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Assessing Biomass Fuel Consumption in Kasigau, Kenya as a Predictor of Hypertension

Conner Hounshell

Western Kentucky University, conner.hounshell207@topper.wku.edu

ASSESSING BIOMASS FUEL CONSUMPTION IN KASIGAU, KENYA AS A PREDICTOR OF HYPERTENSION

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By

Conner L. Hounshell

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CE/T Committee:

Professor Michael Stokes, Chair

Professor Nancy Rice

Professor Craig T. Cobane

ABSTRACT

Cardiovascular disease is the leading cause of death globally and disproportionately affects low- and middle-income countries, such as Kenya. Hypertension is the leading risk factor for cardiovascular disease and is influenced by a variety of factors such as diet, tobacco use, and genetics. One such factor linked to hypertension is exposure to air pollution, but minimal research exists on the effects of household air pollution. Hypertension that is not related to common Western risk indicators, such as waist-to-hip ratio, body mass indices, and hypercholestorlemia, is prevalent in the community of Kasigau, Kenya, along with the prevalence of risks for household air pollution exposure such as cooking with solid fuel types. A survey was conducted in Kasigau to assess the extent of biomass fuel consumption. No significant relationship was found between blood pressure and factors such as fuel type and ventilation practices (e.g. chimney presence and kitchen location), but numerous risk factors for household air pollution exposure were identified.

I dedicate this thesis to the people of Kasigau, Kenya.

ACKNOWLEDGEMENTS

I would like to thank Dr. Nancy Rice for her continuous effort to improve the lives of those in our global community. Her passion for the people of Kasigau, Kenya is unmatched, and the partnership she has helped foster should serve as a model for how we must all work together to solve our common struggles. I would also like to thank the people of Kasigau for their kindness, friendship, and dedication. I cannot thank the translators, participants, and other individuals enough for helping me with this work, and for their commitment to serve those in their community.

I would also like to thank Dr. Michael Stokes for his guidance throughout the development of this thesis. There are many others in the WKU community who have also supported me in this project that I would like to thank, including Dr. Trini Stickle, the Office of Scholar Development, the Mahurin Honors College, the Study Abroad and Global Learning Office, and the Center for Citizenship and Social Justice.

I would finally like to thank my family and friends. To my parents, thank you for all the sacrifices you have made to provide me the opportunities that have made me who I am. To my best friend, Kara Lowry, thank you for your unconditional support and pushing me to be my best self.

VITA

EDUCATION

Western Kentucky University, Bowling Green, KY	May 2020
B.S. in Biology, B.A. in Political Science	
Honors Thesis: *Assessing Biomass Fuel Consumption in Kasigau, Kenya as a Predictor of Hypertension*	
Oldham County High School, Buckner, KY	June 2016

PROFESSIONAL EXPERIENCE

Dr. Nancy Rice's Lab, WKU	Oct. 2017-
Undergraduate Researcher	May 2020
Office of Admissions, WKU	Jan. 2017-
Ambassador, Orientation Leader	May 2020
Kentucky Biomedical Research Infrastructure Network	June 2017-
Undergraduate Summer Biomedical Researcher	Nov. 2017

AWARDS & HONORS

Summa Cum Laude, WKU	May 2020
Scholar of the College, WKU	May 2020
President's List, WKU,	2016-2020
Cherry Presidential Scholar, WKU	Aug 2016
Charles A. Keown Award, WKU Student Government	Apr. 2018
Scholars in Service Scholarship, WKU	Dec. 2017

PROFESSIONAL MEMBERSHIPS

Alpha Epsilon Delta (AED)

INTERNATIONAL EXPERIENCE

Kasigau, Kenya	Jan 2018
Partners in Caring: Medicine in Kenya	

PRESENTATIONS

Hounshell, C. (2012, March 24). *Assessing the Extent of Biomass Fuel Consumption in Kasigau, Kenya and Its Relation to Household Air Pollution Exposure and Hypertension*. Oral Presentation at the WKU Student Research Conference. Bowling Green, KY.

CONTENTS

LIST OF FIGURES

LIST OF TABLES

INTRODUCTION

Cardiovascular diseases (CVDs) are the number one cause of death globally, accounting for an estimated 17.9 million deaths in 2016, or 31% of all global deaths (World Health Organization, 2017). Cardiovascular diseases disproportionately affect low- and middle-income countries (LMICs), with over three quarters of the deaths from CVDs taking place in a LMIC (World Health Organization, 2017). Risk factors for CVDs include high blood pressure, high blood glucose levels, and high cholesterol (World Health Organization, 2017). Over half of the deaths from CVDs are caused by complications of high blood pressure, or hypertension, identifying it as a leading risk factor for CVDs (IFPMA, 2016).

In 2008, an estimated 40% of adults aged 25 or above had been diagnosed with hypertension- approximately 1 billion cases (IFPMA, 2016). By 2025, it is estimated that more than 1.5 billion people will have hypertension (IFPMA, 2016). Two-thirds of those with hypertension live in economically developing countries, likely increasing the number of these cases going undiagnosed, untreated and uncontrolled (IFPMA, 2016). In a 2014 report on noncommunicable diseases, hypertension was highest in Africa, with 30% of adults having raised blood pressure as seen in Figure 1 (World Health Organization, 2014). Hypertension prevalence rates in some sub-Saharan African countries are among the highest in the world and have rapidly increased over the past few decades (Campbell, 2015). The social and economic development of these regions is also hindered as they deal with the health care costs and reduced productivity of workers resulting from the burden of hypertension.

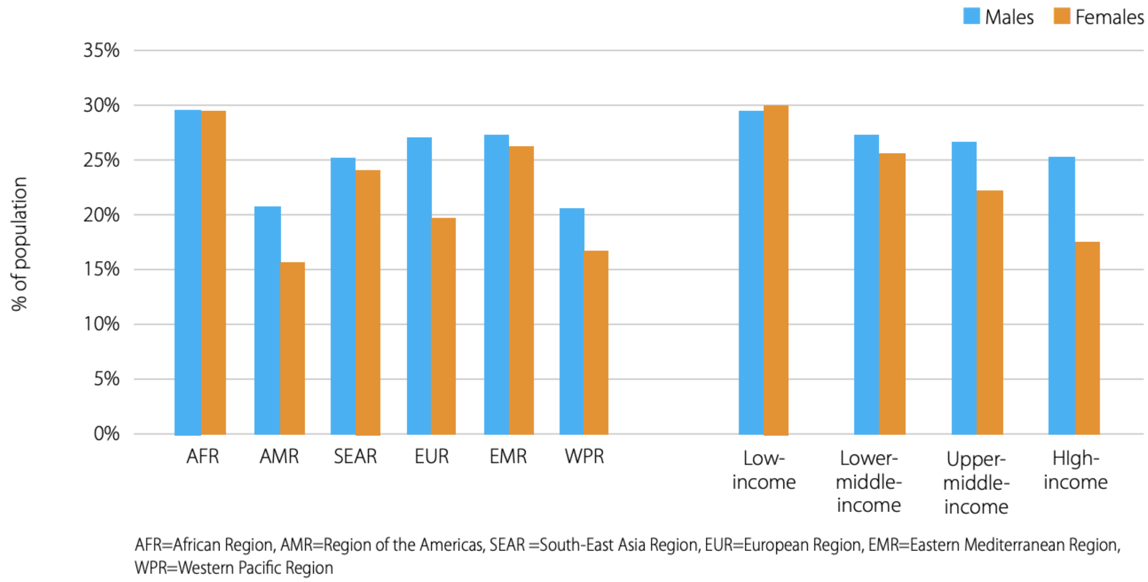

Figure 1. Comparison of WHO Regions by percent of adults with high blood pressure. Reprinted from Global Status Report on Noncommunicable Diseases 2014, World Health Organization (2014).

Hypertension is determined by measuring an individual's blood pressure, which consists of two measurements in millimeters of mercury (mmHg) that are recorded as a ratio. The numerator of this ratio is the systolic blood pressure in the arteries when the heart is in contraction, while the denominator is the diastolic blood pressure in the arteries when the heart is relaxed. According to the American Heart Association's blood pressure chart in Figure 2, a normotensive blood pressure reading is less than 120/80 mmHg, while hypertension occurs when the systolic blood pressure is at or above 130 mmHg and/or the diastolic blood pressure at or above 80 mmHg (American Heart Association, 2017).

BLOOD PRESSURE CATEGORY	SYSTOLIC mm Hg (upper number)		DIASTOLIC mm Hg (lower number)
NORMAL	LESS THAN 120	and	LESS THAN 80
ELEVATED	120 – 129	and	LESS THAN 80
HIGH BLOOD PRESSURE (HYPERTENSION) STAGE 1	130 – 139	or	80 – 89
HIGH BLOOD PRESSURE (HYPERTENSION) STAGE 2	140 OR HIGHER	or	90 OR HIGHER
HYPERTENSIVE CRISIS (consult your doctor immediately)	HIGHER THAN 180	and/or	HIGHER THAN 120

Figure 2. Blood pressure chart with classifications. Reprinted from *Understanding Blood Pressure Readings*, American Heart Association (2017). Retrieved from https://www.heart.org/en/health-topics/high-blood-pressure/understanding-blood-pressure-readings.

Hypertension is a multifactorial disease. Many of the major contributing factors are behavioral, such as unhealthy diet, physical inactivity, and tobacco use, and can be modified; however, individually uncontrollable risk factors exist, such as genetic and environmental factors. One such factor linked to hypertension is exposure to air pollution. Particulate matter (PM), a specific type of air pollution that is produced by activities such as combustion of fossil fuels, may cause an elevation in arterial blood pressure (Brook, 2009). Both acute and long-term exposure to air pollution increases blood pressure, with "robust evidence for exposures to $PM_{2.5}$," a type of PM that has a diameter of less than 2.5 micrometers (Giorgini, 2016). Most research has been focused on ambient air pollution; research on household air pollution is limited.

More than three billion people use solid fuels as the main source of energy in their homes (Amaral, 2016). Biomass fuels, such as wood, dung, and crop waste, are extensively used in LMICs as fuel for cooking and heating due to their low cost and widespread availability (Amaral 2016; Bruce, 2000). Specifically, ca. 900 million Africans (~82%) rely on solid fuels for cooking, with solid-fuel cooking emissions killing nearly 600,000 Africans annually (World Bank, 2014). Incomplete combustion of these solid fuels produces large amounts of air pollution, such as particulate matter, and is a dominant source of indoor air pollution in LMICs (Simoneit, 2002; Sinha, 2018). Exposure to household air pollution has been linked to elevated blood pressure, inflammation, and oxidative stress (Vaziri, 2008). One study showed that for every 10.5 μg/m3 increase in $PM_{2.5}$, a corresponding 2.8 mm Hg increase SBP, and a 2.7 mm Hg increase in DBP occurs (Zanobetti et al., 2004). Another study found that "adjusted mean systolic blood pressure was 2.5 mmHg higher per unit increase in natural log transformed kitchen $PM_{2.5}$ concentration" (Young et al., 2019). Solid fuel use specifically in sub-Saharan Africa has increased over the last 30 years and now remains steady (World Bank, 2014). As these people continue to utilize solid fuel, they are at an increased risk of hypertension and CVD.

The type of cook stove an individual uses also has an effect on the extent of household air pollution exposure, and in turn risk of hypertension and CVD. A study by Jetter et al. (2012) compared a variety of stove types and their resulting emissions. A wood-fired, three-stone stove, which is the most common stove worldwide and common in Africa, produced about six grams of $PM_{2.5.}$ per hour, or 400 cigarettes worth, and was one of the highest polluting stove types (Jetter et al., 2012). Comparatively, a Kenyan ceramic jiko that utilizes charcoal as fuel and is pertinent to this study, had about half the $PM_{2.5}$ emissions of wood-fired, three-stone stoves and fell within the middle range for emissions (Jetter, et al. 2012). These stove types are shown in Figure 3. Emissions from these stoves also varied based on fuel type, with wood producing higher emissions than charcoal (Jetter et al., 2012).

Figure 3. Cook Stoves. Three-stone stove (left). Reprinted from *Action M.A.P.L.E.*, 2020. Retrieved from https://actionmaple.com/wanda-four/.
Kenya ceramic jiko (right). Reprinted from *Design for the other 90%: Kenya*, 2020. Retrieved from http://archive.cooperhewitt.org/other90/other90.cooperhewitt.org/Design/kenya-ceramic-jiko.html

Kenya is a model LMIC located in east Africa with ~75% of its population living in rural areas and on less than $1/day. Access to medical care in Kenya is limited, with approximately 20 doctors/100,000 people (World Bank, 2014). For comparison, the U.S. has 260 doctors/100,000 people (World Bank, 2016). Furthermore, most of these doctors are concentrated in urban areas, resulting in significant disparities in access for rural populations in Kenya. Due to scarce resources and a focus on communicable diseases, chronic diseases are often undetected and untreated. The 2015 Kenya STEPS survey found an age-standardized prevalence for hypertension of 24.5%, while other studies find prevalence ranging from 18.4% to 32.6% (Mohamed, 2018). These numbers are likely underestimating the prevalence due to a lack of awareness and screening for blood pressure, with 56% of Kenyans having never been screened for hypertension (Ministry of Health, 2018). With the high prevalence of cooking indoors using biomass fuel such as wood, dung, and crop residues, Kenya is a model country for the further study of environmental causes of essential hypertension.

An example of this trend is found in the prevalent hypertension of the unique rural population of Kasigau, Kenya. Kasigau is located in the Coast Province in southeastern Kenya and around 30 km north of Tanzania (Figure 4). The approximately 14,000 residents are primarily of the Taita tribe and work as subsistence farmers. The area can be divided into three sub-locations based on where clinics are located: Buguta, Makwasyini (including the villages of Makwasinyi and Kiteghe), and Rukanga (including the villages of Rukanga, Ngambenyi, Jora, and Bungule). Buguta is the largest in population, followed by Rukanga and then Makwasyini.

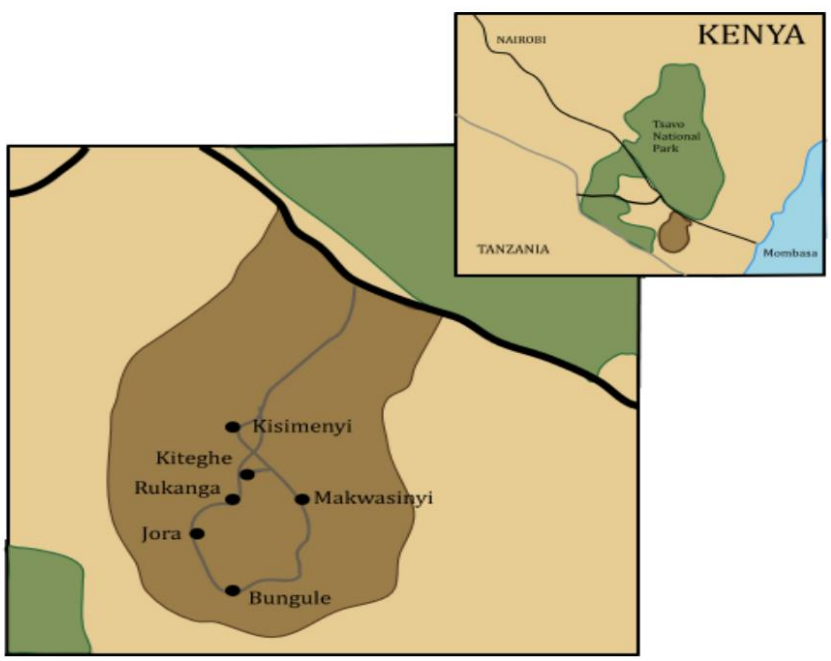

Figure 4. Map of Kasigau. Reprinted from *Kids 4* Kenya. Kids4Kenya, Inc. (2011) Retrieved from http://www.kids4kenya.org/TheSchools.php

Western Kentucky University (WKU), the University of Nairobi, and the villages of Kasigau have partnered for more than 10 years. Since 2006, a group of U.S. physicians and students have conducted rural medical clinics in Kasigau through the Western Kentucky University (WKU) Partners in Caring: Medicine in Kenya (PiC:MiK) program. This program works to address community-identified needs by providing medical care and health education. The sustained partnership has yielded local research assistants, liaisons, and translators that assist with the program. Through information gathered at town meetings, hypertension was identified as a primary concern with the lack of its detection and treatment in the community. Afterwards, research was conducted to determine the prevalence of hypertension in Kasigau. The results are shown in Figure 5, but they are based on the previous classifications of blood pressure. Using the most recent guidelines shown in Figure 2, the amount of hypertension in this community increases. This work also indicated that common Western hypertension-related factors, such as waist-to-hip ratio, body mass indices, and hypercholestorlemia, were inaccurate determinants of the hypertensive condition (Williams, 2012).

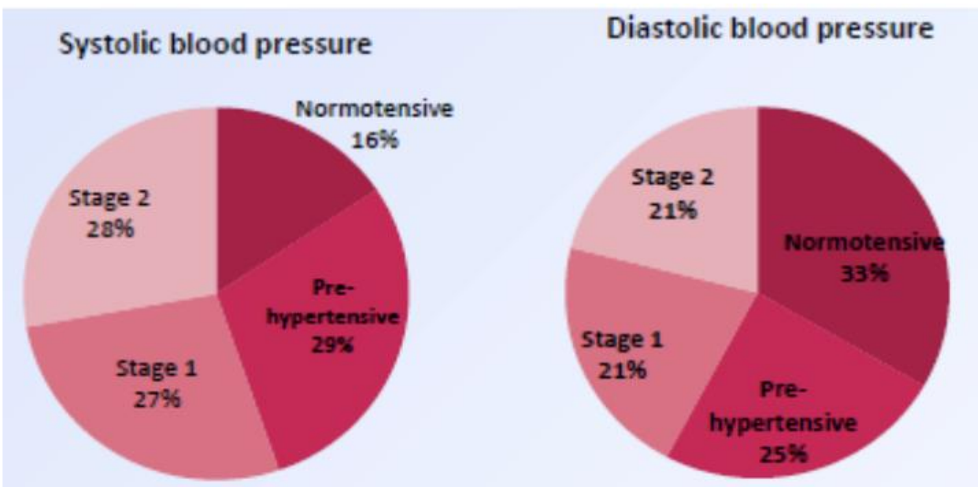

Figure 5. Hypertension Prevalence in Kasigau, Kenya. Reprinted from *The Prevalence of Essential Hypertension in Kasigau, Kenya.* Williams, L. (2012)

In order to expand upon Rice's previous research, this paper looks at another potential cause for prevalent hypertension in the Kasigau population. This work attempts to answer the following question: "What is the extent of biomass fuel consumption in Kasigau, Kenya, and how does this relate to household air pollution exposure and hypertension?" Information on biomass fuel consumption in the community will be gathered through a survey. Survey work is supported by extensive literature as an effective method of data gathering for the factors of household air pollution. In 2009, a survey was conducted in Guatemala to assess children's carbon monoxide exposure during a woodstove randomized control trial (McCracken, 2009). A similar study on new stoves' effectiveness in minimizing air pollution in rural Nepalese households utilized a questionnaire to assess a range of information from cooking practices to building materials (Parajuli, 2016). Numerous other studies on household air pollution utilizing survey work exist (Dasgupta, 2006; Ezzati, 2001; WHO, 2002).

These survey results provide quantifiable, demographic data about solid fuel consumption in rural Kenya and are compared to the respective blood pressures of participants in order to see if there is a correlation between blood pressure and the extent of biomass fuel consumption. The hypothesis is that individuals that use less clean fuel and stove types (i.e. more pollutant fuels and stoves) will have higher blood pressure.

METHODS

Survey Formulation

The goal of the survey is to determine the prevalence, distribution, and predictors of biomass fuel use in the community of Kasigau, Kenya, and the data to be gathered is in Table 1.

Survey Topic	Items
Individual demographics	Age, sex, role in family unit (head of household, child, primary cook), village of residence
Household sociodemographics	Total household members, children < 5 years of age, water source, sanitation type, average weekly expenses, and average number of livestock
Stove type and cooking practice	Stove type, fuel use (type and quantity), seasonal variation in fuel choice, number of cooking events per day, time required for each cooking event
Kitchen characteristics	Kitchen location, roofing, wall, and flooring material, ventilation related factors such as number of doors and windows
Clean fuel availability	Availability of natural gas, kerosene, and electricity, if not used why?

Table 1. Survey data to be gathered

One participant from each household was used to provide sufficient data for conclusions on biomass use and other demographics, with the ideal participant being the household's primary cook. The survey included an identifier question that asked the primary cook to have their blood pressure taken and recorded.

The initial survey is found in Appendix A, as well as a survey translation in Appendix B. This survey was piloted in January 2018. After piloting the questionnaire, it was modified by removing questions and question choices that were time-consuming or confusing to participants. The table on household member demographics was removed.

Questions about the materials used in flooring, walls, and roofing were also removed from the "Characteristics of house" section but kept for the "Characteristics of kitchen" section. On the clean fuels availability and use, the "if becomes available" section was removed, as well as the "LPG/LNG" fuel name, and pipe gas was changed to natural gas for clarification. Finally, the specific questions on each cooking session were limited to ask about one typical cooking session (length, number of people being cooked for, number of helpers, how long the fire is on after cooking). Further surveying was then completed in July 2018 with the revised survey (Appendix C).

In order to provide validity, survey questions were based upon ones previously used for similar studies on household air pollution. These include the World Bank's District Survey Questionnaire and the World Health Organization's World Health Survey (World Bank, 2003; World Health Organization, 2002). As these surveys were developed for multi-country analysis, they were modified to better apply to the Kasigau, Kenya community. Household air pollution studies in Bangladesh and Guatemala included cultural practices, such as wood-fired saunas (Dasgupta, 2006; McCracken, 2009). Kenya-specific practices, such as the use of ceramic jikos in cooking, were therefore included. Another example is the homestead arrangement (multiple homes for multiple families), which required clarifications to be made in questions regarding household characteristics.

Much emphasis was put on making the survey simple and efficient, especially as this was cross-cultural work, which experiences common communication failures (Jong, 2016). The survey was developed by native English speakers and administered to native Kiswahili and various tribal language speakers. Many individuals of the Kasigau community speak both Kiswahili and English; therefore, all documents and the questionnaire utilized were prepared in both languages. The questionnaire was written in English and then sent to a local translator in Kasigau for translation into Kiswahili. To verify this translation, it was sent back to another individual to be translated back into English. This final translation was reviewed to verify the questions were appropriate for gathering the information outlined in the grant proposal. Additionally, the questionnaire was administered with a translator present for clarification of questions. The survey was also conducted electronically for efficiency utilizing Survey Anyplace, which also allowed for offline data collection that was necessary in survey locations with no internet connection (Survey Anyplace, 2018).

Previous survey attempts in Kasigau involved locals both in administering and participating in the survey. Minimal data collection and participation occurred due to skepticism of sharing personal information with members of their own community. To minimize this issue, the surveys were conducted electronically at local health clinics. These clinics serve as community-gathering locations, providing the number of participants necessary to validate results. This also helped connect the purpose of the clinics and this research to improving the health of the Kasigau community. An informed consent form was prepared and signed by participants to ensure their willingness to participate in the study (Appendix D). The electronic system also allowed individuals to complete the survey independently and privately from other community members. These practices were used to help ensure the rights and well-being of participants, to adhere to survey ethics, as well as to improve attitudes and responses of participants (Jong, 2016). IRB approval was obtained (Appendix E).

Data Analysis

As the survey consisted of different measures that could be related to hypertension, including fuel type, stove type, ventilation factors, and cooking practices, it was important to narrow to measures of biomass fuel use that were most supported in connection to hypertension by other research. Fuel type and stove type were determined to be the best measures for analysis due to their direct relation to household air pollution and variation in the amount of household air pollution produced, the factor related to hypertension (Jetter, 2012; Simoneit, 2002; Sinha, 2018; Vaziri, 2008). Fuel type was narrowed to three variables based on responses: wood, charcoal, and gas. Stove type was narrowed to two variables: wood (i.e. three-stone stove) and charcoal jiko burner. These results seemed to show a connection between fuel and stove type (e.g. wood fuel type with three-stone stove type), but after comparing survey results for fuel type and stove type, there were some discrepancies between the two. For example, four participants selected wood as their fuel type, but selected jiko for their stove type. Furthermore, respondents listing their fuel type as gas always classified their stove as jiko, reducing the ability to differentiate in potential exposure levels. As such, fuel type was considered to be the most reliable measure for relating to hypertension.

Ventilation factors have also been related to blood pressure. For example, one study showed that reducing long-term wood smoke exposure through a chimney stove intervention was associated with a reduction in blood pressure in Guatemalan women (McCracken, 2007). Other kitchen characteristics, such as if the cooking is done in an enclosed space or in a location that is inside, attached to, or separate from the house, would seem to increase exposure to household air pollution from such cooking. The existence of a chimney, or lack thereof, as well as the kitchen location and structure, can also be related to hypertension. As these are specifically relating to cooking, only primary cooks blood pressure measures should be considered with these measures.

Three blood pressure measures were taken for each participant and averaged. As blood pressure measures consist of two measurements, systolic and diastolic, it was necessary to determine which measure would be used when analyzing the relationship with fuel type and other factors. Elevated systolic blood pressure has been a stronger indicator of increased risk of death from cardiovascular disease when compared with elevated diastolic pressures (Pastor-Barriuso, 2003). Systolic blood pressure has also been shown to vary to a greater degree than diastolic blood pressure (Musini, 2009). As such, the systolic blood pressure measure of participants was used in analysis with fuel type and other factors.

A normality test was conducted using SPSS Statistics on systolic blood pressure and showed the Shapiro Wilk p-value to be 0.002 (IBM, 2020). As the significance value of this Shapiro-Wilk test was less than 0.05, the data were not normally distributed. In order to normalize the systolic blood pressure data, a logarithmic transform was performed. The Shapiro-Wilk p-value for the transformed data was 0.1785. The transformed systolic blood pressures for only primary cooks were also tested for normality, showing a Shapiro-Wilk p-value of 0.195.

As the independent variable, fuel type, had three categories, a one-way analysis of variance (ANOVA) was conducted, using the statistical analysis tool SPSS, to see the relationships with systolic blood pressure (log transform) as the dependent variable. An ANOVA shows if there are significant differences among the mean blood pressure measures associated with fuel types. Fuel types were standardized as follows: wood=1, charcoal=2, and gas=3.

For the analysis of ventilation factors, an independent sample t-test was conducted to compare the mean blood pressure measures of primary cooks with a chimney and those without a chimney. The independent variable, chimney presence, was coded as follows: chimney=1, no chimney=2. Another one-way ANOVA was conducted to see the relationship between kitchen location and blood pressures of primary cooks. Kitchen locations were standardized based on their relation to the house into three categories: inside=1, attached= 2, separate=3.

RESULTS

Survey Analysis

A total of 64 individuals participated in the initial and revised survey. Fifty-four participants (84%) identified as female, while 10 participants (16%) identified as male, likely due to the attempt to survey primary cooks who are predominately female (Figure 6). The average age of the survey participants was 52y. Forty-six participants (72%) were from the sub-location Rukanga. Fourteen participants (14%) were from the sub-location Makwasinyi. Four participants (6%) were from the sub-location Buguta (Figure 7). Fifty-four participants (84%) identified as the household primary cook (Figure 8).

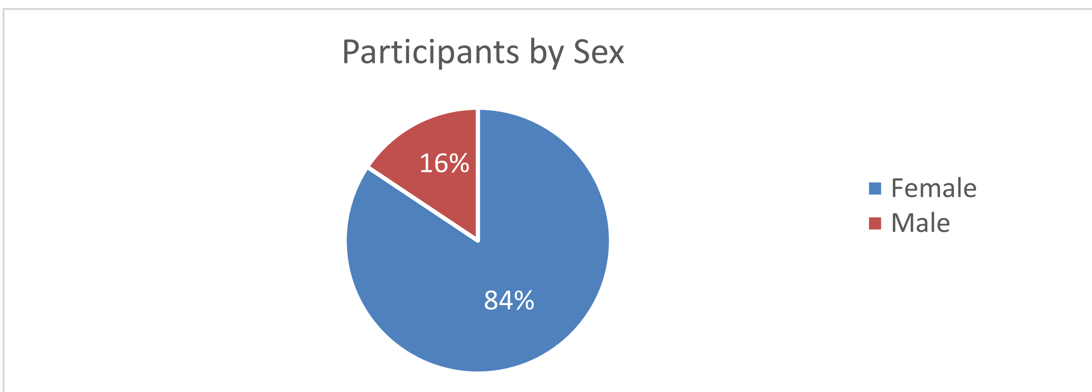

Figure 6. Participants by Sex.

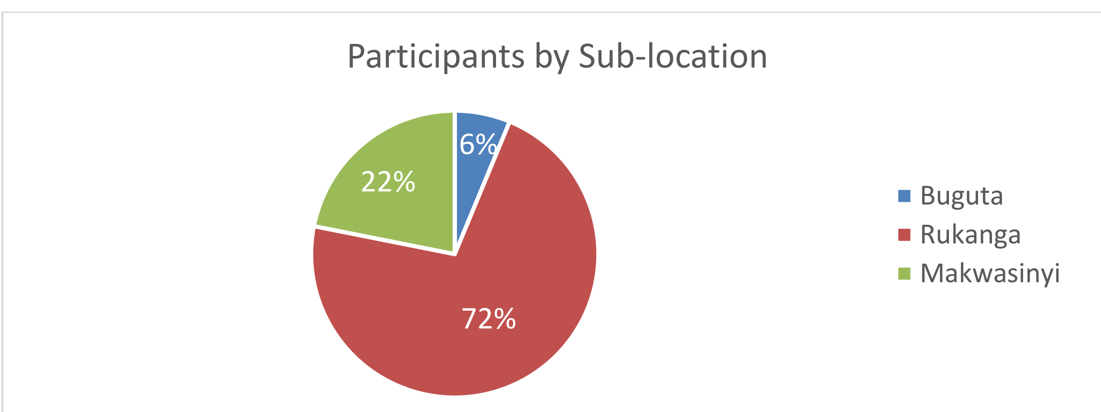

Figure 7. Participants by Sub-location.

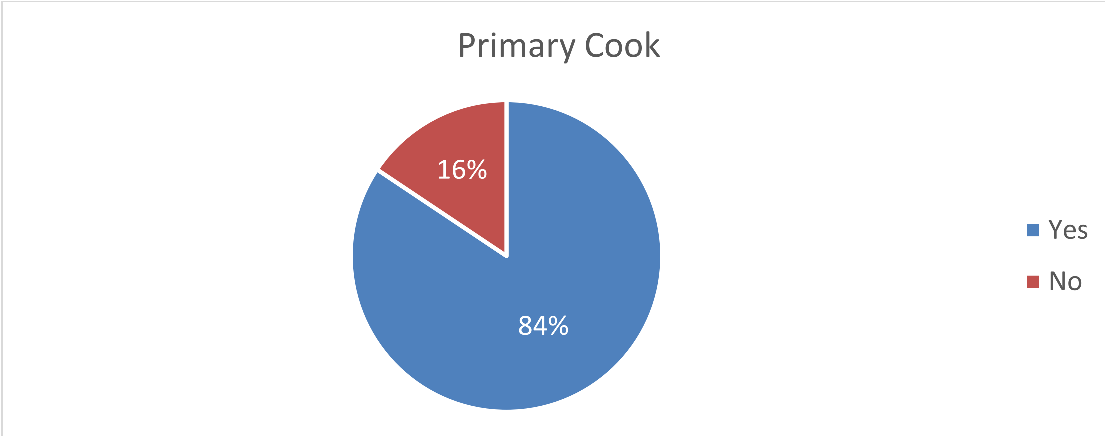

Figure 8. Participants by Primary Cook Identification.

Blood pressure status was determined based on the average of the three systolic blood pressure measures of participants and the parameters outlined by the American Heart Association (2017). Twelve participants (19%) were normotensive with a systolic blood pressure of less than 120 mmHg. Eighteen participants (28%) had elevated blood pressures (e.g. pre-hypertensive) with a systolic blood pressure ranging from 120 to 129 mmHg. Eight participants (12%) were stage 1 hypertensive with a systolic blood pressure ranging from 130 to 139 mmHg. Twenty-six participants (41%) were stage 2 hypertensive with a systolic blood pressure of 140 mmHg or greater (Figure 9).

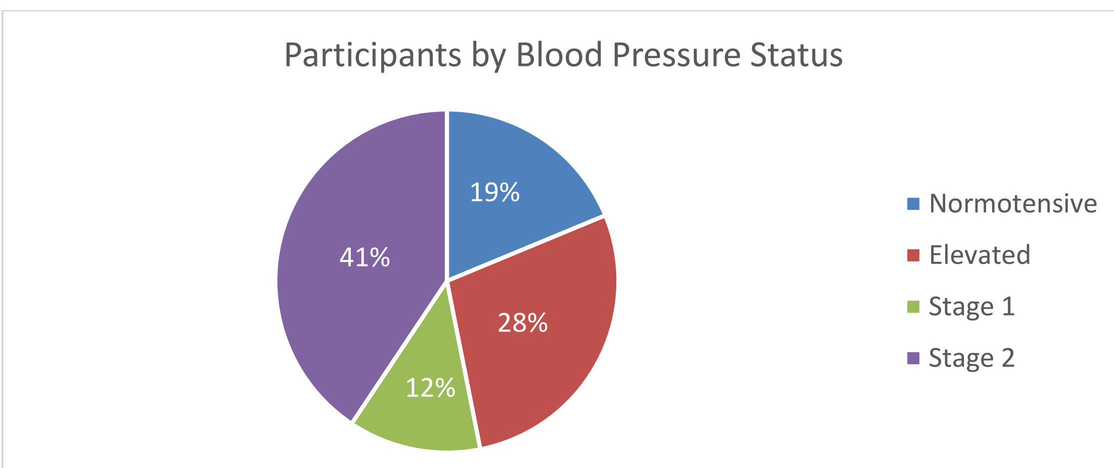

Figure 9. Participants by Blood Pressure Status based on AHA Parameters.

A majority of individuals indicated utilizing unclean fuel and stove types that are in the upper range for air pollution emissions such as particulate matter according to the study by Jetter et al. (2012). Fifty-two participants (81%) indicated their primary fuel type as wood, one of the highest $PM_{2.5}$-emitting fuels. Eight participants (13%) indicated their primary fuel type as charcoal, a less polluting fuel type than wood, but one that still falls in the mid-range for fuel emissions. Four participants (6%) indicated their primary fuel type as gas, but all four also listed either charcoal or charcoal and wood as well (Figure 10). Although the stove type question was later dropped from the revised survey after fuel type seemed to be a more accurate indicator of cooking practices, data from the preliminary survey indicated about 70% of the participants utilized three-stone stoves. As the variable of fuel type was likely closely related to stove type, that only 19% of participants selected a fuel type other than wood indicates a greater likelihood of around 80% of participants using three-stone stoves, the highest-emissions stove type.

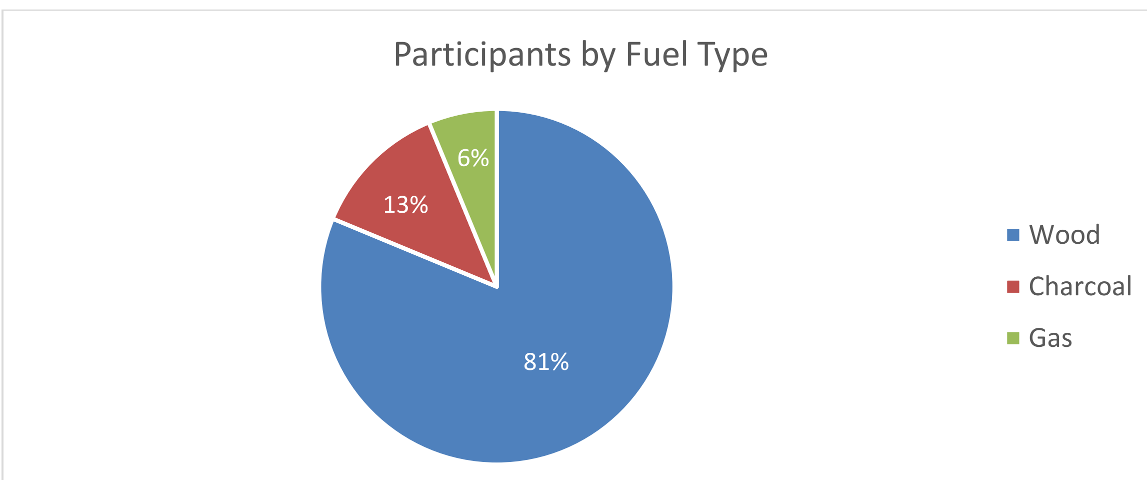

Figure 10. Participants by Fuel Type.

Other aspects of cooking practices seem to indicate participants primarily cooking in enclosed spaces with poor ventilation. The different kitchen location options are shown in Figure 11. Forty-eight participants (75%) indicated cooking in a location separate from the house but in an enclosed space (Stove 5). Eleven participants (17%) indicated cooking in a room attached to the house (Stoves 3 and 4). Two participants (3%) indicated cooking in a room inside the home (Stove 2), while three participants (5%) indicated cooking inside the main room of the home (Stove 1). For statistical analysis, kitchens were classified into 3 categories: inside (Stoves 1 and 2), attached (Stoves 3 and 4), and separate (Stove 5). The percentages of these categories are shown in Figure 12. These cooking spaces often have poor ventilation, with only seven participants (11%) indicating the presence of a chimney (Figure 13). A majority of participants indicated cooking three times or more a day, with most cooking sessions lasting 30 minutes to an hour.

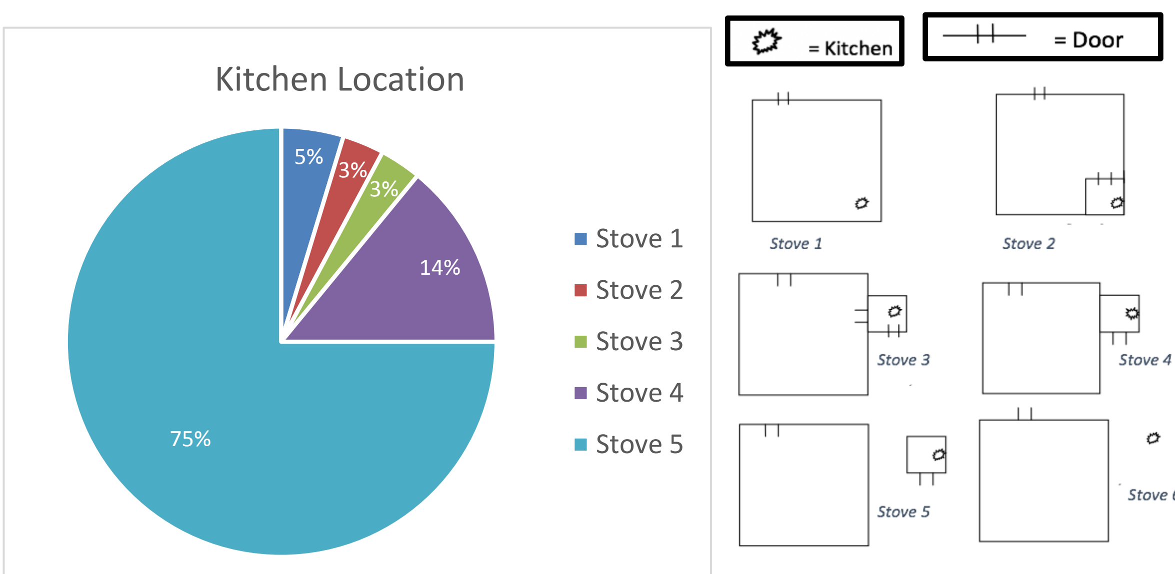

Figure 11. Participants by Kitchen Location.

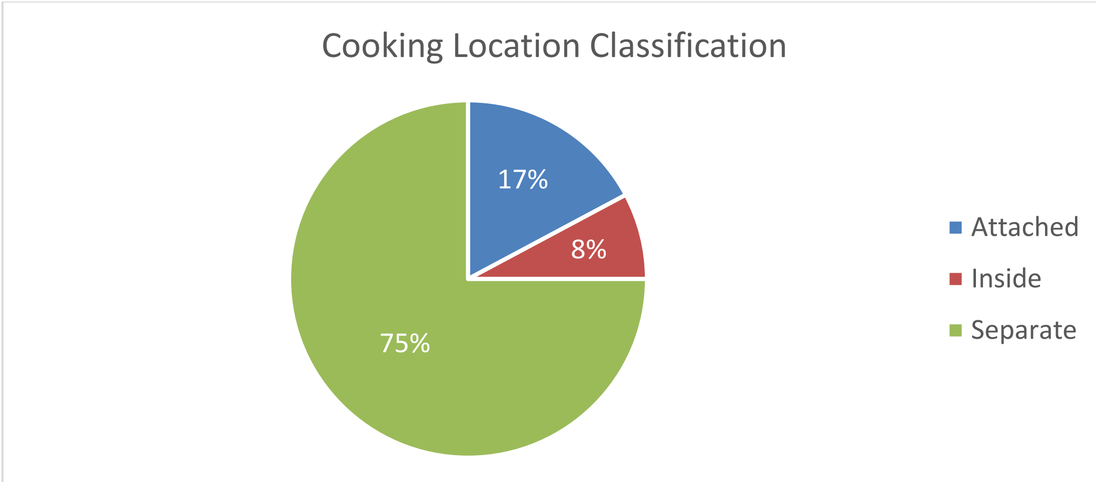

Figure 12. Participants by Kitchen Location Classification

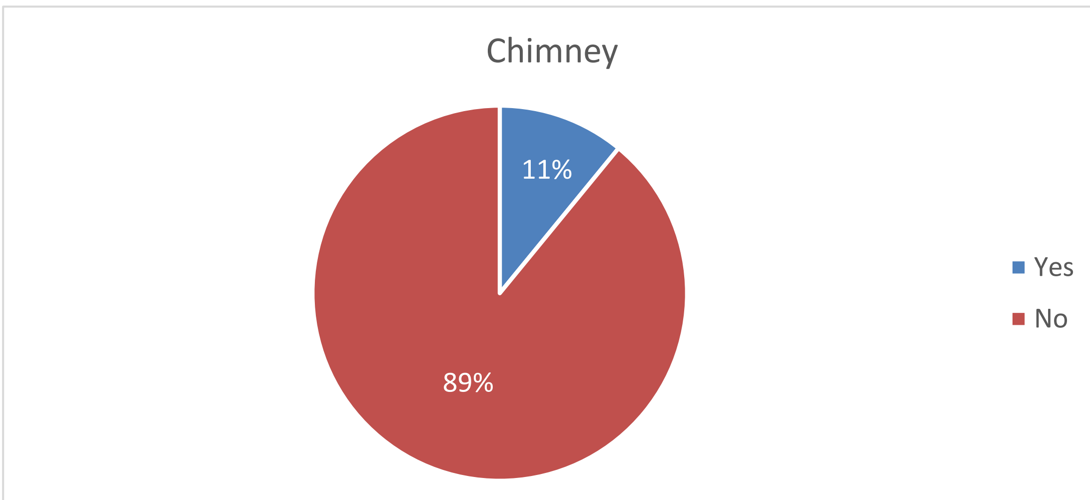

Figure 13. Participants by Chimney Presence.

Statistical Analysis

The data used for the one-way ANOVA comparing fuel type and systolic blood pressure is shown in Appendix F. The ANOVA was conducted with the independent factor as the fuel type and the dependent factor as the log transform of systolic blood pressure. The p-value of the ANOVA was 0.836 (df=63). This p-value is much greater than the necessary p-value of <0.05, indicating no significant difference in systolic blood pressures based on fuel type.

The independent sample t-test comparing chimney presence and systolic blood pressure of primary cooks had a p-value of 0.638 (df= 52) when equal variances were assumed (based on the test of equality of variances with a p-value of 0.473, indicating equal variance across groups). This p-value is much greater than the necessary p-value of <0.05, indicating no significant difference in systolic blood pressures between primary cooks with a chimney and primary cooks without a chimney.

The one-way ANOVA comparing kitchen location (inside vs attached vs separate) and systolic blood pressure of primary cooks had a p-value of 0.793 (df=53). This p-value is much greater than the necessary p-value of <0.05, indicating no significant difference in systolic blood pressures between primary cooks based on their kitchen location.

The results of all statistical tests performed on variables relating to systolic blood pressure are summarized in Table 2 below:

Variable	**Test Performed**	**p-value**	**Degrees of freedom**
Fuel type	One-way ANOVA	0.836	63
Chimney presence	Independent sample t-test	0.638	52
Kitchen location	One-way ANOVA	0.793	53

Table 2. Statistical tests performed on variables related to blood pressure.

DISCUSSION

There are a few conclusions that can be drawn from the results of this survey. First, hypertension is still a prevalent condition in the Kasigau, Kenya population, as determined in previous research. Fifty-three percent of the surveyed individuals were hypertensive, with 41% being stage 2 hypertensive with systolic blood pressures over 140 mmHg. Of the remaining 50% of participants, 30% were pre-hypertensive with elevated blood pressures from 120-129 mmHg. These percentages are nearly equivalent to past work that has identified around 55% of the population as hypertensive, but the percentage of individuals in stage 2 hypertension is greater than previously observed (Williams, 2012). However, if blood pressure measures from Williams's study were classified under the updated blood pressure guidelines utilized in this study, the percentage of the population classified as hypertensive, including those classified as stage 2 hypertensive, would be similar to this study. This change in blood pressure guidelines therefore complicates conclusions about changes in hypertension prevalence. The survey participants were also likely not a representative sample of the broader population, as the average age of participants was 52 years old and the sample was overwhelmingly female due to attempts to survey household primary cooks. This selection bias could account for the higher percentage of individuals in the stage 2 hypertensive state. Furthermore, if household air pollution exposure from cooking is a risk for elevated blood pressure and hypertension, 84% of participants identifying as primary cooks could indicate a higher level of exposure and risk for hypertension. Participants were also overwhelming from the Rukanga sub-location (72%).

The second conclusion is that individuals in Kasigau have a number of risk factors associated with household air pollution exposure. First, high rates of unclean fuel and stove types were observed in the population. Nearly 95% of participants indicated the use of solid fuels, which are known to produce large amounts of air pollution (Simoneit, 2002; Sinha, 2018). Eighty-one percent of participants indicated using wood as their primary fuel type. Wood has one of the highest emission levels of all fuel types (Jetter et al., 2012). If operating under the assumption that fuel type indicates stove type, and based on preliminary analysis of responses, around 80% of participants use a three-stone stove type, one of the highest emission stove types with low combustion efficiency (Jetter et al., 2012). Another 13% of participants indicated using charcoal as their primary fuel, likely for the use of a ceramic, jiko stove type; both types fall within the middle range for emission levels. Only 6% indicated the use of other fuels in the form of gas (which was likely interpreted by participants as kerosene, a lower emission fuel type), but in combination with other solid fuel types.

These unclean fuel and stove types are also used for cooking that occurs predominantly indoors. All participants selected a kitchen location that was in an enclosed space. Seventy-five percent of kitchens were in a room separate from the home, 17% in a room attached to the home, and the remaining 8% inside the home (3% in a room in the home and 5% in the main area of the home). These locations also often lack ventilation factors, such as chimneys, which have been shown to reduce air pollution exposure up to 78% (Accinelli, 2015). Only 11% of participants indicated the presence of a chimney. Multiple cooking sessions a day, with a majority of participants indicating cooking three times a day for 30-60 minutes, in enclosed spaces with poor ventilation indicate frequent exposure to household air pollution. Specific air pollution measures need to be taken to confirm this conclusion.

The third conclusion is that there are no significant differences in systolic blood pressures based on any of the variables analyzed, including fuel type, chimney presence, and kitchen location. The p-value for the ANOVA performed on fuel types was much greater than the value needed for significance, indicating no relationship between fuel type and systolic blood pressure. As the p-value was so large, efforts to improve the study by increasing sample size would likely not change significance. The lack of significant differences in blood pressure based on primary fuel type could be due to a variety of factors. First, fuel type could have no effect on blood pressure, but as different fuel types have different emission levels and increases in emissions are related to increases in blood pressure, some relationship seems possible (Jetter et al., 2012; Young et al., 2019; Zanobetti et al., 2004). Fuel type is likely only one of many factors affecting the blood pressure of individuals in Kasigau and might have a small effect. Another could be that differences in fuel type use might not be very large. Survey participants were asked to indicate their primary fuel type, and as such could often use fuel types other than what they indicated. This is likely indicated by the participants who listed multiple fuel sources, such as those who selected gas as their primary fuel type. This would result in participants' fuel type classifications not being mutually exclusive and resulting in non-significant differences in systolic blood pressure.

The sample sizes for fuels other than wood were also smaller than necessary for the adequate power of the test. For the one-way ANOVAs with three variables, in order to have 80% power with alpha=0.05, the sample size per group needed to be at least 14. Both variables of fuel type and kitchen location have group sample sizes smaller than 14, indicating insignificant power. The necessary sample sizes for significant power for the independent sample t-test on chimney presence are also larger than those collected. As p values were large, this likely would not affect conclusions. A much larger sample size would be needed to make any conclusions about statistical relationships between factors in this survey and blood pressure.

The p-values of statistical tests for the variables of chimney presence and kitchen location were also much greater than the value needed for significance, indicating no relationship between these variables and the systolic blood pressure of primary cooks. This could again be due to these only being some of many factors affecting the blood pressure of participants.

Although some improvements were made in the survey between the first and second attempts, further improvements could be implemented to provide more reliable data on factors that indicate a risk of air pollution exposure. One improvement would be with the stove type question. Including images of the different stove types could be beneficial to ensuring that participants are selecting stove types based on their construction instead of the type of fuel used, as some of the stove type names included the fuel frequently used with the stove (i.e. wood-burning stove). Another improvement could be with the cooking location question. As the differing layout options indicated the location of the kitchen instead of the cook stove, it seemed that some participants were indicating locations that were different than where most cooking and potential air pollution exposure would occur. Modifying the question to ask specifically for the location of the cook stove would help to ensure participants are selecting the location of cooking. The question could also be changed to ask if participants primarily cook in an enclosed space or outdoors, and if this space is inside, attached, or separate from the house as these are the primary factors for exposure levels. Another improvement would be to better quantify fuel use. Participants gave a variety of responses that were difficult to compare with possible differences in fuel prices, amount of fuel in a specific package (i.e. bag of charcoal). Quantifying fuel use based on the mass of fuel consumed would likely be the best measure for comparison, but this is likely difficult for participants to measure individually. The correct translation of fuel types also needs to be ensured to clarify fuel use, such as if participants were indicating use of gas or kerosene.

An important next step in this research would be to directly measure household air pollution in individual homes in Kasigau. This would allow for quantification of air pollutants, such as carbon monoxide and particulate matter, that could be compared to aspects of this survey such as fuel type and stove type. These measurements could also provide direct levels of household air pollution exposure that could be analyzed in real-time against the blood pressure of household members, ideally the primary cook, to see if a relationship is present. Randomized sampling based on households would be necessary to make conclusions.

Although no relationship between fuel type and blood pressure was indicated in the results, other aspects of this research suggest a high risk of household air pollution exposure for participants. These risk factors, such as high-polluting cook stoves, would suggest possible interventions that could help alleviate the health impacts of air pollution exposure like hypertension and cardiovascular disease, such as the previously mentioned study that showed a reduction in blood pressure in Guatemalan women through a chimney stove intervention (McCracken, 2007). Reducing the impacts of hypertension and cardiovascular disease is an important public health issue that is deeply integrated with global issues such as poverty. Household air pollution exposure is predominant in poor populations, supported by the World Health Survey results which present a greater use of solid fuel sources and traditional stoves in poor homes in countries such as Kenya (World Health Organization, 2012). Local implications exist as impoverished populations in America could also benefit from this work. In Appalachia and Native American reservations, similar biomass consumption rates are seen for heating, likely leading to similar air pollution exposures; therefore, parallel studies could be conducted (Paulin, 2016). With changes in EPA standards for solid-fuel cooking and heating devices to reduce emissions, research could be done to see if there is a reduction in the prevalence of diseases such as hypertension and cardiovascular disease (Bernstein, 2014). Practices developed in this survey are also applicable to the study of other epidemiologically-transitioning communities in order to spur chronic disease research in LMICs where Western-specific knowledge is failing.

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APPENDIX A: INITIAL SURVEY

Biomass Consumption Assessment

Survey Questionnaire

1. Provide your name
2. What village are you from?
3. What is your sex?
   a. Male
   b. Female
4. How old are you?
   a. ______ Years
5. What sex is the head of your household (most important decision maker)?
   a. Male
   b. Female
6. What is your relationship to the head of the household?
   a. Parent
   b. Spouse
   c. Child
   d. Other specify ______
7. How many people normally live in your house?
8. What is the total monthly (cash) expenditure of your household in KES?

Modified from World Bank Indoor Air Pollution District Survey Questionnaire

9. Total number of people living in your house (not homestead)?

Person ID	1	2	3	4	5	6	7	8	9	10
Name										
Relation to interviewee Parent (P), spouse (S), child (C), other (O)										
Sex Male (M), Female (F)										
Age										
Daily time spent in the kitchen during cooking (hours)										
Highest education None (0), Primary (1) Secondary (2) Greater than secondary (3)										

Characteristics of house

10. How many rooms are in your house?
11. The roof of your house is made of what material?
    a. Tile
    b. Thatched
    c. Metal
    d. Other specify ______

Modified from World Bank Indoor Air Pollution District Survey Questionnaire

12. What material are your walls made of?

    a. Brick
    b. Concrete/cinder block
    c. Metal
    d. Wood/mud
    e. Other specify ______

13. What material is your floor made of?

    a. Brick
    b. Concrete/cinder-block
    c. Wood/Mud
    d. Dirt
    e. Other specify ______

14. Water source

    a. Well
    b. Homestead tap linked into community line
    c. Community bore hole
    d. Local creeks or rain catch
    e. Other specify ______

15. Toilet

    a. Latrine
    b. Sit on composting
    c. Flush
    d. None
    e. Other specify ______

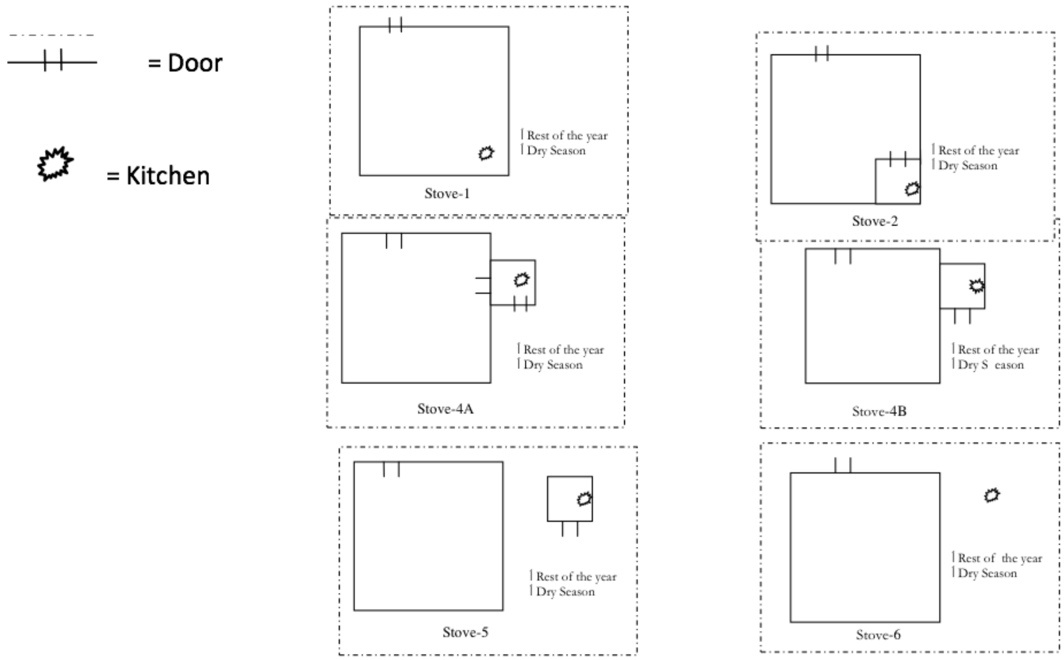
Modified from World Bank Indoor Air Pollution District Survey Questionnaire

Characteristics of kitchen

16. What material is your roof made of?
    a. Tile
    b. Thatched
    c. Metal
    d. Other specify ______
17. What material are your walls made of?
    a. Brick
    b. Concrete/cinder block
    c. Metal
    d. Wood/mud
    e. Other specify ______
18. What material is your floor made of?
    a. Brick
    b. Concrete/cinder-block
    c. Wood/Mud
    d. Dirt
    e. Other specify ______

Modified from World Bank Indoor Air Pollution District Survey Questionnaire

19. Location of kitchen (choose picture that resembles your household)



Other- see interviewer

20. Do family members sleep in the same room where cooking occurs?

a. Yes

b. No

Primary Stove

21. What is your stove type?

a. Gas

b. Electric

c. Kerosene

d. Open fire

e. Ceramic jiko

f. Other specify ______

Modified from World Bank Indoor Air Pollution District Survey Questionnaire

22. What fuel type do you use?
    a. Firewood
    b. Straw
    c. Other crop residue
    d. Animal residue
    e. Charcoal
    f. Kerosene
    g. Other specify ______
23. Do you have a chimney?
    a. Yes
    b. No

Fuel Choice

24. How many times a day does the household typically cook?
25. How many meals does the household have in a day?
26. Do you use fuel to keep warm?
    a. Yes
    b. No
27. If yes, how many months do you use fuel to keep warm?
28. Does the presence of mosquitoes and bugs affect the amount of time you keep the stove/fire going?
    a. Yes
    b. No

29. Do you burn materials and use smoke to keep mosquitoes and bugs away?
    a. Yes
    b. No

Modified from World Bank Indoor Air Pollution District Survey Questionnaire

30. Based on a single month, fill in the following

ID	Fuel Name	Total expenditure on fuel for cooking (in KES)	Quantity consumed (e.g. kg, stick, etc)
1	Fire wood		
2	Straw		
3	Other crop residue		
4	Animal residue		
5	Charcoal		
6	Kerosene		
7	Others (specify)		

Modified from World Bank Indoor Air Pollution District Survey Questionnaire

31. Clean fuels availability and use

Fuel name	Are clean fuels available? (Yes=1, No=0)	If currently available		If becomes available	
		Do you use it? (Yes=1, No=0)	If don't use, why not? (Inconvenient to use=1, Fire hazards=2, Not cheaper=3, No reason=4, Large initial investment=5, Others (specify)	Do you use it? (Yes=1, No=0)	If don't use, why not? (Inconvenient to use=1, Fire hazards=2, Not cheaper=3, No reason=4, Large initial investment=5, Others (specify)
Pipe gas					
LPG/LNG					
Electricity					
Kerosene					

Cooking Exposure

32. Are you the primary cook for the household?

a. Yes
b. No

33. If yes, BP measure (see interviewer) ________

Modified from World Bank Indoor Air Pollution District Survey Questionnaire

34. Are there any other persons in the household who cook on a regular basis

a. Yes
b. No

35. If yes, provide information for each person who cooks on a regular basis

ID of cook (from question 10)	Age at which started to cook?	How many days does the person cook in a month?	On a typical day, how often does the person cook?

36. On a typical day, how many sessions of cooking are done?

Cooking session	How long is it? (in minutes)	Number of people being cooked for?	Who cooks?	Number of helpers? (excluding children)	How many children present?	How long is the fire on after cooking? (in minutes)
First						
Second						
Third						
Fourth						

Modified from World Bank Indoor Air Pollution District Survey Questionnaire

APPENDIX B: TRANSLATED SURVEY (IN KISWAHILI)

UTAFITI KUHUSU MATUMIZI YA MAZINGIRA

Maswali Ya Utafiti

1. Majina yako kamili:...
2. Unatoka kijiji gani?...
3. Jinsia yako.
   a. Mwanaume.
   b. Mwanamke.
4. Tafadhali eleza una umri wa miaka mingapi?
   a. Miaka ______
5. Je, ni nani kiongozi mkuu nyumbani unapoishi? (Haswa, kiongozi anayetoa maamuzi)?
   a. Mwanaume
   b. Mwanamke
6. Je, Una uhusiano gani na kiongozi huyo wa jamii?
   a. Mzazi
   b. Mwanandoa
   c. Mtoto
   d. Mengineo (Tafadhali elezea) ______
7. Je, ni watu wangapi wanaishi nyumbani unapoishi?
8. Tafadhali eleza ni pesa/shilingi ngapi zinazotumika kila mwezi kukimu mahitaji ya nyumbani unapoishi? (Kshs..................)

Modified from World Bank Indoor Air Pollution District Survey Questionnaire

APPENDIX C: REVISED SURVEY

Biomass Consumption Assessment

Survey Questionnaire

1. Provide your name
2. What village are you from?
3. What is your sex?
    a. Male
    b. Female
4. How old are you?
    a. ______ Years
5. Are you the head of the household (most important decision maker)?
    a. Yes
    b. No
6. How many people normally live in your house?
7. What is the total monthly (cash) expenditure of your household in KES?

Characteristics of house

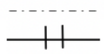
8. How many rooms are in your house?
9. Water source
    a. Well
    b. Homestead tap linked into community line
    c. Community bore hole
    d. Local creeks or rain catch
    e. Other specify ______
10. Toilet
    a. Latrine
    b. Sit on composting
    c. Flush
    d. None
    e. Other specify ______

Modified from World Bank Indoor Air Pollution District Survey Questionnaire

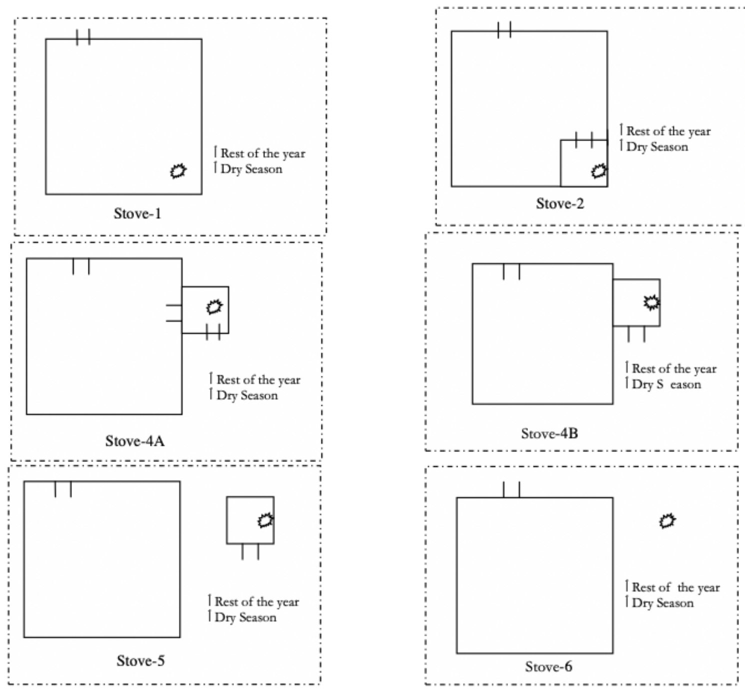
Characteristics of kitchen

11. What material is your roof made of?
    a. Tile
    b. Thatched
    c. Metal
    d. Other specify ______
12. What material are your walls made of?
    a. Brick
    b. Concrete/cinder block
    c. Metal
    d. Wood/mud
    e. Other specify ______
13. What material is your floor made of?
    a. Brick
    b. Concrete/cinder-block
    c. Wood/Mud
    d. Dirt
    e. Other specify ______

14. Location of kitchen (choose picture that resembles your household)


= Door


= Kitchen



Other- see interviewer

15. Do family members sleep in the same room where cooking occurs?

a. Yes
b. No

Primary Stove

16. What is your stove type?

a. Gas
b. Kerosene
c. Open fire
d. Ceramic jiko
e. Other specify ______

17. What fuel type do you use?
    a. Firewood
    b. Straw
    c. Other crop residue
    d. Animal residue
    e. Charcoal
    f. Kerosene
    g. Other specify ______
18. Do you have a chimney?
    a. Yes
    b. No

Fuel Choice

19. How many times a day does the household typically cook?
20. How many meals does the household have in a day?
21. Do you use fuel to keep warm?
    a. Yes
    b. No
        i. If yes, how many months do you use fuel to keep warm?

22. Do you burn materials and use smoke to keep mosquitoes and bugs away?
    a. Yes
    b. No

Modified from World Bank Indoor Air Pollution District Survey Questionnaire

23. Based on a single month, fill in the following

ID	Fuel Name	Total expenditure on fuel for cooking (in KES)	Quantity consumed (e.g. kg, stick, etc)
1	Fire wood		
2	Straw		
3	Other crop residue		
4	Animal residue		
5	Charcoal		
6	Kerosene		
7	Others (specify)		

24. Clean fuels availability and use

Fuel name	Are clean fuels available? (Yes=1, No=0)	If currently available	
		Do you use it? (Yes=1, No=0)	If don't use, why not? (Inconvenient to use=1, Fire hazards=2, Not cheaper=3, No reason=4, Large initial investment=5, Others (specify)
Natural Gas			
Electricity			
Kerosene			

Modified from World Bank Indoor Air Pollution District Survey Questionnaire

Cooking Exposure

25. Are you the primary cook for the household?
    a. Yes
    b. No
26. If yes, BP measure (see interviewer) _______
27. Are there any other persons in the household who cook on a regular basis
    a. Yes
    b. No
28. If yes, provide information for each person who cooks on a regular basis

ID of cook (from question 10)	Age at which started to cook?	How many days does the person cook in a month?	On a typical day, how often does the person cook?

29. On a typical day, how many sessions of cooking are done?
30. Please provide information on a typical cooking session

	How long is it? (in minutes)	Number of people being cooked for?	Number of helpers? (excluding children)	How long is the fire on after cooking? (in minutes)
Typical Cooking session				

Modified from World Bank Indoor Air Pollution District Survey Questionnaire

APPENDIX D: INFORMED CONSENT DOCUMENT

INFORMED CONSENT DOCUMENT

Project Title: The Molecular Epidemiology of Essential Hypertension in Kasigau, Kenya
Investigator: Dr. Nancy Rice, WKU Biology, 270-745-5995

You are being asked to participate in a project conducted through Western Kentucky University. The University requires that you give your signed agreement to participate in this project.

You must be 18 years old or older to participate in this research study.

The investigator will explain to you in detail 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. A basic explanation of the project is written below. Please read this explanation and discuss with the researcher any questions you may have.

If you then decide to participate in the project, please sign this form in the presence of the person who explained the project to you. You should be given a copy of this form to keep.

1. **Nature and Purpose of the Project:**
   This project is designed to understand the frequency of high blood pressure and its associated risk factors in the Kasigau area of Kenya versus Nairobi, Kenya.

2. **Explanation of Procedures:**
   We will measure the frequency and current management of hypertension and evaluate the frequency of indoor air pollution in the Kasigau area. This will involve taking several noninvasive measurements of blood pressure, height, weight, and pulse rate. We will also take one larger spit sample or cheek swab to look for genetic variation in certain genes known to be associated with high blood pressure.

   Following sample collection, you will be asked a series of questions about your household regarding biomass fuel use. Please answer to the best of your ability and as accurately as possible. We anticipate that the total amount of time spent for each participant will be approximately 1 ½ hours.

3. **Discomfort and Risks:**
   There will be no known risk associated with this project.

4. **Benefits:**
   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 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 Kenya.

WKU IRB# 18-201
Approved: 11/30/17
End Date: 11/30/18
Expedited
Original: 11/30/17

5. **Confidentiality:**
All participants will be assigned a number to maintain confidentiality. No names will be recorded or presented in the data.

6. **Refusal/Withdrawal:**
Refusal to participate in this study will have no effect on any future services you may be entitled to from the University or the Kenyan Ministry of Health. Anyone who agrees to participate in this study is free to withdraw from the study at any time with no penalty.

You understand also that it is not possible to identify all potential risks in an experimental procedure, and you believe that reasonable safeguards have been taken to minimize both the known and potential but unknown risks.

______________________________ ____________
Signature of Participant Date

______________________________ ____________
Witness Date

THE DATED APPROVAL ON THIS CONSENT FORM INDICATES THAT
THIS PROJECT HAS BEEN REVIEWED AND APPROVED BY
THE WESTERN KENTUCKY UNIVERSITY INSTITUTIONAL REVIEW BOARD
Paul Mooney, Human Protections Administrator
TELEPHONE: (270) 745-2129

WKU IRB# 18-201
Approved: 11/30/17
End Date: 11/30/18
Expedited
Original: 11/30/17

APPENDIX E: IRB APPROVAL

WKU® INSTITUTIONAL REVIEW BOARD
OFFICE OF RESEARCH INTEGRITY

DATE:	November 30, 2017
TO:	Nancy Rice, PhD
FROM:	Western Kentucky University (WKU) IRB
PROJECT TITLE:	[1161082-1] The Molecular Epidemiology of Essential Hypertension in Kasigau, Kenya
REFERENCE #:	IRB 18-201
SUBMISSION TYPE:	New Project
ACTION:	APPROVED
APPROVAL DATE:	November 30, 2017
EXPIRATION DATE:	November 30, 2018
REVIEW TYPE:	Expedited Review

Thank you for your submission of New Project materials for this project. The Western Kentucky University (WKU) IRB has APPROVED your submission. This approval is based on an appropriate risk/benefit ratio and a project design wherein the risks have been minimized. All research must be conducted in accordance with this approved submission.

This submission has received Expedited Review based on the applicable federal regulation.

Please remember that informed consent is a process beginning with a description of the project and insurance of participant understanding followed by a *signed* consent form. Informed consent must continue throughout the project via a dialogue between the researcher and research participant. Federal regulations require each participant receive a copy of the consent document.

Please note that any revision to previously approved materials must be approved by this office prior to initiation. Please use the appropriate revision forms for this procedure.

All UNANTICIPATED PROBLEMS involving risks to subjects or others and SERIOUS and UNEXPECTED adverse events must be reported promptly to this office. Please use the appropriate reporting forms for this procedure. All FDA and sponsor reporting requirements should also be followed.

All NON-COMPLIANCE issues or COMPLAINTS regarding this project must be reported promptly to this office.

This project has been determined to be a Minimal Risk project. Based on the risks, this project requires continuing review by this committee on an annual basis. Please use the appropriate forms for this procedure. Your documentation for continuing review must be received with sufficient time for review and continued approval before the expiration date of November 30, 2018.

Please note that all research records must be retained for a minimum of three years after the completion of the project.

If you have any questions, please contact Paul Mooney at (270) 745-2129 or irb@wku.edu. Please include your project title and reference number in all correspondence with this committee.

APPENDIX F: DATA FOR FUEL TYPE ANOVA

	FuelType	SBP	LOGSBPforFue
1	2.00	123.00	2.09
2	2.00	123.00	2.09
3	2.00	136.00	2.13
4	2.00	157.00	2.20
5	2.00	129.00	2.11
6	2.00	119.00	2.08
7	2.00	142.00	2.15
8	2.00	133.00	2.12
9	3.00	122.00	2.09
10	3.00	129.00	2.11
11	3.00	133.00	2.12
12	3.00	142.00	2.15
13	1.00	120.00	2.08
14	1.00	141.00	2.15
15	1.00	213.00	2.33
16	1.00	111.00	2.05
17	1.00	143.00	2.16
18	1.00	101.00	2.00
19	1.00	154.00	2.19
20	1.00	161.00	2.21
21	1.00	129.00	2.11
22	1.00	120.00	2.08
23	1.00	151.00	2.18
24	1.00	119.00	2.08
25	1.00	120.00	2.08
26	1.00	192.00	2.28
27	1.00	156.00	2.19
28	1.00	100.00	2.00
29	1.00	134.00	2.13
30	1.00	118.00	2.07
31	1.00	187.00	2.27
32	1.00	123.00	2.09
33	1.00	123.00	2.09
34	1.00	153.00	2.18
35	1.00	123.00	2.09
36	1.00	112.00	2.05
37	1.00	155.00	2.19
38	1.00	145.00	2.16
39	1.00	126.00	2.10
40	1.00	160.00	2.20
41	1.00	146.00	2.16
42	1.00	137.00	2.14
43	1.00	149.00	2.17
44	1.00	132.00	2.12
45	1.00	142.00	2.15
46	1.00	124.00	2.09
47	1.00	126.00	2.10
48	1.00	134.00	2.13
49	1.00	110.00	2.04
50	1.00	115.00	2.06
51	1.00	119.00	2.08
52	1.00	155.00	2.19
53	1.00	95.00	1.98
54	1.00	114.00	2.06
55	1.00	139.00	2.14
56	1.00	173.00	2.24
57	1.00	123.00	2.09
58	1.00	126.00	2.10
59	1.00	196.00	2.29
60	1.00	146.00	2.16
61	1.00	158.00	2.20
62	1.00	147.00	2.17
63	1.00	163.00	2.21
64	1.00	124.00	2.09