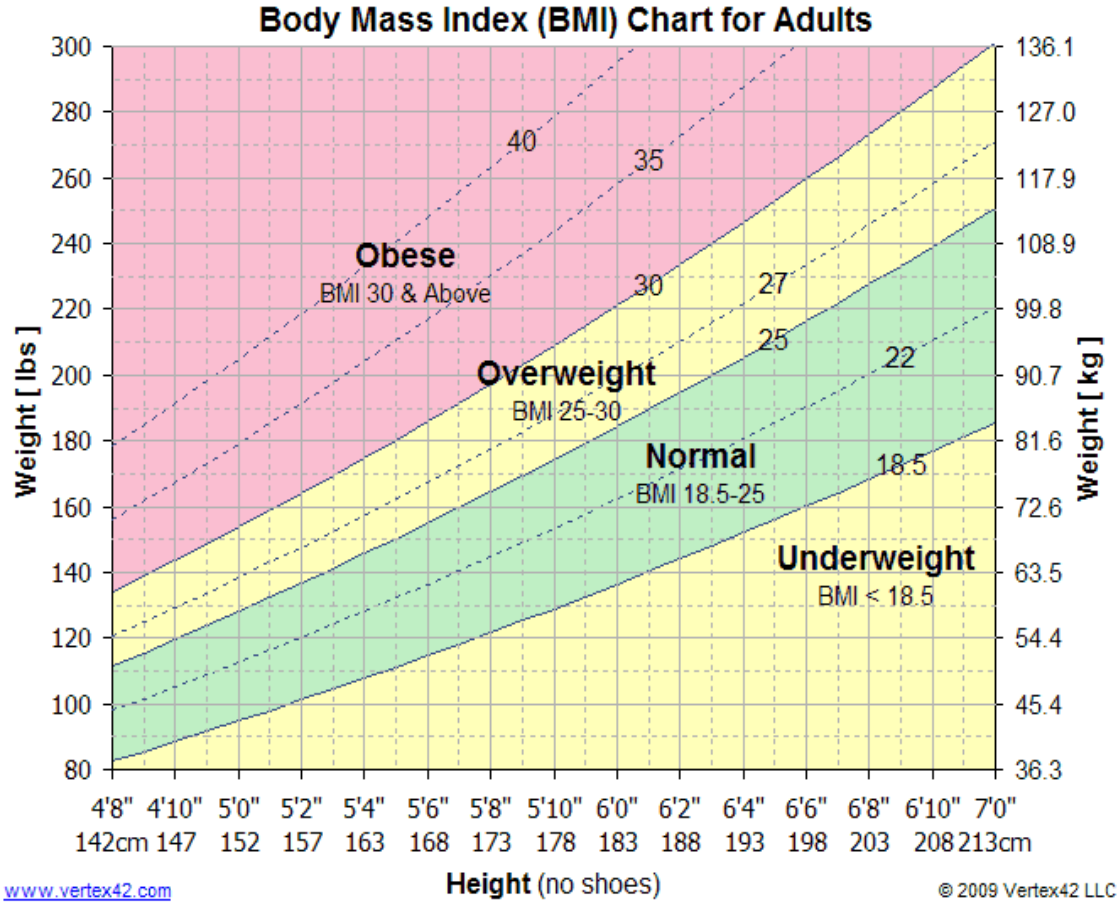

Figure 7. Body Mass Index Chart for Adults- The suggested BMI range is between 18.5-25% body fat. A BMI lower than 18.5 is considered underweight, overweight is from 25-30% and obese is 30% and above.

When one analyzes the overall BMI of the people of Kasigau based upon sub-location, we can observe that in all 3 sub-locations the majority of people fall into the healthy range of BMI (Figure 8). The people of Rukanga had the most number of individuals in the overweight or obese categories and Buguta had the highest number of underweight individuals (Figure 8).

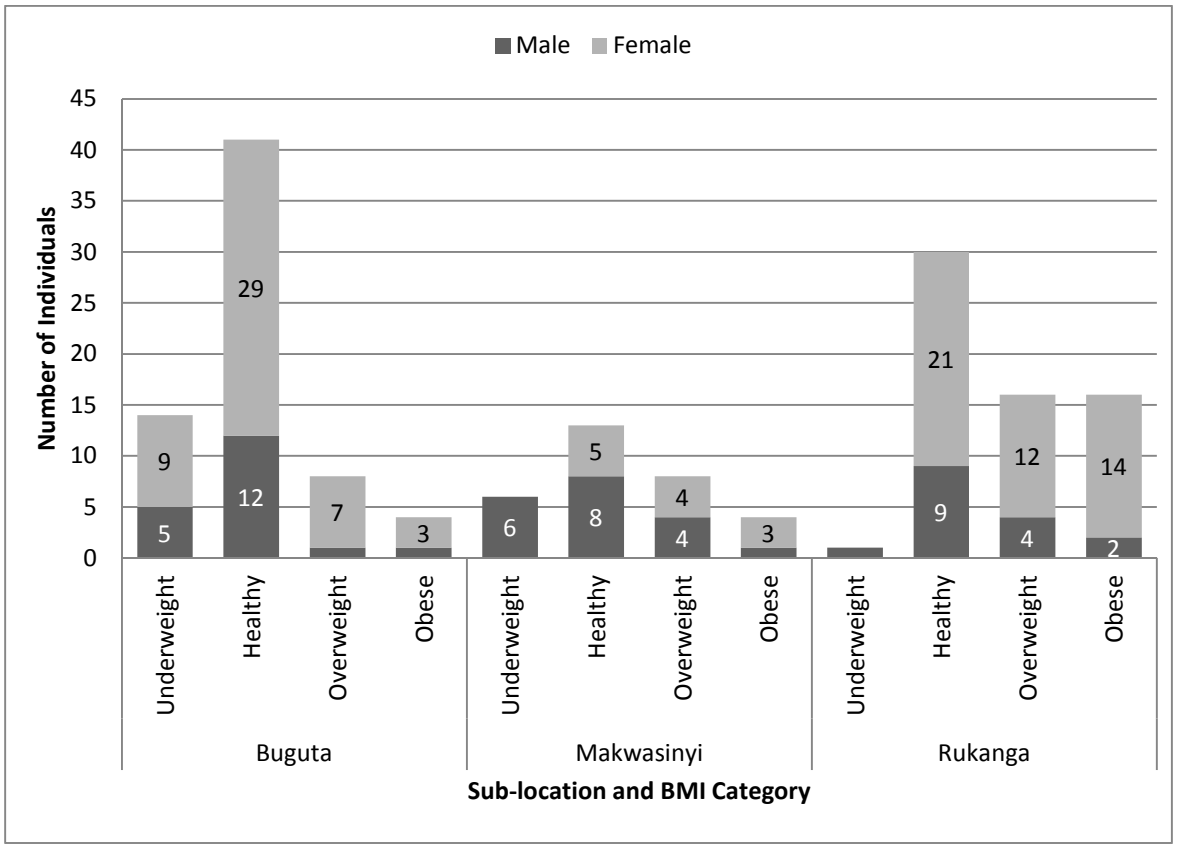

Figure 8. BMI of Individuals in Kasigau based on Sub-location- A graphical representation of sub-location and BMI category plotted against number of individuals. Along the x-axis each village is represented by individuals in each category, underweight, healthy, overweight, and obese. The populations can be further compared by looking at the distribution of males and females within each category. The targeted healthy BMI range was from 18.6%-24.9% body fat.

For each of the sub-locations, the healthy BMI was the predominant range represented. Sixty-one percent of the individuals from Buguta had healthy BMIs, 42% percent of the individuals from Makwasinyi had healthy BMIs, and 48% percent of the individuals from

Rukanga had healthy BMIs. Overall, the majority of individuals in Kasigau present with healthy BMI, (57%) (Figure 9).

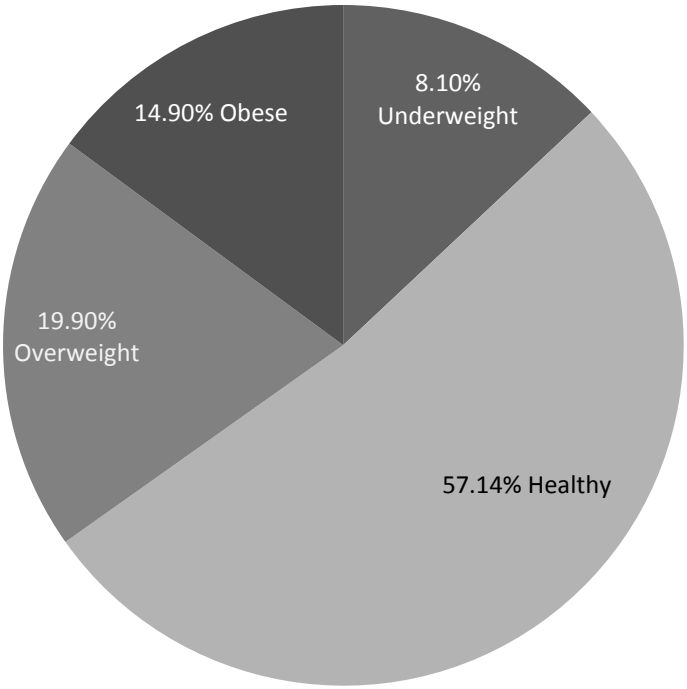

Figure 9. Total % Distribution of BMI in Kasigau- Fifty seven percent of study participants were considered to have a healthy BMI.

Pearson Correlations between BMI and systolic blood pressure determined there was no significant correlation between BMI and systolic blood pressure in any sub-location or the total population overall (Table 3).

Systolic BP vs BMI				
Sub-location	Buguta	Makwasinyi	Rukanga	Kasigau
Correlation coefficient	---	.134	.078	.166
P value	>0.05	>0.05	>0.05	.0367

Table 3. Correlation data for Systolic blood pressure and BMI for each Kasigau sublocation- A chart denoting Pearson correlation coefficients (r values) and P values for the comparison of Systolic blood pressure and BMI. None of the r values were significant ($r<0.50$) and none of the p values were significant ($p>0.05$).

When Rukanga was compared to the other two sub-locations for BMI differences, it was found to be significantly higher. When these data were further subdivided by gender, it was found that the females in Buguta were responsible for the overall village differences in female BMI. Makwasinyi females versus Buguta females had a p value less than .05 as well as Rukanga females versus Buguta females. This is because Buguta BMI for females is significantly lower than BMI for females in Rukanga and Makwasinyi (Table 5). Only 20% of the females in Buguta were overweight or obese, while 56% of females in Makwasinyi and Rukanga were overweight or obese. Females in Makwasinyi also showed significant variance from males in Makwasinyi ($p<.05$) (Table 4). The average BMI for males in Makwasinyi was 20.6, while the average BMI for females in Makwasinyi was 27.5.

Factor	Comparison	Diff of Ranks	Q	P <.05
BMI	Rukanga vs Buguta	38.312	4.683	Yes
	Rukanga vs Makwasinyi	27.416	2.680	Yes
	F Mak vs M Mak	66.531	3.87	Yes
	F Mak vs F Bug	48	3.19	Yes
	F Ruk vs F Bug	39.055	4.082	Yes
	Makwasinyi vs Buguta	10.896	1.076	No
	F Mak vs F-Ruk	8.945	0.593	No
	F Ruk vs M Ruk	17.388	1.289	No
	M Ruk vs M Mak	40.197	2.541	No
	M Ruk vs M Bug	34.618	2.188	No
	F Bug vs M Bug	12.952	1.025	No
	M Bug vs M Mak	5.579	0.369	No

Table 4. One Way ANOVA data comparing BMI between sub-groups of the population- A compilation of comparison parameters determined significant by the P values obtained from One-way ANOVA test of variance using Dunn's method. The data in table 4 was all determined to be significant if they varied enough that difference in compared groups was unlikely just by chance ($P<0.05$).

Another risk factor for EH is high WHR. In order to determine whether the prevalence of EH in Kasigau was correlated with this anthropometric value, WHRs were calculated by dividing the circumference measured at the waist by the circumference measured at the widest part of the hips. WHR data were obtained for all of our study participants. According to a study conducted by Mayo Clinic, a normal WHR for women is <0.85 and <0.90 in men. A high WHR is ≥0.85 in women and ≥0.90 in men [17]. In each sub-location, females had WHRs above the recommended 0.85 value, approaching the moderate to high risk ranges for WHR. For males, the Rukanga population was within the healthy range, but WHR for males across the other sub-locations and overall in Kasigau had averages higher than 0.90 (Table 5).

Waist to Hip Ratio

Male	*Female*	*Sub-location*
0.928 ± .097 *n*=19	0.8666 ± .075 *n*=48	**Buguta**
1.004 ± .615 *n*=19	0.8712 ± .069 *n*=12	**Makwasinyi**
0.898 ± .059 *n*=16	0.9741 ± .771 *n*=47	**Rukanga**
0.946 ± .367 *n*=54	0.9143 ± .072 *n*=107	**Kasigau**

Table 5. Waist to hip ratio in Kasigau, Kenya- WHR for males and females of Kasigau separated into sub-location. The healthy WHR range for females is below .85 and for males is below .90. Overall, the majority of people in Kasigau have a high WHR.

The significance of WHR as a predictor of EH and cardiovascular disease is a result of the difference in weight distribution of a particular individual. A person that has more of their weight distributed in their mid-section and chest *i.e*. "apple body shape" has more fat concentrated around the heart, and is more likely to have heart problems. A person who has a lower WHR, with more of their body fat concentrated around their hips, and away from their heart, i.e. "pear body shaped", is at less of a risk for CVD [18]. Based on this parameter, the people of Kasigau may be at higher risk for CVD.

Systolic BP vs WHR

Sub-location	Buguta	Makwasinyi	Rukanga	Kasigau
Correlation coefficient	.226	.337	.0557	.169
P value	>0.05	>0.05	>0.05	.0334

Table 6. Correlation data for Systolic blood pressure and WHR for each Kasigau sub-location- A chart denoting Pearson correlation coefficients (r values) and P values for the comparison of Systolic blood pressure and WHR. None of the r values were significant (r<.50) and only the p value for Kasigau overall was significant (p=.0334).

Table 6 indicates that while WHR were high, they did not significantly correlate with systolic blood pressure; correlation values were less than 0.50. The only significant *p* value was *p*=.0334 for the overall Kasigau population. This means that the data were significantly different, but because the r value was less than 0.50, it was not a correlated relationship (Table 6).

Blood cholesterol level is another risk factor for EH, and thus CVD. The desirable range for total cholesterol is below 200 mg/dL. Borderline high cholesterol is considered between 200-239 mg/dL, and a cholesterol level of 240 mg/dL or greater is considered high [19]. The risk of CVD is elevated especially if high cholesterol is a coupled with several other behavioral or genetic risk factors [19].

Cholesterol (mg/dL)

	Male	**Female**
Buguta	168.86 ± 11.171 *n*=16	180.5 ± 23.878 *n*=40
Makwasinyi	174.06 ± 17.221 *n*=17	182.92 ± 18.213 *n*=12
Rukanga	184.73 ± 31.102 *n*=15	186.62 ± 26.502 *n*=45
Kasigau	175.67 ± 21.721 *n*=48	183.57 ± 24.484 *n*=97

Table 7. Cholesterol levels in Kasigau, Kenya- Shows total cholesterol levels measured in units of milligrams of cholesterol per deciliter. The sub-locations are located in the left hand column, while the cholesterol levels are listed below either the male or female sub-headings.

Kasigau overall had normal cholesterol levels, which can most likely be attributed to a low fat diet. As shown in Table 8 the average cholesterol level in Kasigau is 175.67

mg/dL for males and 183.57 mg/dL for females, both well below the 200 mg/dL guideline that marks the beginning of an elevated risk level for CVD and other disease.

Cholesterol was not correlated with systolic blood pressure ($r<0.50$) nor were the data related any more than by random chance ($p>0.05$) (Table 8). The overall cholesterol levels in the people of Kasigau are very healthy, and based on the r and p values, it can be concluded that cholesterol is not a contributing factor to EH in the region.

Systolic BP vs Cholesterol

Sub-location	Buguta	Makwasinyi	Rukanga	Kasigau
Correlation coefficient	.0097	.236	---	.0673
P value	>0.05	>0.05	>0.05	>0.05

Table 8. Correlation data for Systolic blood pressure and cholesterol for each Kasigau sub-location- A chart denoting Pearson correlation coefficients (r values) and p values for the comparison of systolic blood pressure and cholesterol. None of the r values were significant (r<.50) and none of the p values for Kasigau overall or any one sub-location were significant (p>.05).

As expected, systolic and diastolic blood pressures were strongly correlated, as they both increase and decrease together. This adds support that our measurements were accurate. Diastolic p value was to the -18 power ($p < 0.05$), and r was .626 ($r > 0.50$) for Kasigau. All the r and p values for each sub-location were also significant, denoting the strong positive correlation between systolic and diastolic blood pressure.

Systolic BP vs Diastolic BP

Sub-location	Buguta	Makwasinyi	Rukanga	Kasigau
Correlation coefficient	.663	.702	.506	.626
P value	1.36 x 10^-9	1.06 x 10^-5	2.69 x 10^-5	1.16 x 10^-18

Table 9. Correlation data for systolic blood pressure and diastolic blood pressure for each Kasigau sub-location- A chart denoting Pearson correlation coefficients (r values) and p values for the comparison of systolic and diastolic blood pressures. All of the r values were significant ($r>0.50$) and all of the p values were significant ($p<0.05$).

As previously mentioned, when compared across sub-locations, the ANOVA results of systolic blood pressure indicated that there was a significant between the EH levels of Buguta when compared to the other two sub-locations. We hypothesized that this could be due to differences in the economies of the 3 sub-locations. Buguta is the most impoverished of the three sub-locations, and that this may be a contributing factor to the lower blood pressure there. High blood pressure can be linked to wealth in some cases, since wealthier populations can afford to eat a higher fat diet, engage in other unhealthy activities, and get less exercise [6 and references therein, 20]. Indeed, when the income of Buguta is analyzed in comparison to Rukanga and Makwasinyi, 50% of the Buguta population falls within the lowest category of less than 500 kSh per month (Table 10). This is ~2 fold more than Makwasinyi and Rukanga. The majority of residents in Makwasinyi and Rukanga fell within the intermediate 500-1500 kSh income range. This supports the hypothesis that other socioeconomic factors may also contribute to EH in Kasigau.

Income (kSh)			
Sub-location	**<500**	**500-1500**	**>1500**
Rukanga	27.66%	52.60%	19.70%
Makwasinyi	24%	48%	28%
Buguta	50.70%	31.50%	17.80%

Table 10. The Monthly Income of Kasigau- A chart diagramming the survey responses of the study participants regarding their household's typical monthly income. The amount is in Kenya shilling units (kSh). The responses were broken into three groups: those that made less than 500 kSh per month, those that ranged between 500 and 1500 kSh per month, and those that made over 1500 kSh per month.

CHAPTER 4

DISCUSSION

The three main conclusions that can be drawn from this study of EH prevalence in Kasigau, Kenya are that EH is indeed prevalent, that the common anthropometric risk factors of BMI, WHR, and cholesterol are not the main or singular factors responsible for this increased incidence, and that other socioeconomic factors may contribute to the EH observed in Kasigau. The latter two findings suggest that other studies should be conducted using these foundational data to document the socioeconomic factors such as income, occupation, education level, stress levels, and dietary habits –all information that can be extracted from the surveys that were given as a component of the research data collected in this Partner's in Caring trip to Kenya.

The fact that there is a high prevalence of EH in Kasigau that is not correlated with normal anthropometric measures, suggests that other genetic factors may be involved in this multifaceted disease. Our data support the hypothesis that epigenetic and or polymorphic changes of the renin-angiotension gene system may have occurred that effect the body's ability to regulate salt absorption and secretion, thus inducing salt-sensitive EH. Further research is currently being undertaken using DNA extracted from the buccal cells of study participants. Genomic DNA is being isolated to see if polymorphic variation in the *ACE, AGT, AT1*, and *HSD11B2* genes known to correlate

with salt-sensitive hypertension, do in fact exist in the Kasigau population. These data will be used to quantify the global methylation of hypertensive versus normotensive to correlate epigenetic changes with salt-sensitive hypertension. This gene system is referred to as RAAS (renin-angiotensin-aldosterone system) and many other studies are being undertaken to try to determine the genetic modifications that affect RAAS. Specifically in untreated black South Africans, polymorphisms in the *CYP11B2* the aldosterone synthase gene, have been shown to correlate with a higher systolic blood pressure [21].

It is also important to consider how this study's data fit in to the paradigm that already exists, and to compare this study to ones focused on sub-Saharan Africa as well as general studies on the global prevalence and impact of EH. Numerous studies have indicated that people of African descent have a higher prevalence of EH than Caucasians [20, 22, 23 and references therein, 24]. The National Health and Nutritional Survey (NHANES) showed that in the US blacks had a 32% rate of hypertension, while whites had a 23% rate of hypertension [23]. The Kasigau population in this study was determined to have a 67% rate of EH, a considerably larger portion. Another study indicates that in the year 2000, sub-Saharan Africa had a 27.7% rate of hypertension, and established market economies had a 37.7% rate of hypertension. Tanzania, Kenya's southern neighbor, was shown to have a 31.3% rate of hypertension by that same study [24]. Our data have significantly higher values for rates of hypertension than this study as well. The US population had a 28.6% incidence of EH from 1999-2002 [6], which is a much smaller number than the EH prevalence figure we found.

To improve upon this study, the expanding the sample group size should be considered. The goal of the study was to conduct the research with approximately ~200 Kenyans. This number was reduced to 161 as many of the volunteers that were recruited did not show up, a more representative cross section was attempted to be obtained, and pieces of data were misplaced. If there had been more participants, it would have more accurately represented the villages, the age categories, and the genders. More females volunteered and showed up for the study than males and some of the villages within the sub-locations are so small that it is difficult to obtain a proper representative sample.

Another aspect to hypertension research that could be added to this project would be conducting a urinalysis. A mircoalbumin test can be run as part of a urinalysis, and it indicates overall kidney health. If microalbumin, a protein that is supposed to remain in the blood, is leaking into the urine, it is a sign of kidney damage. Aside from patients with diabetes, it is also a useful test for hypertensive individuals because hypertension can induce long term kidney damage [25]. The degree of albumin in the urine could indicate the amount of kidney damage which in turn could quantify the effect of EH on an individual. A urinalysis would provide yet another parameter by which to measure EH.

Now that a pilot study on essential hypertension in the Kasigau region of Kenya has been conducted, the next step is to investigate the conclusions made from this research. The long term goal is not to merely determine the root cause of EH. The purpose of this research is to get to the source of this endemic disease problem and

provide relief for the people suffering from EH which predisposes them to other chronic NCDs. Hopefully by preventing one of the leading risk factors for NCDs, EH, we will in effect lesson the burden of NCDs in developing countries such as Kenya by providing cost-effective therapeutic programs against EH. CVD is one of the many chronic diseases that are having the greatest impact on developing nations. The successful techniques we develop for preventing, treating, and controlling chronic high blood pressure in our model population of Kasigau, Kenya, can be applied to and used by other developing populations to lessen the impact of the current cardiovascular disease pandemic and the total global disease burden. It has been suggested that successful programs for controlling hypertension involve the use of multidisciplinary teams, more inclusion of community health workers in the process, and more emphasis on getting the patients involved in their care [11]. Such being the case, just making the community and the Kenyan Ministry of Health and Sanitation more aware of the seriousness of the problem of high blood pressure and its implications in other NCDs seems like it would go a long way. A study in conducted in two rural Kentucky counties that had a high prevalence of EH analyzed the implementation of a community wide hypertension control program and noted that over a 5 year period, both blood pressure and CVD death rates decreased when compared with a control county [26]. This leads me to believe that with education and the right EH intervention programs put into effect, the same could happen in this small rural African community. Another study emphasized two low-cost preventative measures that can be applied to diet in Africans. The first is simply decreasing sodium intact, and the second is increasing potassium intake, as both of

those adjustments have been shown to decrease EH [6]. Education on the detrimental effects of obesity was also suggested, although it may be tougher to see strides made BMI, because culturally, being heavy in Kenya is seen as a sign of wealth and status and is more of an attractive feature.

I think it is clear that progress can be made in this small rural community of Kasigau without involving an extensive overhaul of any systems the already have in place. The biggest factor may simply be education in the area of NCDs and high blood pressure's relation to diseases like CVD, and modifying their diets. Reducing salt intake would be of especial importance if it is indeed shown that there are genetic modifications in this population's RAAS. Once the genetic research and an extensive study regarding the socioeconomic factors are completed, and good picture of the region should be obtainable, and thus a program developed to lessen their NCD and CVD burden. Hopefully, the results of the work done on this population system can be applied to other Kenyan and East African communities.

APPENDIX 1: HSRB APPROVAL

WKU

A LEADING AMERICAN UNIVERSITY WITH INTERNATIONAL REACH

HUMAN SUBJECTS REVIEW BOARD

In future correspondence, please refer to HS11-174, March 4, 2011

Dr. Rice
Biology
WKU

Dr. Rice:

Your research project, *The Molecular Epidemiology of Essential Hypertension in Kasigau, Kenya*, was reviewed by the IRB and it has been determined that risks to subjects are: (1) minimized and reasonable; and that (2) research procedures are consistent with a sound research design and do not expose the subjects to unnecessary risk. Reviewers determined that: (1) benefits to subjects are considered along with the importance of the topic and that outcomes are reasonable; (2) selection of subjects is equitable; and (3) the purposes of the research and the research setting is amenable to subjects' welfare and producing desired outcomes; that indications of coercion or prejudice are absent, and that participation is clearly voluntary.

1. In addition, the IRB found that you need to orient participants as follows: (1) signed informed consent is not required; (2) Provision is made for collecting, using and storing data in a manner that protects the safety and privacy of the subjects and the confidentiality of the data. (3) Appropriate safeguards are included to protect the rights and welfare of the subjects.

   This project is therefore approved at the Expedited Review Level until March 4, 2012.

2. Please note that the institution is not responsible for any actions regarding this protocol before approval. If you expand the project at a later date to use other instruments please re-apply. Copies of your request for human subjects review, your application, and this approval, are maintained in the Office of Sponsored Programs at the above address. Please report any changes to this approved protocol to this office. A Continuing Review protocol will be sent to you in the future to determine the status of the project. Also, please use the stamped approval forms to assure participants of compliance with The Office of Human Research Protections regulations.

Sincerely,

Paul J. Mooney, M.S.T.M.
Compliance Manager
Office of Research
Western Kentucky University

cc: HS file number Rice HS11-174

INSTITUTIONAL REVIEW BOARD WKU APPROVED

IRB APPLICATION # 11-174
APPROVED 3/4/11 to 3/4/12
EXEMPT EXPEDITED FULLBOARD
DATE APPROVED 3/4/11

APPENDIX 2: INFORMED CONSENT

INFORMED CONSENT DOCUMENT

Project Title: _The Molecular Epidemiology of Essential Hypertension in Kasigau, Kenya
Investigators: _Nancy Ricc, Biology, 270-745-5995

To Be Read to All Potential Participants:

You are being asked to participate in a project conducted through Western Kentucky University. The University requires that you give your agreement to participate in this project. We will explain the project to you in detail including the purpose of the project, the procedures to be used, and the potential benefits and possible risks of participation. You may ask any questions you have to help you understand the project.

This project is designed to assess the prevalence of high blood pressure and its associated risk factors in the Kasigau area of Kenya. The main objective of this study will be to test the hypothesis that a high prevalence of salt-sensitive hypertension exists in the people of Kasigau, Kenya which results from genetic differences in the hormonal system known to regulate salt excretion called the renin-angiotensin gene system.

To test this hypothesis, we will measure the prevalence and current management of hypertension and evaluate the frequency of common environmental risk behaviors associated with high blood pressure. This will involve taking several noninvasive measurements of blood pressure, height, weight, and pulse rate. We will also collect a small blood sample by finger stick to measure glucose levels- to test for diabetes, and lipid levels- to test for high cholesterol. We will also take one larger blood sample by a needle venous puncture to look for genetic variation in certain genes known to be associated with high blood pressure. If you are found to have high blood pressure, you may also be asked to provide a 24-h urine sample for salt analysis.

Following sample collection, you will be asked a series of questions. Please answer to the best of your ability and as accurately as possible. There will be only minimal discomfort and no risk associated with this project. Ultimately your information, along with that of all participants, will be used to determine key epidemiological and genetic information regarding mechanisms that lead to hypertension in the people of Kasigau, Kenya; this new scientific knowledge will be directly translatable into prevention, treatment, and control of hypertension and will ultimately be used to enhance the health and well-being of the people of Kasigau.

All participants will be assigned a number to maintain anonymity. No names will be recorded or presented in the data. Refusal to participate in this study will have no effect on any future services you may receive from WKU. Anyone who agrees to participate in this study is free to withdraw at any time with no penalty.

Your continued participation in the study will imply your consent. Do you wish to continue?

THE DATED APPROVAL ON THIS CONSENT FORM INDICATES THAT
THIS PROJECT HAS BEEN REVIEWED AND APPROVED BY
THE WESTERN KENTUCKY UNIVERSITY HUMAN SUBJECTS REVIEW BOARD
Paul Mooney, Compliance Coordinator
TELEPHONE: (270) 745-4652

IRB APPLICATION # 11-174
APPROVED 3/4/11 to 3/4/12
EXEMPT EXPEDITED FULLBOARD
DATE APPROVED 3/4/11

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