SOCIAL AND BEHAVIORAL DETERMINANTS OF NON-COMMUNICABLE DISEASE RISK IN KENYA

A Dissertation

by

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Submitted to the Office of Graduate and Professional Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

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August 2018

Major Subject: Health Education

ABSTRACT

More than half, 75%, of global deaths from non-communicable diseases (NCDs) occur in low and middle-income countries (LMICs). In Kenya, there is evidence of increasing prevalence of NCDs and risk factors such as overweight and obesity, unhealthy diet and inadequate physical activity. The purpose of this dissertation was to: 1) To examine national prevalence and correlates of overweight and obesity in Kenya, 2) To investigate the relationship between fruit and vegetable (FV) intake and NCDs (obesity, type 2 diabetes, and hypertension), and 3) To utilize syndemic theory to identify individuals with multiple NCDs and risk factors.

This cross-sectional study utilized secondary data from the 2015 Kenya WHO Stepwise Survey. A total of 4350 adults were analyzed using descriptive statistics, logistic regression, structural equation modelling, and latent class analysis.

This dissertation found that 28.09% of the sample was overweight or obese. Women, completing primary education or more, being middle wealth category or higher, and aging were significantly associated with overweight or obese. Only 6% of the sample consumed adequate FV a day as recommended by the World Health Organization. A conceptual model of the relationship between FV and NCDs showed differing paths associated by demographic characteristics. Latent class analysis resulted in demonstrated higher probability of NCD risk among individuals residing in urban areas, high education, and high wealth status.

The results of this dissertation support literature of growing burden of NCDs and risk factors in Kenya and similar LMICs. The results suggest that tailored interventions that consider both behavioral and ecologic leverage points are needed to tackle NCDs in Kenya.

DEDICATION

To my mother, Bhai Omar Hamza for always inspiring me to seek the best and highest level of education since I was a child. To my father, Said Mohammed Mkuu for the always believing and supporting my dreams. This journey could not have been possible without the sacrifices of my immigrant parents, their prayers, words of encouragement and phone calls.

To the love of my life, my husband, Cody Aaron Keef, for being the most patient and supportive partner. Your presence and love made the most arduous season of my life amicable. To Steve V. Wonder, for always joining me for breakfast, your unconditional love and loyalty.

ACKNOWLEDGEMENTS

My favorite Swahili proverb is “Umoja Ni Nguvu” meaning unity is strength. This dissertation and the journey leading towards it would not have been possible without the guidance, support, and prayers of many family members, teachers, mentors and friends.

To my siblings, Abdulrahim, Ilham and Rayanah Mkuu, thank you for always being a source of joy and great memories.

To my grandmother, Amina Shaffi, who raised 10 children as a single mother and learned to speak many African languages in order to connect with people. You have always been an inspiration to me and I will forever be grateful for all the lessons from you.

To aunty Naima Amir, my second mother. Part of the energy I cultivated during this journey was harnessed from the spirit of your infinite love and unconditional support.

To my uncle Adam Omar Hamza, who taught me the importance of perseverance and whose indomitable spirit lingered through the long nights I spent writing as PhD Student. Thank you for not letting me go to bed till I learned my times tables as a child, you taught me grit.

To my best friends Sara Sapp and Gregory Cotes, as we realize our dreams, the best part of the journey has been having you beside me. From HOSA-Future Health Professionals to our current lives, we get to carry each other.

To the Mailman clan, Elyse Bevers, Suma Setty, Sarah Ramteke, Patric Prado, Leona Zahlan, Jennifer Decuir, Lashana Lewis, Tameir Holder, and Grace Lee, thank you for always being there, for inspiring me, and always supporting even the most ridiculous of my ideas.

To the best community a Kenyan girl could have moved to at 15 years, Bell, Florida. From inspiring teachers including Charlene Caraway, Lisa Hudson, Terri Golden, Bill Martin, 1SG Jon Meinholz, and David Gray at Bell High School. Learning the value of self-less service at the Bell Library and the Gilchrist Country Character Council. In addition, earning lifelong friends, Charity Ware, Bryan Freeman, Kara Smith Cline, Lauren Hudson, Whitney Lazin, Joy Powell, James Gilman, Darcy Willis, and Geneva and Carl Cornwell and many others. Bell is the place where the journey towards realizing my American dream and the foundation for valuable support and mentorship.

To my mentors, Lloyd Devault, Karen and Jim Koeninger, Susan Horky, Jill Sonke, Jenny Lee, Shilpa Patel, Nadia Islam, Tawandra Rowell-Cunsolo, Michelle S. Davis, Michelle R. Smith, Nathaniel Smith, Thometta Cozart, Steve Owens, Nafissa Cisse Egbuonye, Ann Amuta-Jimenez, and Chychy Smith, thank you for being part of my supportive professional village.

Dr. Idethia Harvey, I could not have asked for a more supportive chair. I will forever be grateful for everything I have learned from you. Dr. Adam Barry, you inspired me to pursue graduate school and supported me in my doctoral studies, thank you will never be enough. Dr. Tamika Gilreath, thank you for inspiring me to challenge myself and to. Dr. Fred Nafukho, your input and contributions were immense, you undoubtedly improved the quality and context of my work.

Thanks also go to my fellow Aggie graduate students, fellow research assistants at the Transdisciplinary Center for Health Equity Research, and faculty in Health & Kinesiology. I am thankful to POWER and Dr. Goodson providing the tools and courage as a writer. Thanks to Dr. Lisako Mckyer for adopting me as one of her own and inviting me to be a part of her incredible mentoring moments. Thanks to Dr. James Burdine for including me in his community project, I learned so much from being involved. Thanks to Dr. Timothy Lightfoot for the invaluable insights and professional development lessons. I will always cherish my experience as an Aggie.

In the words of Maya Angelou, “I come as one, but stand as 10,000.” I will forever be grateful for this privilege and pray that I will honor this responsibly with humility, integrity, and grace. God is great.

CONTRIBUTORS AND FUNDING SOURCES

I would like to thank my committee members, Dr. Harvey, Dr. Barry, Dr. Gilreath, and Dr. Nafukho for their guidance and support throughout the course of this research.

The data analyzed in this dissertation were collected by the Kenya National Bureau of Statistics and the Kenya Ministry of Health in collaboration with several organizations.

Graduate study was supported by the Diversity Fellowship, Texas A&M University, a scholarship award from the Association of Former Students, and a Graduate and Teaching Assistantship from the Department of Health & Kinesiology and Department of Educational Administration and Human Resource and Development, Texas A&M University.

NOMENCLATURE

BMI	Body Mass Index
CFI	Comparative Fit Index
CI	Confidence Interval
CM	Centimeters
CVD	Cardiovascular Diseases
DF	Degrees of Freedom
FV	Fruit and Vegetables
KG	Kilograms
LL	Lower Limit
LMIC	Low and Middle Income Country
M	Meters
N	Number of Participants
NCDs	Non-Communicable Diseases
OR	Odds Ratio
Overweigh/Obese	Overweight or Obese
RMSEA	Root Mean Square Error of Approximation
SE	Standard Error
SES	Socio-economic status
SSA	Sub-Saharan Africa
T2D	Type 2 Diabetes
TLI	Tucker Lewis Index

UL	Upper Limit
WHO	World Health Organization
WRMR	Weight Root Mean Square Residual
χ 2	Chi-Square Test

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CHAPTER I

INTRODUCTION

Non-Communicable Diseases, a Global Challenge

Globally, there is an epidemiological transition resulting in a shift of the leading causes of death from infectious disease dominated to a growing burden of deaths from non-communicable chronic diseases (NCDs) (Mendoza & Miranda, 2017). The increasing prevalence of NCDs worldwide can be explained by the demographic transition theory (Bray, Jemal, Grey, Ferlay, & Forman, 2012; Kirk, 1996; Mendoza & Miranda, 2017). The demographic transition theory proposes that populations change in the following stages; 1) death and birth rates are high with slow population growth rates and limited food supplies; 2) declining mortality rates and increasing life expectancy due to improvements in infrastructure, sanitation, and food supplies and shift from primarily infectious to chronic diseases; and 3) declining birth rates due to an in increase access to contraception, and increase in life expectancy and urbanization (Kirk, 1996). Although life expectancy is increasing, NCDs such as cancer, cardiovascular diseases (CVDs), type 2 diabetes (T2D) and other conditions are dominating as leading causes of death worldwide (World Health Organization, 2017c).

Globally, NCDs are the leading cause of death as seventy percent of all deaths are directly caused by NCDs (World Health Organization, 2017a). The four clusters of NCDs, CVDs, cancers, chronic respiratory diseases, and T2D are responsible for 80% of all premature NCD-related deaths (World Health Organization, 2017a) and are expected to increase and continue as leading causes of death globally. For example, an estimated 17.3 million people died from CVDs in 2008, and it is projected that 23.6 million people will die from CVD related conditions such as stroke and heart disease in 2030 (World Health Organization, 2017a).

The increasing burden of NCDs is associated with the growing global overweight and obesity pandemic (Gakidou et al., 2017; Mathers & Loncar, 2006). Overweight and obesity are defined as having abnormal or excessive fat accumulation (World Health Organization, 2017d). Overweight and obesity rates have more than doubled since 1980 (World Health Organization, 2017d). Worldwide, more than 1.9 billion adults are currently either overweight or obese, of which 600 million are the latter (World Health Organization, 2017d). The rise in overweight and obesity worldwide is associated with an increase of obesogenic environments. The obesogenic environments are characterized as settings that foster behaviors such as sedentary lifestyles and consumption of high-calorie foods and beverages that are associated with an increase in overweight and obesity risk (Caspi, Sorensen, Subramanian, & Kawachi, 2012; Lovasi, Hutson, Guerra, & Neckerman, 2009).

Non-Communicable Diseases in Low- and Middle-Income Countries

The majority of global deaths from NCDs (75%) originate from low and middle income countries (LMICs) (World Health Organization, 2017a). The growing burden of NCDs in LMICs is associated with increasing obesity rates, as obesity is one of the leading risk factors for NCDs (Ford, Patel, & Narayan, 2017; Forouzanfar et al., 2016). The obesity epidemic in LMICs has been linked to urbanization which fuels obesogenic environments thus fostering an increase in NCD risk behaviors such as consumption of high-calorie and sugary foods, increased alcohol and tobacco use, and reduced physical activity levels (Ford et al., 2017; Popkin, Adair, & Ng, 2012).

Non-Communicable Diseases in Sub-Saharan Africa

The Sub-Saharan Africa (SSA) region, home to a significant number of LMICs (The World Bank, 2017b) is also experiencing an increase in the global trend of increasing prevalence of NCDs and obesity (Gakidou et al., 2017; Kengne et al., 2017). Epidemiological estimates illustrate that NCDs are among the leading causes of death in the region, resulting in 33% of all deaths (World Health Organization, 2017a). The SSA region is also reported to have the highest prevalence of hypertension, a leading risk factor for CVDs (World Health Organization, 2017e). Approximately 46% of adults in the SSA region suffer from hypertension, and there is evidence of increasing mortality from cardiovascular-related diseases in the region (Mensah et al., 2015; World Health Organization, 2017e).

In addition to the massive burden that infectious diseases put in the SSA region, NCDs are gradually rising to the top of the leading causes of death concerns in the region (World Health Organization, 2017c). The latest Global Burden of Disease Report demonstrates that despite the decrease in infectious and tropic disease deaths such as malaria and HIV, chronic diseases such as T2D, stroke, heart disease and cancer are rising in the region (Cooper, Kaufman, & Bovet, 2017; Mensah et al., 2015). The combination of both non-communicable and communicable diseases as significant causes of death has been termed as the “double burden” of disease (Bygbjerg, 2012; Min, Zhao, Slivka, & Wang, 2018). This double burden has been recorded in several SSA countries including Ethiopia, Ghana, and Kenya as populations have been found to exhibit both NCD and infectious diseases (Alicke et al., 2017; Kimani-Murage et al., 2015; Misganaw et al., 2017).

The double burden of both NCDs and communicable diseases extends epidemiological trends at the national and community level; it also affects individuals. The overlapping and collision of both NCDs and infectious conditions is also being reported among individuals as there is increasing evidence supporting that individuals are suffering from both NCDs and infectious diseases (Oni et al., 2015; Prioreschi et al., 2017). For example, syndemic suffering has been observed as some individuals suffer from co-occurring conditions such as having both heart disease and HIV, HIV and T2D, and tuberculosis and hypertension (Chimbetete et al., 2017; Prioreschi et al., 2017; Stolbrink & Mortimer, 2018).

Despite growing evidence of high prevalence and mortality from NCDs, and projections of rising prevalence in the upcoming years, limited data in SSA comprehensively examine prevalence and distribution of the social determinants and risk factors for NCDs exists (Nyirenda, 2016). Studies conducted in the region demonstrate that the growing NCD challenge parallels the global overweight and obesity pandemic (Amugsi, Dimbuene, Mberu, Muthuri, & Ezeh, 2017; Choukem et al., 2017; Ng et al., 2014). Overweight and obesity prevalence as high as 43% has been reported in LMICs countries such as Ghana (Ofori-Asenso, Agyeman, Laar, & Boateng, 2016). Moreover, studies have found that overweight and obesity are significantly associated with NCDs in the region (Ajayi, Sowemimo, Akpa, & Ossai, 2016; F. Wu et al., 2015).

Overweight and obesity, and NCDs share common modifiable behavioral risk factors (Ajayi et al., 2016; World Health Organization, 2017c; World Health Organization, 2017d). It is widely accepted that behavioral risk factors such as unhealthy diet, physical inactivity, alcohol, and tobacco use are among the leading behaviors significantly associated with both overweight and obesity and NCDs globally(Gakidou et al., 2017; Mokdad et al., 2003).

In addition to overweight and obesity and behavioral risk factors, there is also evidence demonstrating that socio-demographic factors also influence NCD risk. Studies conducted in high and middle income countries show that individuals from low socio-economic (SES) backgrounds are at a higher risk of NCDs due to a lack of access to healthy living environments (Havranek et al., 2015; Kanjilal et al., 2006; Zilanawala et al., 2015). In LMICs however, the results are mixed. Studies show that wealthy individuals in LMICs have greater risk of NCDs (Bosu, 2016; Olack et al., 2015; Steyn, Nel, Parker, Ayah, & Mbithe, 2011), The individuals who are wealthy are more likely to live in urbanized environments and exhibit obesogenic behaviors (Ajayi et al., 2016; Sartorius, Veerman, Manyema, Chola, & Hofman, 2015; F. Wu et al., 2015).

Urban environment; however, might also influence high NCD prevalence among low SES individuals as studies conducted among urban slum dwellers also demonstrate high prevalence rates of conditions such as hypertension and T2D (Hulzebosch, van de Vijver, Oti, Egondi, & Kyobutungi, 2015; M. D. Joshi et al., 2014; Olack et al., 2015). A recent systematic review of NCD also demonstrates that individuals from low socioeconomic backgrounds are experiencing inequities in NCD outcomes such as higher mortality rates from NCDs such as lung cancer and chronic obstructive pulmonary disease (Sommer et al., 2015). Despite the majority of studies demonstrating a high prevalence of NCDs in urban areas, rural studies also show high prevalence of NCDs and behavioral risk factors among individuals living in LMICs (Price et al., 2018; Yan et al., 2015). There is a need for data that is nationally representative to further disentangle the associations between NCDs, socio-demographic factors, and behavioral risk factors.

Non-Communicable Diseases in Kenya

Preventable NCDs are now among the top leading causes of death in Kenya, a LMIC located in Eastern Africa (Ministry of Health, 2014). Cardiovascular-related deaths such as cerebrovascular diseases (i.e., stroke) and ischemic heart diseases are the 7th and 8th leading causes of death, respectively (Ministry of Health, 2014). Approximately 370,000 individuals or twenty-seven percent of the deaths are associated with NCDs among persons between 30 to 70 years of age in Kenya, annually (Ministry of Health, 2015a). Non-communicable chronic conditions (i.e., CVDs, respiratory diseases, cancer, digestive diseases, and psychiatric conditions) are associated with up to 50 to 70 percent of all hospitalizations in Kenya (Ministry of Health, 2015a).

Alongside growing threat of NCDs in Kenya, overweight and obesity are also an increasing concern. Nationwide prevalence of overweight and obesity in Kenya is yet to be determined; however, there is a growing effort to examine the status of overweight and obesity in the country. The Kenya Demographic and Health Survey (KDHS) reported that 23% of women 15-59 years of age were either overweight or obese (Kenya National Bureau of Statistics, 2014). The most recent KDHS reported that 35% of women 15-49 years were either overweight or obese (Kenya National Bureau of Statistics, 2014). The World Health Organization conducted STEPwise Survey among Kenyans to collect national overweight and obesity data among men and women. The survey found that 39% of women and 18% of men were overweight or obese (overweight/obese) (Ministry of Health, 2015b). Moreover, regional studies report high prevalence of obesity among Kenyans (Ayah et al., 2013; Mathenge, Foster, & Kuper, 2010; Oti, Vijver, Agyemang, & Kyobutungi, 2013), with one study reporting a prevalence rate of 39.8% of overweight and 15.8% of obesity (Christensen et al., 2008).

Regional studies in Kenya demonstrate significant relationships between obesity and NCDs (Githinji et al., 2017; M. D. Joshi et al., 2014; Olack et al., 2015; van, Oti, Agyemang, Gomez, & Kyobutungi, 2013). For example, the odds of having T2D were 2 to 3 times higher for obese individuals in Nairobi (Ayah et al., 2013). The increasing obesity rate in Kenya has been attributed to increasing obesogenic health-related behaviors (e.g., sedentary lifestyle and unhealthy nutrition) that have been reported in similar LMICs (Allen et al., 2017; Ezzati & Riboli, 2013; F. Wu et al., 2015; Yusuf et al., 2014). Regional studies in Kenya demonstrate that those who consume alcohol, smoke tobacco products, and eat high caloric diets have a higher risk of being overweight or obesity, and being diagnosed with NCDs (Githinji et al., 2017; M. D. Joshi et al., 2014; Olack et al., 2015).

Individuals from higher SES in Kenya are significantly more likely to consume higher amounts of processed meat, eggs, fat, and alcohol compared to individuals from lower SES groups who consume significantly higher mean fiber and carbohydrates (e.g., beans and corn/maize) (Mbochi, Kuria, Kimiywe, Ochola, & Steyn, 2012). In addition to consuming higher amounts of processed foods, higher income groups have a significantly higher energy and fat intake compared to low income groups (Steyn et al., 2011). The differences in food consumption patterns by SES in Kenya can also be explained by the avenues at which individuals purchase their foods. Researchers examining differences between individuals who did not purchase food at supermarkets and those who did purchase from supermarkets in Kenya have found that supermarket consumers are significantly more likely to be overweight or obese (Demmler, Ecker, & Qaim, 2018; Kimenju, Rischke, Klasen, & Qaim, 2015). Individuals shopping at supermarkets significantly consume unhealthy diets characterized as having higher calories and highly processed (Rischke, Kimenju, Klasen, & Qaim, 2015).

Along with behavioral risk factors, socio-demographic characteristics such as aging, exposure to environmental pollutants in urban environments, gender, ethnicity, and residence have also been reported as risk factors for NCDs as well as overweight and obesity (Ayah et al., 2013; Christensen et al., 2009a; Haregu, Khayeka-Wandabwa et al., 2016; M. D. Joshi et al., 2014; Ondicho, Omondi, & Onyango, 2016).

The demographic transition model used to explain population changes over time postulates that a nation's growth cycle relates to its economic growth at the time and influences health outcomes (Omran, 2005). As nations advance in economy, infrastructure, and experience advancement in health resources, health outcomes shift from majority infectious disease dominated to NCDs (Omran, 2005). The demographic transition factors which include population growth, increased life expectancy, economic growth, and urbanization can be used to explain the increase of NCDs in Kenya. The demographic transition in Kenya can be observed though;

1. Continued population growth from 31 million in 2000 to 48 million in 2016 (The World Bank, 2017a).
2. Increased life expectancy from 50 years in 2000 to 62 years in 2016 (The World Bank, 2017a).
3. Increased Gross Domestic Product resulting in (i.e., improvements in infrastructure) Kenya's movement from a low-income country to a low- and middle-income country (The World Bank, 2015; The World Bank, 2017b).
4. Increased urban population from 20% in 2000 to 26% in 2016 (The World Bank, 2017c).

Recent research has provided evidence of the demographic transition on disease outcomes within Kenya. Kenyans living in urban areas are more likely to be overweight or obese or living with NCDs than Kenyans living in rural areas (Christensen et al., 2009b; Mathenge et al., 2010; Steyn et al., 2011). The increase in obesity and NCDs in urban areas has been associated with decreased health protective behaviors such as consumption of healthy diets (Bloomfield et al., 2013; Mbochi et al., 2012). Additionally, as the life expectancy of Kenyans increases, the risk of NCDs increases. Several studies in Kenya have demonstrated that increasing age is a risk factor for both obesity and NCDs (Ayah et al., 2013; Christensen et al., 2016; Mugure, Karama, Kyobutungi, & Karanja, 2014; Ploubidis et al., 2013).

Deaths from NCDs are preventable and could be averted by reducing modifiable risk factors such as tobacco and alcohol use, unhealthy eating, and increasing physical activity (Bauer, Briss, Goodman, & Bowman, 2014; World Health Organization, 2011; World Health Organization, 2017c; World, 2011). To curb the public health challenge of rising prevalence of NCDs in LMICs, the WHO developed a framework for LMICs which focuses on obesogenic behaviors such as unhealthy diet (i.e., reducing salt intake or replacing trans-fat with polyunsaturated fat) and physical activity (World Health Organization, 2011).

Dissertation Aim

Over the last decade, Kenya has experienced an emergence of literature on the increasing burden of obesity, NCDs, and related health behaviors. Despite growing concern and recognition of obesity and NCDs prevalence in the country, there is a gap in examining national level predictors and health behaviors related to the conditions. The objective of the proposed dissertation was to examine the national-wide prevalence and predictors of overweight and obesity, NCDs, and protective health-related behaviors associated with the conditions using secondary data from the 2015 Kenya STEPWise survey.

To accomplish the objective, the dissertation will include the following specific aims:

1. To provide global background on NCDs and overweight and obesity epidemics and introduce the scope of NCDs in Kenya. (Chapter I)
2. To examine national prevalence and explore demographic characteristics and health behaviors associated with overweight and obesity in Kenya. (Chapter II)
3. To investigate the relationship between adequate fruit and vegetable intake on established risk factors for NCDs (overweight/obesity, T2D, and hypertension). (Chapter III)
4. To utilize syndemic theory to identify individuals with multiple NCD risk factors. (Chapter IV)
5. To provide discussion and implications of findings from the dissertation. (Chapter V)

CHAPTER II

PREVALENCE AND PREDICTORS OF OVERWEIGHT AND OBESITY IN KENYA

Introduction

Globally, overweight and obesity rates have dramatically increased during the last four decades (World Health Organization, 2017d). The latest overweight and obesity estimates report that approximately 1.9 billion adults are overweight or obese of which 600 million are obese, doubling the rates from 1980 (World Health Organization, 2017d). In low middle-income countries (LMICs), there is growing evidence of increasing and high prevalence of overweight and obesity (Black et al., 2013; Ford et al., 2017; Ziraba, Fotso, & Ochako, 2009). In Kenya, emerging research documents high overweight and obesity rates with one study reporting a prevalence rate of 53% (Christensen et al., 2009b; M. D. Joshi et al., 2014; Kimani-Murage et al., 2015; Mbochi et al., 2012; Mkuu, Epnere, & Chowdhury, 2018; Ondicho et al., 2016).

Overweight and obesity is a public health challenge as the conditions are associated with increasing the risk of several health conditions. Globally, overweight and obesity are significantly associated with increased risk of non-communicable diseases (NCDs) such as heart disease, cancer, and type-2 diabetes (T2D), the leading causes of morbidity and mortality worldwide (Benjamin et al., 2018; Ligibel et al., 2014; Saydah et al., 2014). Researchers in Kenya also link obesity to increased risk of NCDs such as type 2 diabetes and cardiovascular risk (i.e., high blood pressure) (Ayah et al., 2013; Kaduka et al., 2012; Mathenge et al., 2010; Oti et al., 2013).

Obesity is associated with negatively influencing maternal-child health outcomes globally (World Health Organization, 2017d). For example, overweight and obese women are at higher risk for maternal complications that may lead to maternal mortality (Sebire et al., 2001). Among mothers who are overweight or obese, their offspring are more likely have adverse health outcomes such as low birth weight (Marchi, Berg, Dencker, Olander, & Begley, 2015; McDonald, Han, Mulla, Beyene, & Knowledge Synthesis Group, 2010). Children with overweight or obese mothers are also more likely to be overweight and obese (Hillier, Pedula, Vesco, Oshiro, & Ogasawara, 2016). Likewise, overweight and obese Kenyan women are more likely to have overweight and obese children (Gewa, 2010; Pawloski, Curtin, Gewa, & Attaway, 2012).

Despite evidence regarding the consequences of high prevalence and adverse health outcomes associated with overweight and obesity in Kenya, scarce studies have examined the demographic characteristics and health-related behaviors associated with increased overweight and obesity risk. The limited overweight and obesity studies conducted in Kenya are mostly region-focused (Christensen et al., 2008; Ettarh, Van de Vijver, Oti, & Kyobutungi, 2013; Mbochi et al., 2012; Steyn et al., 2011) and disproportionally consist of studies that only examine women (Ettarh et al., 2013; Mbochi et al., 2012; Mkuu et al., 2018; Steyn et al., 2011).

The most recent Kenya Demographic and Health Survey found that 35% of the female sample population were overweight or obese (Kenya National Bureau of Statistics, 2014). Findings from regionally-based studies report higher overweight and obesity prevalence rates among women compared to men (Bloomfield et al., 2013; Christensen et al., 2008), higher prevalence rates among urban-dwellers compared to rural-dwellers (Mathenge et al., 2010; Steyn et al., 2011), and higher prevalence among those of higher socioeconomic status (SES) compared to those with low SES (Mbochi et al., 2012; Steyn et al., 2011). However, one study found that among slum dwellers the prevalence rate of obesity was 43.4% among women and 17.3% among men, contradicting the results that showed a high prevalence rate of overweight and obesity among individuals in higher SES bracket (Ettarh et al., 2013).

To the best of the researchers' knowledge, no study has examined the prevalence and predictors of overweight and obesity using a national-sample of Kenyan men and women. Additionally, very few studies have explored the relationship between health behaviors, overweight, and obesity in Kenya. Sedentary activity (Chau, van der Ploeg, Hidde P, Merom, Chey, & Bauman, 2012; Pulsford, Stamatakis, Britton, Brunner, & Hillsdon, 2013), alcohol consumption(Traversy & Chaput, 2015) and consumption of fruits and vegetables (FV) (Rautiainen et al., 2015; Schwingshackl et al., 2015; Shelton & Knott, 2014) are well recognized as influencing factors for overweight and obesity. In Kenya, there is some evidence that sedentary activity and low consumption of fruits and vegetables influence risk of overweight and obesity; however, results are conflicting as some studies find significant results (Mbochi et al., 2012; Steyn et al., 2011) and others do not (Kimani-Murage et al., 2015). In addition, there is a gap in the literature in examining the relationship between overweight and obesity and fruits and vegetable consumption or sedentary activity for Kenyans. The objectives of this chapter are (1) to examine the socio-demographic characteristics associated with overweight and obesity in Kenya using a nationally representative sample; and (2) to ascertain the relationship between overweight and obesity and health behaviors (e.g., sedentary activity, alcohol consumption, and FV consumption).

Methods

Sample

This study used secondary data from the 2015 WHO Kenya STEPwise Survey of 4,350 adults aged 18 – 69 years. The nationally representative survey was designed to provide national indicators associated with NCDs for community-dwelling adults 18 – 69 years of age. The survey used a multistage probability sampling by region (e.g., urban versus rural), household, and sex and age groups of the Kenya National Bureau of Statistics, Fifth National Sample Surveys and Evaluation Programme (NASSEP V) (Ministry of Health, 2015b). The NASSEP V uses Enumeration Areas (EAs) or counties generated from Kenya's 2009 Population Housing Census (Ministry of Health, 2015b). The first stage involved selecting 200 clusters of which 50% were urban and 50% were rural. Then from each of the urban and rural clusters, 30 households were selected through systematic random sampling. Lastly, using Personal Digital Assistants (PDAs), each eligible individual from the sample household was selected according to biological sex and 12-year age-cohorts using a programmed Kish Grid method of sampling (e.g., where participants are selected within selected units (Ministry of Health, 2015b). Further information regarding the sampling frame can be found in the 2015 Kenya WHO STEPWise report (Ministry of Health, 2015b).

Inclusion criteria for the study are individuals are1) between 18 and 69 years of age and 2) able to provide informed consent for participation (Ministry of Health, 2015b). A total of 4,500 eligible adults, aged 18 to 69 years, participated in the survey, with a response rate of 95% (Ministry of Health, 2015b). For this study, we excluded women who reported to be currently pregnant (N = 136, 3.02%) and individuals who were found to be under the age of 18 during data cleaning (N=14, 0.31%). Multiple imputation was used as a method to address missing data. The final sample consisted of (n = 4,350).

Dependent Variables

Body mass index. Weight in kilograms and height in centimeters were collected. Body Mass Index (BMI) was calculated by dividing the weight in kilograms by meters squared. The study used World Health Organization's (WHO) definition and categorization for BMI (i.e., BMI between 25.0 – 29.9 was defined as overweight and a BMI of $\geq$ 30.0 defined as obese) (World Health Organization, 2017d). A dichotomous outcome variable indicating whether participants were overweight or obese (overweight/obese) was calculated (underweight/normal (BMI$\leq$ 24.99) =0, overweight/obese (BMI $\geq$ 25) =1).

Independent Variables

Demographic Characteristics. Participant demographic characteristics were assessed using biological sex (women = 1, male = 0), age as a continuous variable as well as recorded into 12 year age groups (18-29=1, 30-44=2, 45-59=3, and 60-59=4), education as a categorical variable re-coded as (less than primary education = 0, completed primary education or above = 1), marital status as a categorical variable re-coded as (married/cohabitating = 1, separated/divorced = 2, never married = 3, and widowed = 4), residence as a categorical variable re-coded as (rural = 0, urban = 1), and wealth index/ category as a categorical variable re-coded as (poorest/poor = 0, middle/rich/and richest = 1).

Health Behaviors. Health behaviors included in this study were alcohol consumption in the last 30 days (yes = 1, no = 0), sedentary activity (i.e., minutes spent sitting or reclining on a typical day) and average FV consumption. To examine sedentary activity, participants were asked to share how many hours and minutes they spent sitting or reclining on a typical day. A measure of total amount of sedentary activity was calculated by converting the number of hours reported to minutes by multiply by sixty then adding the time to the reported number of minutes for a total. Thus, the sedentary variable reflected total amount of time spent sitting or reclining in minutes on a typical day.

Fruits and vegetable (FV) consumption involved examining the reported frequency of consuming FV using the following four questions: 1) *In a typical week, on how many days do you eat fruit?* 2) *How many servings of fruit do you eat on one of those days?* 3) *In a typical week, on how many days do you eat vegetables?* and 4) *How many servings of vegetables do you eat on one of those days?* A nutrition card with examples of local fruits and vegetables was displayed to participants to give examples for serving size. A continuous variable of average fruits and vegetables consumed during a typical day was calculated. The variable was calculated first by multiplying the number of days the participants consumed fruit by the number of servings reported in a typical day. The number was then divided by 7 to create a daily consumption average. The daily average number of vegetables consumed was calculated using the same formula. After, a continuous score of average FV in a typical day was constructed by summing the average fruit and average vegetables on a typical day. The continuous variable was used in the model. A dichotomous variable was also calculated measuring whether participants consumed at least 5 servings of FV as recommended by the World Health Organization for descriptive purposes (World Health Organization, 2017b).

Analysis

Data analysis was conducted using STATA 14. The data was weighted during analysis to account for the multistage cluster sampling design using "svyset" commands that account for stages of sampling. Data weighing prevents underestimation of sampling error as statistical packages often assume data was collected using simple random sampling (Treiman, 2014). Results from missing data analysis demonstrated that the variable for marriage was missing (n=1, 0.02%), overweight/obese was missing (n=79, 1.75%), average FV was missing (n=53, 1.18%), and sedentary minutes (n=63, 1.4%). Multiple imputations was used as a method to address missing data by replicating the data using 20 datasets using 1234 iterative random seed draws.

Descriptive analysis was conducted to provide details on demographic characteristics of the sample. Proportions for categorical variables and means and standard errors for continuous variables were calculated. Chi Square analysis was used to examine significant demographic characteristics associated with being overweight/obese. Logistic regression analysis was conducted first to examine demographic characteristics that were significantly associated with the outcome variable being overweight/obese (No = 0, Yes = 1).

Logistic regression models were also conducted to examine the relationship between overweight/obese and NCD health-related behaviors, (i.e., sedentary activity, consumption of fruits and vegetables, and alcohol consumption) controlling for sociodemographic variables, gender, age, marital status, education, residence, and wealth that have been found to influence overweight and obesity status in Kenya (Christensen et al., 2008; Mbochi et al., 2012; Mkuu et al., 2018; Steyn et al., 2011). A p-value of less than 0.05 was considered significant.

Results

Sociodemographic Results

The mean age of participants was 34.66 (SE = 0.44) with majority being under the age of 44 years (18-29 year olds= 45.03% and 30-44 year olds=32.87%). The sample was evenly distributed by biological sex with (50.41%) men and (49.59%) women. Overall, the majority of the sample were married or cohabitating (64.75%), lived in rural areas (61.47%), had at least secondary education or above (64.25%), and were in the middle to richest wealth categories (60.17%). Table 2.1 displays descriptive results of the sample.

Table 2.1: Descriptive characteristics of study sample (n=4,350)

	Proportion/ Mean	SE	95% CI	
			UL	LL
Sex				
Men	50.40%	0.01	0.48	0.53
Women	49.60%	0.01	0.47	0.52
Age Groups				
Age	34.66	0.44	33.79	35.53
18-29	45.03%	0.02	0.41	0.49
30-44	32.87%	0.01	0.31	0.35
45-59	16.56%	0.01	0.15	0.18
60-69	5.54%	0.00	0.05	0.07
Marital Status				
Married/Cohabitating	64.75%	0.01	0.62	0.68
Divorced/Separated	5.82%	0.01	0.05	0.07
Never Married	23.72%	0.02	0.21	0.27
Widowed	5.71%	0.01	0.05	0.07
Education Level				
Incomplete Primary or below	35.75%	0.02	0.31	0.41
Complete Primary or above	64.25%	0.02	0.59	0.69
Wealth Status				
Poorest/Poor	39.83%	0.03	0.33	0.47
Middle/Rich/Richest	60.17%	0.03	0.53	0.67
Residence				
Rural	61.47%	0.04	0.53	0.69
Urban	38.53%	0.04	0.31	0.47
Weight Status				
BMI	23.39	0.22	22.95	23.83
Underweight/Normal	71.91%	0.02	0.69	0.75
Overweight/Obese	28.09%	0.02	0.25	0.31

The mean BMI of the sample was 23.38 (SE=0.22). More than a quarter, (28.08%) of participants were overweight/obese. The proportion of participants who consumed alcohol within the past month was (19.90%). The average number of fruits and vegetables consumed on a typical day was 2.10 (SE = 0.09). The proportion of participants who reported consuming the recommended 5 or more servings of FV per day was (6.11%). The average time spent sitting or reclining in a day was 152.70 (SE=3.85) minutes. Table 2.2 provides descriptive results of health behaviors for the sample.

Table 2.2: Descriptive results of health behaviors among the sample.

	Proportion/ Mean	SE	95% CI UL	95% CI LL
Current Alcohol Drinker	19.84%	0.01	0.17	0.23
Adequate Fruit & Veg per Day	6.15%	0.01	0.04	0.08
Average Fruit& Veg/Day	2.10	0.08	1.95	2.26
Sedentary minutes/Day	152.70	3.85	145.11	160.30

Chi-Square results demonstrated that socio-demographic characteristics significantly associated with overweight/obese were biological sex, age, marital status, education level, wealth status and residence. Women had a significantly higher proportion of overweight/obese compared to men (38.58% vs. 17.177%). Middle-aged individuals had significantly higher proportion of overweight/obese with (32.42%) of 30-44 year olds and (35.56%) of 45-59 year olds being overweight/obese compared to 18-29 year olds.

Married individuals had the highest (31.75%) proportion of being overweight/obese followed by widowed individuals (30.53%). Individuals with completed primary education had significantly higher proportion of overweight/obesity compared to those with less than primary education (33.09% vs. 19.06%). Individuals who were in the middle wealth category or higher had (36.11%) proportion of overweight/obese compared to poor or poorest individuals (15.96%). Urban participants had (36.75%) proportion of overweight/obesity compared to rural participants (22.65%). Table 2.3 provides descriptive results of overweight/obesity by characteristics.

Table 2.3: Descriptive results of overweight/obesity by socio-demographic characteristics.

	Overweight/ Obese Proportion	SE	95% CI		
			UL	LL	p
Sex					<0.05
Men	17.77%	0.02	0.14	0.23	
Women	38.58%	0.02	0.35	0.43	
Age Groups					<0.05
18-29	21.79%	0.02	0.19	0.25	
30-44	32.42%	0.03	0.27	0.38	
45-59	35.56%	0.03	0.31	0.41	
60-69	31.55%	0.04	0.25	0.39	
Marital Status					<0.05
Married/Cohabitating	31.75%	0.02	0.28	0.35	
Divorced/Separated	23.28%	0.03	0.17	0.30	
Never Married	18.70%	0.03	0.14	0.25	
Widowed	30.53%	0.04	0.24	0.38	
Education Level					<0.05
Incomplete Primary or below	19.06%	0.02	0.16	0.22	
Complete Primary or above	33.09%	0.02	0.30	0.37	
Wealth Status					<0.05
Poorest/Poor	15.96%	0.01	0.14	0.18	
Middle/Rich/Richest	36.11%	0.02	0.32	0.40	
Residence					<0.05
Rural	22.65%	0.02	0.20	0.26	
Urban	36.76%	0.02	0.32	0.42	
Current Alcohol Drinker					p = 0.05
Yes	21.41%	0.04	0.15	0.30	
No	29.74%	0.02	0.27	0.33	
Adequate Fruit & Veg per Day					p = 0.97
Yes	28.01%	0.03	0.22	0.35	
No	28.14%	0.02	0.25	0.32	

Logistic Regression Results: Sociodemographic Characteristics and overweight/obesity

A logistic regression analysis model examining the relationship between overweight or obese and sociodemographic factors (e.g., age, biological sex, marital status, level of education, wealth status, and residence) was significant, $F(10, 1.4e+11) = 56.73$ $p < 0.001$. The model demonstrated that age, biological sex, marital status, level of education, wealth status and residence were significant socio-demographic characteristics associated with being overweight/obese. The odds of being overweight or obese increased by age. Participants who were between 30 – 44 years of age (OR = 2.27; 95% CI:1.89-2.74), between the ages of 45 – 59 years (OR = 2.94; 95% CI: 2.37-3.66), and between the ages of 60 – 69 years (OR = 3.14; 95% CI:2.37-4.18) were significantly more likely to be overweight/obese compared to participants 18-29 years of age controlling for marital status, biological sex, education, wealth, and residence.

The odds of being overweight or obese were significantly higher for women compared to men (OR = 3.51, 95% CI: 3.00-4.10) controlling for marital status, age, education, wealth, and residence. Married or cohabitating participants were significantly more likely to have higher odds of overweight or obesity compared to never-married participants (OR = 1.47, 95% CI: 1.18-1.82) controlling for biological sex, age, education, wealth, and residence. Participants with completed primary education level or above were significantly more likely to be overweight or obese (OR = 1.89, 95% CI:1.61-2.22) compared to those with lower education level controlling for biological sex, age, marital status, wealth, and residence.

Participants who were in the middle wealth categories or above were significantly more likely to be overweight or obese (OR = 2.80, 95% CI 2.36-3.32) compared to those who were in the poor or poorest wealth categories controlling for biological sex, age, education, marital status, and residence. Participants who lived in an urban area were significantly more likely to be overweight or obese compared to participants who lived in rural areas (OR = 1.42, 95% CI 1.22-1.65) controlling for biological sex, age, education, wealth, and marital status.

An interaction model examining education and wealth status was significant (DF 198, N = 4,340, p<0.001). The interaction model demonstrated no significant interaction effect between education and wealth status and being overweight or obese (OR = 0.87, 95% CI .57 – 1.34). Table 2.4 demonstrates the logistic results of socio-demographic characteristics and being overweight or obese.

Health Behaviors associated with overweight and obesity

A logistic regression model examining associations between being overweight or obese and health behaviors (e.g., being a current alcohol drinker, adequate fruit and vegetable intake, and the number of minutes spent sitting in a typical day) and controlling for socio-demographic characteristics (age, marital status, biological sex, residence, wealth, and education) was conducted. The model was significant F (13, 2.7e+07) =44.39, p<0.001). The model indicated that average FV intake (OR = 1.03, 95% CI .996-1.07), and average sedentary minutes per day (OR = 1.04, 95% CI .1.00-1.00) were not a significant predictor of overweight/obesity controlling for socio-demographic risk factors. Consuming alcohol within the last month was significantly associated with less odds of being overweight/obese (OR = 0.68, 95% CI 0.55-0.82) controlling for socio-demographic characteristics. The following socio-demographic characteristics were significant with overweight/obese in the model; being married (OR = 1.46, 95% CI 1.17-1.81), being a women (OR = 3.20, 95% CI 2.71-3.77), living in an urban environment (OR = 1.43, 95% CI 1.23-1.67), and being in the middle wealth category or higher (OR = 2.74, 95% CI 2.31-3.25). Additionally, overweight/obese odds increased by age compared to 18-29 year olds; (30-44 years= (OR = 2.32 95% CI 1.93-2.80), 45-59 year olds= (OR = 2.98, 95% CI 2.40-3.71), 60-69 year olds= (OR = 3.12, 95% CI 2.34-4.14)). Detailed logistic regression results are provided in Table 2.5.

Table 2.4: Logistic Regression Results of Sociodemographic Characteristics and Overweight/ Obese.

Covariates	Odds Ratio (OR)	SE	95% CI for OR. LL	UL
Constant	0.02	0.004	0.02	0.03
Age Groups				
18-29		Reference		
30-44	2.27	0.22	1.89	2.74
45-59	2.94	0.33	2.37	3.66
60-69	3.14	0.46	2.37	4.18
Sex				
Men		Reference		
Women	3.51	0.28	3.00	4.10
Marital Status				
Single/Never Married		Reference		
Married/Cohabitating	1.47	0.16	1.18	1.82
Divorced/Separated	0.93	0.16	0.67	1.31
Widowed	1.05	0.18	0.75	1.48
Education Level				
No School/Incomplete Primary		Reference		
Complete Primary or more	1.89	0.15	1.61	2.22
Wealth Status				
Poor and Poorest		Reference		
Middle, Rich and Richest	2.80	0.24	2.36	3.32
Residence				
Rural		Reference		
Urban	1.42	0.11	1.22	1.65

Table 2.5: Logistic Regression Results behaviors and Overweight/Obese Controlling for Socio-demographic Factors

Covariate	Odds Ratio (OR)	SE	95% CI for OR Lower	95% CI for OR Upper
Constant	0.02	0.004	0.017	0.03
Average Fruit & Veg/Day	1.04	0.02	1.00	1.08
Current Alcohol Drinker	0.68	0.08	0.55	0.85
Sedentary minutes/Day	1.00	0.0003	1.00	1.00
Age Groups				
18-29		Reference		
30-44	2.32	0.22	1.93	2.80
45-59	2.98	0.33	2.40	3.71
60-69	3.12	0.45	2.34	4.15
Sex				
Men		Reference		
women	3.20	0.27	2.71	3.77
Marital Status				
Single/Never Married		Reference		
Married/Cohabitating	1.46	0.16	1.17	1.81
Divorced/Separated	0.95	0.17	0.68	1.34
Widowed	1.05	0.18	0.75	1.48
Education Level				
Less than Primary		Reference		
Primary Education or more	1.87	0.15	1.59	2.20
Wealth Status				
Poor and Poorest		Reference		
Middle, Rich and Richest	2.74	0.24	2.31	3.25
Residence				
Rural		Reference		
Urban	1.43	0.11	1.23	1.67

Discussion

This study sought to examine the national prevalence of overweight and obesity in Kenya and ascertain sociodemographic and health behaviors that influence the increased risk of overweight or obesity. The average BMI of the sample was 23.38 with 28.09% being overweight/obese. The prevalence rate of overweight and obesity in our study aligns with previous studies in Kenya (Christensen et al., 2008; Ettarh et al., 2013) and compares to similar LMICs (Commodore-Mensah, Samuel, Dennison-Himmelfarb, & Agyemang, 2014; Jones-Smith, Gordon-Larsen, Siddiqi, & Popkin, 2012; Kirunda, Fadnes, Wamani, Van den Broeck, & Tylleskär, 2015).

The odds of being overweight or obese increased significantly as age increased. The results are comparable to studies showing increased overweight and obesity among older individuals in Kenya (Kimani-Murage et al., 2015; Mbochi et al., 2012; Ondicho et al., 2016). The rise of overweight and obesity risk by older age is particularly concerning for older individuals. Older individuals are at increased risk of being diagnosed with chronic diseases (Arokiasamy et al., 2017), and overweight and obesity is an established risk factor for chronic disease (Ligibel et al., 2014; Saydah et al., 2014; World Health Organization, 2017d). Interventions aimed to reduce overweight, and obesity among older individuals may contribute to curbing NCD prevalence rate, morbidity, and mortality.

Globally, women have the highest risk of being overweight or obese (Fryar, Carroll, & Ogden, 2012; Ng et al., 2014). Similar to other studies in Kenya, this study found that women were significantly more likely to have a higher prevalence rate of being overweight or obese compared to men (Ettarh et al., 2013; Jayne, Scrimgeour, Polhemus, Otieno, & Bovill, 2011; Oti et al., 2013). In this study, women were four times more likely to be overweight or obese compared to men. Research conducted in Kenya that focused exclusively on women confirmed the high prevalence rate (Christensen et al., 2008; Mbochi et al., 2012; Steyn et al., 2011). Researchers have reported the overweight and obesity prevalence rate as high as 43.3% among women (Christensen et al., 2008; Mbochi et al., 2012; Steyn et al., 2011). Among women, overweight and obesity increases the risk of adverse maternal and health outcomes and increases risk for NCDs (Gathirua-Mwangi, Zollinger, Murage, Pradhan, & Champion, 2015; Onubi, Marais, Aucott, Okonofua, & Poobalan, 2016). In Kenya, studies show higher risk of chronic disease such as T2D and hypertension among women who are overweight or obese (Olack et al., 2015; Oti et al., 2013). The weight status of women has been shown to influence child-health outcomes of offspring (Godfrey et al., 2017; Ziauddeen, Roderick, Macklon, & Alwan, 2018). Children whose mothers were overweight or obese were also found to have increased risk of being overweight or obesity (Kimani-Murage et al., 2015).

In Kenya, there is a double burden of overweight and obesity and malnutrition that adds to the complexity of maternal-child health outcomes. The double burden has been demonstrated by studies showing both under-nutrition and over-nutrition in the country (Kimani-Murage et al., 2015; Pawloski et al., 2012). A recent study found that mothers who were overweight or obese were more likely to consume foods that lack proper nutrients and that were high caloric (Kimani-Murage et al., 2015). This nutritional outcome might be explained by geographic variability and quality or access to healthy foods (i.e., geographically influences on the types and quality of available foods (Pawloski et al., 2012). Mothers who were overweight or obese not only consumed high caloric, high sugar, and high-fat foods (e.g., starchy staples) may provide similar foods to their children. The foods may result in over-nutrition causing overweight and obesity among the mothers and under-nutrition for children (Kimani-Murage et al., 2015). Children of overweight or obese mothers may not be receiving essential healthy nutrients typically found in healthy diets (i.e., fruits and vegetables) which are rich in nutrient properties (Arimond & Ruel, 2004; Garrett & Ruel, 2005). Curbing overweight obesity among women through focusing on healthy nutrition might have implications for reducing both maternal and child nutritional health outcomes.

Socioeconomic status (SES), that is having completed primary education or being in the middle, rich, or richest wealth category, was a significant predictor of being overweight or obese in this study. We found that individuals with completed primary education and those who were middle class or higher were significantly more likely to be overweight or obese. An interaction model between the level of education and wealth status was not significant. Unlike middle and high-income countries where individuals from low SES are more likely to be overweight or obese (Bhurosy & Jeewon, 2014; McCormack et al., 2017; Ogden et al., 2017), studies in Kenya and similar LMICs support findings of higher prevalence with increasing SES (Kirunda et al., 2015; Mbochi et al., 2012; Neupane, Prakash, & Doku, 2015; Steyn et al., 2011). This study also found that married individuals were significantly more likely to be overweight and obese. The higher risk of overweight or obesity among married individuals may be explained by increase in access to higher wealth or second income. This finding has implications for public health as there may be broader cultural implications, for example, the preference for a larger body size as a sign of high wealth or social status (Appiah, Otoo, & Steiner-Asiedu, 2016; Ettarh et al., 2013; Tuoyire, Kumi-Kyereme, Doku, & Amo-Adjei, 2017). Thus, public health professionals need to consider more than health education initiatives to curb overweight and obesity in Kenya as cultural and environmental factors may play a more significant role. We recommend further studies to focus on disentangling drivers of overweight or obesity beyond SES in Kenya.

Findings mirror studies in Kenya and other LMIC demonstrating that individuals from urban areas are significantly more likely to be overweight or obese (Christensen et al., 2008; Mkuu et al., 2018; Pawloski et al., 2012; Steyn et al., 2011). The explanation of higher overweight and obesity among urban dwellers has been associated with environmental factors that increase the risk of overweight or obesity (Mbochi et al., 2012). Obesogenic environments which are characterized as environments with higher access to processed foods, lower access to healthy food options such as fresh fruit and vegetables, low access to safe and convenient places for engaging in physical activity have been associated with increased overweight and obesity in LMICs (Ford et al., 2017; Oyeyemi et al., 2012; Popkin et al., 2012). Individuals living in urban areas may be more likely to have jobs that require prolonge sedentary activity such as sitting.

This study found no significant association between average sedentary activity or average intake FV consumption and being overweight or obese. Adults in Kenya are reported to have high physical activity (Ayah et al., 2013; Joshi et al., 2014; Van de Vijver et al., 2013). A very low proportion of adults consumed adequate FV, supporting findings from previous studies in Kenya (Bloomfield et al., 2013; Hulzebosch et al., 2015; Muchira et al., 2015). Sedentary activity is increasingly being recognized as a factor influencing NCD risk (Biswas et al., 2015; Owen, Bauman, & Brown, 2009; Thyfault, Du, Kraus, Levine, & Booth, 2015) however, the rests of this study did not find any significant relationship between sedentary time and overweight/obesity. The self-reported nature of the measure might have influenced the findings. This found that current alcohol consumers had lower odds of overweight/obese. The results supporting findings of mixed evidence on alcohol's effect on overweight and obesity (Traversy & Chaput, 2015).

Strengths and Limitations

This study has several limitations. First, the cross-sectional nature of the study limits ability to examine trends over time. The use of secondary data limited the breadth and depth of exploration of behaviors. Although, the WHO STEPWise survey provides comprehensive behavioral factors associated with NCDs and obesity, the operationalization of some variables was imited. For example, fruit and vegetable intake was measured using recall of both the number of days participants consumed fruits and vegetables and the quantity consumed on an average day. The variable may be profoundly influenced by recall bias. Other nutritional data collection such as 24 or 48-hour dietary recall may elicit the improved memory of the participants' dietary habits (Rutishauser, 2005).

Despite the limitations, this study has several strengths. This study provides a foundation as the first nationally representative sample to examine overweight and obesity in Kenya among both men and women. This study is the first to examine the prevalence rate of overweight and obesity and socio-demographic characteristics and behavioral risk factors among Kenyans using a nationally representative sample. The use of the WHO STEPWise survey is a strength as the methods, and survey instruments have been found to be reliable (Bonita, Winkelmann, Douglas, & de Courten, 2003; Janghorbani et al., 2007; Riley et al., 2016).

Conclusion

To the best of the researchers' knowledge, this study provides the first national lens of the scope of overweight and obesity among both men and women in Kenya finding a prevalence of 28%. Aging individuals, women, urban residents, individuals with high education and wealth were significantly more likely to be overweight or obese. The findings support regional studies conducted in Kenya and call for research further exploring drivers of overweight or obesity among higher risk groups. Behavioral factors which included alcohol, adequate intake of fruits and vegetables, and sedentary activity were not significant factors associated with overweight or obesity. Behavioral studies utilizing objectively measured health behaviors are needed to further ascertain behavioral factors associated with overweight and obesity.

This study has implications for practice. The findings supporting evidence of higher overweight or obesity among aging individuals calls for targeted and tailored interventions among older individuals. Interventions may need to move beyond education as a tool for prevention as highly educated individuals are at higher risk of overweight and obesity. Interventions or programs focused on shifting the culture and perceptions of overweight and obesity may be more impactful.

CHAPTER III

FRUIT AND VEGETABLE CONSUMPTION AND ASSOCIATION WITH NON-COMMUNICABLE DISEASE RISK FACTORS

Introduction

Approximately 5.2 million lives each year have the potential to be saved through adequate consumption of fruits and vegetables (FV) (World Health Organization, 2017b). The consumption of FV is widely recognized as essential to the prevention of non-communicable diseases (NCDs) (Hartley et al., 2012; D. Hu, Huang, Wang, Zhang, & Qu, 2014; Wang et al., 2014). The World Health Organization (WHO) recommends the consumption of five or more servings of FV per day (World Health Organization, 2017b). Data from several studies suggest that individuals who consume the recommended servings of FV are significantly more likely to have reduced risk of NCDs such as cancer, cardiovascular disease, and longer life expectancy (Bellavia, Larsson, Bottai, Wolk, & Orsini, 2013; Oyebode, Gordon-Dseagu, Walker, & Mindell, 2014; Wang et al., 2014). Moreover, the consumption of the recommended amount of FV is associated with acquiring adequate micro- and macronutrients (Fulton et al., 2017; Tontisirin, Nantel, & Bhattacharjee, 2002). Consuming adequate FVs could also curb malnutrition, a major challenge especially in Low- and Middle-Income Countries (LMICs) (Tontisirin et al., 2002).

There is a growing body of literature that illustrates a nutritional transition resulting in a double burden of malnutrition and obesity in Kenya (Jayne et al., 2011; Kimani-Murage et al., 2015; Pawloski et al., 2012). This nutrition transition as has been documented in other LMICs is characterized by an increase of consumption of high calorie, high sugar, and processed foods as these foods cost less and are easily accessible compared to fresh FV (Popkin, 2017; Zhou et al., 2015). In Kenya, Kimani et al., (2015) found that 7.5% of women reported being underweight, and 32% reported being either overweight or obese. In addition, overweight (43%) and obese (37%) mothers had children who were diagnosed with stunted growth (Kimani-Murage et al., 2015). The overweight and obese women in the study reported unhealthy diets that consisted of high caloric foods consumption (Kimani-Murage et al., 2015). Similarly, researchers found that individuals can be anemic and overweight (Jayne et al., 2011). Jayne et al. (2011) found 16.9% of overweight and obese females and 10.8% of underweight females were anemic, illustrating nutritionally inadequate diets (Jayne et al., 2011).

In order to curb the growing NCD public health challenge in LMICs, the WHO released a report titled "From Burden to 'Best Buys': Reducing the Economic Impact of Non–Communicable Diseases in Low- and Middle-Income Countries" (World Health Organization, 2011). The report outlines effective prevention strategies for control of NCDs and recommends evidence-based interventions including addressing unhealthy diets (World Health Organization, 2011). Like other LMICS, recent studies in Kenya demonstrate the high and increasing prevalence of NCDs such as type 2 diabetes, cancer, and hypertension (Ayah et al., 2013; Korir, Okerosi, Ronoh, Mutuma, & Parkin, 2015; Shabani, Cogburn, Ngugi, Macfarlane, & Mahoney, 2016). As a result of high and increasing NCD prevalence, health policies in Kenya that are modeled after the 'Best Buys' stress nutrition as an important factor for preventing NCDs. The Kenya Health Policy 2014-2030 aim is to "*attain the highest possible standard of health in a responsive manner,"* and halt and reverse the burden of NCDs through health information, research, and development (Ministry of Health, 2014, p.32). The 2011 Kenya National Food and Nutrition Security Policy outlines food and nutrition objectives aimed at striving towards the goals outlined in the Kenya Health Policy 2014-2030 (Ministry of Health, 2014). In the policy, the government commits to supporting efforts to prevent NCDs through the promotion of the consumption of healthy foods and diet and promoting programs on prevention and management of diets related to NCDs. In the "National Nutrition Action Plan 2012-2017" espoused to meet the Food and Nutrition Security Policy, there are two objectives; (1) to prevent, manage and control diet-related non-communicable diseases and (2) to enhance evidence-based decision making through research and practice (Ministry of Public Health, and Sanitation, 2012).

Despite nationwide evidence of high and increasing NCDs in Kenya as well as policies aimed at increasing consumption of healthy diets to prevent NCDs, there is a gap in the literature in examining the nationwide scope of adequate consumption of FV. In Kenya, very few studies have examined FV consumption. Two studies (Steyn et al. 2011; Kimani-Murage, 2015) provide some evidence of the relationship between FV and chronic disease risk. The studies found that FV consumption was associated with overweight and obesity (Kimani-Murage et al., 2015; Steyn et al., 2011). In order to fill this gap, this study aimed to investigate the associations between FV consumption, socio-demographic characteristics, and health behaviors among a nationally representative sample of Kenyan adults.

Methods

Sample

This study utilized secondary data from 2015 nationally representative Kenya WHO STEPwise Survey. Data were analyzed to investigate the pathways between FV consumption, socio-demographic characteristics, and NCD risk factors. The 2015 Kenya WHO STEPwise survey used a three-stage cluster sampling design adopted from the Kenya National Bureau of Statistics sampling frame to obtain a nationally representative sample. The sample was obtained using a three-stage sampling design; first, clusters were selected by region (rural vs. urban), then by households, and lastly, individuals were selected according to sex and age (male vs. female and 12-year age groups) (Ministry of Health, 2015b). A total of 4,500 individuals participated in the survey with a response rate of 95% (Ministry of Health, 2015b). More details on sampling are provided in the 2015 Kenya WHO Stepwise Report (Ministry of Health, 2015b). For this study, participants who were younger than 18 years old (n = 18) and pregnant women (n = 132) were excluded resulting in a total of 4,350 participants being analyzed.

Measures

Fruits and Vegetable (FV) Consumption. Participants were asked, to report their average FV consumption in a typical week and amount consumed on a typical day. A nutrition card was used as a guide and provided participants with examples of local FV as well as defined and showed examples and size of servings. The following questions were administered to each participant.

Fruit Consumption:

1) *In a typical week, on how many days do you eat fruit? 2) How many servings of fruit do you eat on one of those days?*

Vegetable Consumption

2) *In a typical week, on how many days do you eat vegetables? 2) How many servings of vegetables do you eat on one of those days?*

A continuous variable was created operationalizing the average consumption of FV reported by each participant. The average fruit consumed a day was calculated by multiplying the number of days a participant reported to consume fruit by the number of servings reported on one of those days and the result was divided by 7 to reflect the number of fruit consumed in one day during a typical week. The number of vegetables consumed a day in a typical week was also calculated using the same method described for fruit. The number of fruits consumed a day and the number of vegetables consumed a day during a typical week were then added together to create a continuous variable reflecting average total FV consumed a day. The continuous variable was used in analysis/modeling. The World Health Organization (WHO) recommends consumption of five or more servings of FV per day ((World Health Organization, 2017b). A dichotomous dependent variable (e.g., consuming 5 or more servings = 1, and not meeting recommendations <5 servings = 0) was created for descriptive analysis.

Socio-demographic characteristics. The following variables were assessed; biological sex (woman = 1, man = 0), age as a continuous variable, education re-coded as (less than primary = 1, primary complete = 2, and secondary or more = 3), marital status (never married = 1, married or cohabitating = 2, separated or divorced = 3, widowed = 4), residence (rural = 0, urban = 1), and wealth index status (poor or poorest = 0, middle, rich or richest = 1). Health behaviors examined included; daily smoker (yes = 1, no = 0), alcohol consumption in the last 30 days (yes = 1, no = 0), and sedentary activity (average minutes spent sitting or reclining on a typical day).

Overweight or Obese. Height and weight were measured according to the WHO STEPwise survey protocol (Ministry of Health, 2015b). Weight in kilograms (Kg) and height in centimeters (cm) were provided. Height in cm was converted to meters (m) by 100. BMI was calculated by dividing the weight in kilograms by meters squared (Kg/m^2). The continuous BMI measure, as well as a, recode of categories of BMI as defined by WHO; underweight or normal weight was defined as having a BMI below 24.99, and overweight or obesity (overweight/obese) was defined as having a BMI equal to or above 25 (World Health Organization, 2017d). A categorical variable was created (overweight/obese = 1, not overweight/obese = 0).

Hypertension. The survey provides three systolic and diastolic blood pressure measurements. The average of the last two blood pressure measurements (e.g., systolic and diastolic) was calculated. Hypertension was defined as having an average systolic blood pressure of greater or equal to 140 mmHg and or average diastolic blood pressure of greater or equal to 90 mmHg or taking blood pressure medication during the last two weeks (World Health Organization, 2015; World Health Organization, 2017e). A dichotomous categorical variable was created (hypertension = 1, not hypertensive = 0).

Type 2 Diabetes. The survey provides continuous fasting blood glucose measurements that were collected according to the WHO STEPwise protocol {{293 World Health Organization 2006}}(World Health Organization, 2006b) (World Health Organization, 2006) (World Health Organization, 2006) (World Health Organization, 2006). Type 2 diabetes (T2D) was defined as having a measured fasting plasma glucose value ≥ 7.0 mmol/L (126 mg/dl) or currently taking medication for high glucose during the last two weeks (World Health Organization, 2006). A dichotomous categorical variable of T2D was created (T2D = 1, not T2D = 0).

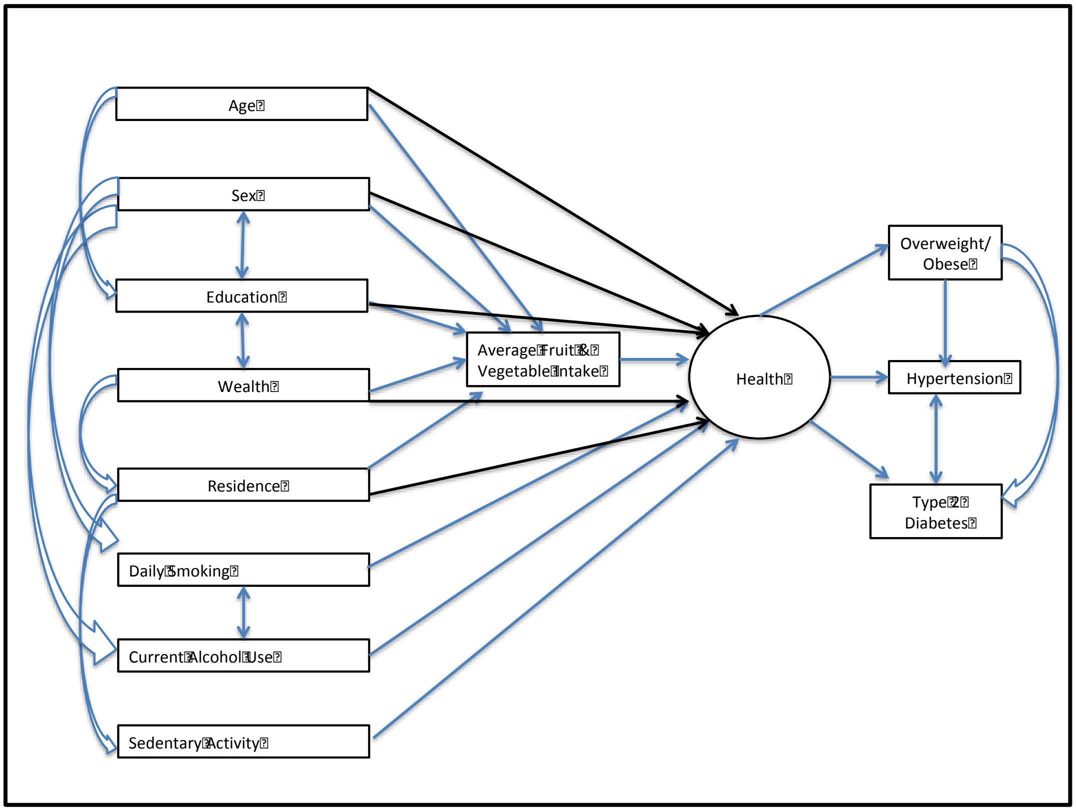
Analysis

Descriptive analysis was conducted to provide details on socio-demographic characteristics, health behaviors, and NCDs of the sample (e.g., age, biological sex, education, wealth status, region, daily smoker, current alcohol drinker, sedentary time per day, average FV intake, BMI and overweight/obesity, hypertension, and T2D) using STATA 14.

Structural equation modeling (SEM) was conducted using MPLUS Version 8.0 (Muthén & Muthén, 2015). Utilizing SEM as an analysis technique for this study was appropriate as SEM is typically used as a methodology to assess the fit of theoretic conceptual models to data at hand (Kline, 2004). Data analysis was conducted using a stepwise fashion as the primary purpose of this study was to identify a model that fits the data to explain the direct and indirect pathways between average daily FV intake, socio-demographic characteristics (e.g., age, biological sex, education, wealth category, and residence) and behavioral factors (e.g., sedentary activity, daily smoking, and current alcohol use), and NCDs (e.g., overweight/obesity, hypertension and T2D).

During the analysis process, relationships between variables of interests were hypothesized in the model through utilizing findings from existing literature demonstrating the significant relationship between socio-demographic and behavioral factors, and NCDs in Kenya (Bloomfield et al., 2013; Haregu et al., 2016; Kimani-Murage et al., 2015). Since the model's variables of interest (overweight/obesity, T2D, and hypertension) were binary categorical variables, each model was estimated using weighted least-square parameter estimates as the algorithm is designed to handle missing data in MPLUS (Asparouhov & Muthén, 2010). The model was revised using suggested modification indices to improve the fit of the model. Figure 3.1 illustrates the initial hypothesized model explaining pathways between socio-demographic characteristics, health behaviors, and NCD outcomes.

Figure 3.1. Initial hypothesized model of FV intake and NCD outcomes.



The following goodness-of-fit indices were used to examine model fit; the chi-squared test (χ^2) which assess the overall fit of the model and is used to assess perfect fit. A non-significant χ^2 indicates that the model fits perfectly (p-value>0.05). The χ^2 statistic, however, is sensitive to sample size and since the sample size of this study is large, (n = 4,350), the other goodness of fit indices were used to assess model fit (L. Hu & Bentler, 1999; Kline, 2004). The Root Mean Square Error of Approximation (RMSEA) favors the model with the least number of parameters (i.e., most parsimonious) is the most commonly reported fit statistic. The RMSEA shows how the model with unknown parameters would fit the population covariance matrix (Hooper, Coughlan, & Mullen, 2008). The recommended cutoff point for a good fit for RMSEA is below 0.06 (L. Hu & Bentler, 1999). The Comparative Fit Index (CFI) is a measure least affected by sample size and compares the sample covariance matrix to the null model. The measure assumes that the latent variables are uncorrelated. A value of CFI greater than 0.95 is considered an indicator of good model fit (Cheung & Rensvold, 2002; Hooper et al., 2008; L. Hu & Bentler, 1999). The Tucker Lewis Index (TLI) is another comparative fit index that compares the model at hand with the null model which assumes that all observed variables are uncorrelated. A TLI value of above 0.95 is considered an indicator of a good fit (L. Hu & Bentler, 1999). Finally, the Weighted Root Mean Square Residual (WRMSR) uses a variance-weighted approach for a variety of scales (e.g., categorical data) and has unequal variance. A WRMSR value of less than 1 has been suggested as indicative of adequate fit (Yu, 2002).

The following models were computed using a step-by-step process in order to guide modifications and arrive at the final hypothesized model.

1. The model examined the health as a latent factor with hypertension, T2D, and overweight/obese.
2. The model examined the pathways between NCDs (hypertension, T2D and overweight/obese) and socio-demographic factors.
3. The model examined the pathways between average FV consumption and socio-demographic factors.
4. The model examined the pathways between health behaviors (daily smoker, current drinker, and average sedentary activity) and socio-demographic factors.
5. The model examined the pathways between NCDs and health behaviors.
6. The final model examined the pathways between FV, health behaviors and NCDs while utilizing results from models 1-5, existing literature and modification indices.

Results

Descriptive Statistics

The sample consisted of primarily middle-aged adults with the mean age of 34.58 years (SE = 0.44). Majority of participants were men (50.42%), completed primary school education (64.25%), were in the middle-to-richest wealth category (60.17%), and resided in rural areas (61.47%). The proportion of participants who reported consuming alcohol within the past 30 days was (19.84%), and (8.68%) reported to be daily smokers.

The average of participants' BMI was 23.37 kg/m^2 (SE = 0.22) with (28.13%) being categorized as overweight or obese. The prevalence of hypertension in the sample was (24.57%) (SE = 0.01) and 1.89% (SE = 0.003) for T2D. Table 3.1 provides a summary of a description of the socio-demographic, NCDs, and health behavior characteristics that were tested the models tested.

Table 3.1: Sociodemographic characteristics statistics

	Proportion/Mean	S.E	95% CI UL	95% CI LL
Sex				
Men	50.40%	0.01	0.48	0.53
Women	49.60%	0.01	0.47	0.52
Age Groups				
Age	34.58	0.44	33.71	35.44
18-29	45.03%	0.02	0.42	0.49
30-44	32.87%	0.01	0.30	0.35
45-59	16.56%	0.01	0.15	0.18
60-69	5.54%	0.00	0.05	0.07
Education Level				
Below Primary	35.75%	0.02	0.31	0.41
Primary Complete or more	64.25%	0.02	0.59	0.69
Wealth Status				
Poorest/Poor	39.83%	0.03	0.33	0.47
Middle/ Rich/ Richest	60.17%	0.03	0.53	0.67
Residence				
Rural	61.47%	0.04	0.53	0.69
Urban	38.53%	0.04	0.31	0.47
Daily Smoker	8.68%	0.01	0.07	0.11
Current Alcohol Drinker	19.84%	0.01	0.17	0.23
Hypertensive	24.57%	0.01	0.22	0.27
Type 2 Diabetes (T2D)	1.89%	0.00	0.01	0.03
Weight Status				
Body Mass Index (BMI)	23.38	0.22	22.94	23.82
Overweight/Obese	28.09%	0.02	0.25	0.31
Sedentary minutes/Day	152.32	3.80	144.83	159.80

The average FV consumed in a day was 2.10, the average number of vegetables consumed per day was more, 1.31 than the average number of fruits consumed per day 0.79.

Majority of participants did not consume 5 or more servings as recommended by the World Health Organization as only 6.15% of participants consumed adequate amounts (WHO, 2004). Figure 3illustrates average fruit, vegetable, and FV consumption per day. Table 3.2 presents the summary statistics of the average FV reported.

Figure 3.2: Summary of average FV consumed on a typical day.

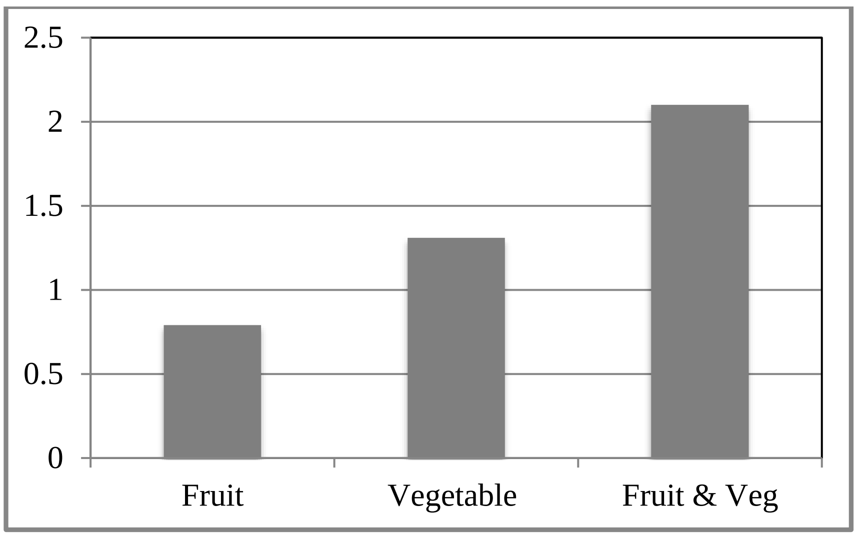


Table 3.2: Summary statistics of average FV consumed in a day.

Average Fruit & Vegetables/Day			95% CI	
	Proportion/Mean	**S.E.**	**UL**	**LL**
Five or more servings/Day	6.15%	0.01	0.05	0.08
Average Fruit/Day	0.79	0.04	0.71	0.87
Average Vegetables/Day	1.31	0.05	1.21	1.42
Average Fruit& Veg/Day	2.10	0.08	1.95	2.25

Table 3.3: Correlation matrix of variables

	Overweight/ Obese	Hypertension	Type 2 diabetes	Average FV	AGE	Woman	Urban	Middle, Rich, Richest	Above Primary Education	Current Drinker
Overweight/Obese										
Hypertension	0.298									
Type 2 diabetes	0.308	0.337								
Average FV	0.095	0.065	0.03	3.377						
AGE	0.156	0.393	0.292	0.037	180.273					
Woman	0.28	0.012	0.104	-0.023	0.002	0.242				
Urban	0.179	-0.002	0.077	0.048	-0.104	-0.067	0.25			
Middle, Rich, Richest	0.322	0.079	0.112	0.119	-0.091	-0.052	0.426	0.24		
Above Primary Education	0.196	0.024	-0.027	0.159	-0.224	-0.147	0.208	0.361	0.242	
Current Drinker	-0.165	0.075	-0.024	0.044	0.061	-0.362	0.041	0.008	0.029	0.137

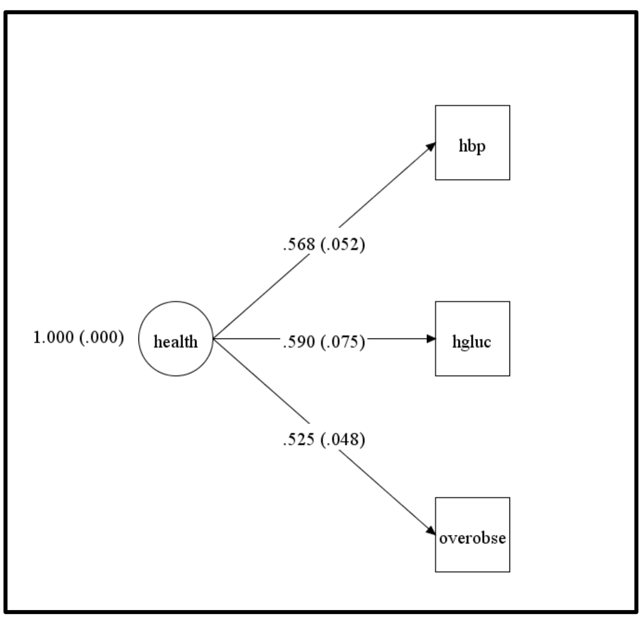
Structural Equation Modeling Results

A series of structural equation models (SEM) were run to examine direct and indirect pathways to lead to the final model explaining pathways between FV intake, demographic variables, and health outcomes. Table 3.3. shows the correlation results of the variables and demonstrates that variables were uncorrelated.

Model 1: Health as a Latent Factor

The first model examined the conceptual construct of *health* which was hypothesized to be influenced by hypertension (hbp), type 2 diabetes (hgluc) and overweight or obese (overobse). Figure 4 demonstrates the hypothesized figure of the latent construct *health* with significant standardized estimates. The model had a reported $\chi^2 = 0.00$ ($p \leq 0.05$), RMSEA = 0, CFI = 1, TFI = 1 and WRMR = 0.017 with 3 degrees of freedom. The model is displayed in Figure 3.3.

Figure 3.3: Health as a latent factor



Note: health = latent factor, overobse = being overweight or obese, hbp = hypertension, and hgluc = type 2 diabetes (T2D).

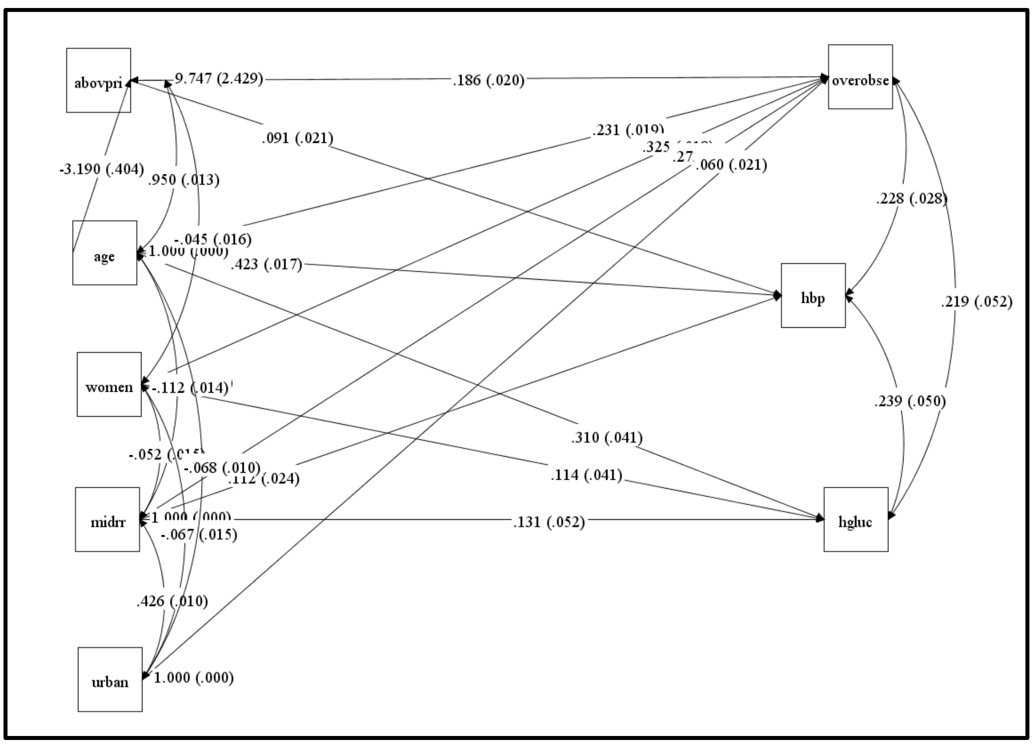
The standardized results found significant direct pathways between hypertension and health (standardized estimate = 0.568, $p \leq 0.05$), T2D and health (standardized estimate = 0.59, $p \leq 0.05$), and overweight or obese and health (standardized estimate = 0.525, $p \leq 0.05$). Overall, 27.5% ($p \leq 0.05$) of the variance in overweight or obesity, 32.3% ($p \leq 0.05$) of the variance in hypertension, and 34.8% health explained ($p \leq 0.05$) of the variance in T2D. As a result of poor model fit (ie. The model fit indices were just identified,) and because only 2% of the sample identified as having T2D, a decision was made to run the rest of the models using the measured outcomes (hbp, hgluc, and overobese) instead of including them as a function of the latent construct of health.

Model 2: Path Model NCD and Socio-demographic Factors

The model examining the pathways between NCDs (hypertension, T2D, and overweight or obese) and socio-demographic factors (age, sex with men as the reference, region with rural as the reference, middle class or higher with those who were poor or poorest as reference, and education with those with incomplete primary as the reference). The model had overall good fit with a reported $\chi^2 = 13.547$ ($p \leq .05$) RMSEA = 0.054, CFI = 0.997, TFI = 0.919 and WRMR = 0.444 with 1 degrees of freedom. There were significant positive pathways between overweight or obese and age (standardized estimate = 0.231, $p \leq 0.05$), women (standardized estimate = 0.325, $p \leq 0.05$), completing primary education or higher (standardized estimate = 0.186, $p \leq 0.05$), being in middle wealth category or higher (standardized estimate = 0.272, $p \leq 0.05$) and living in urban areas (standardized estimate = 0.060, $p \leq 0.05$).

The following significant pathways for hypertension were age (standardized estimate = 0.423, $p \leq 0.05$), completing more than a primary education (standardized estimate = 0.091, $p \leq 0.05$), and being in the middle-wealth category or higher (standardized estimate = 0.112, p≤0.05). Significant positive pathways between T2D and socio-demographic factors included age (standardized estimate = 0.310, p≤0.05), being a woman (standardized estimate = 0.114, p≤0.05) and being in the middle wealth category or higher (standardized estimate = 0.131, p≤0.05). Overall, 26.2% (p≤0.05) of the variance in overweight/obesity, 17.7% (p≤0.05) of the variance in hypertension, and 12.1% (p≤0.05) of the variance in T2D was explained by socio-demographic characteristics. Figure 3.4 demonstrates the model explaining significant standardized pathways between socio-demographic characteristics and NCDs.

Figure 3.4: Demographic pathways and NCDs

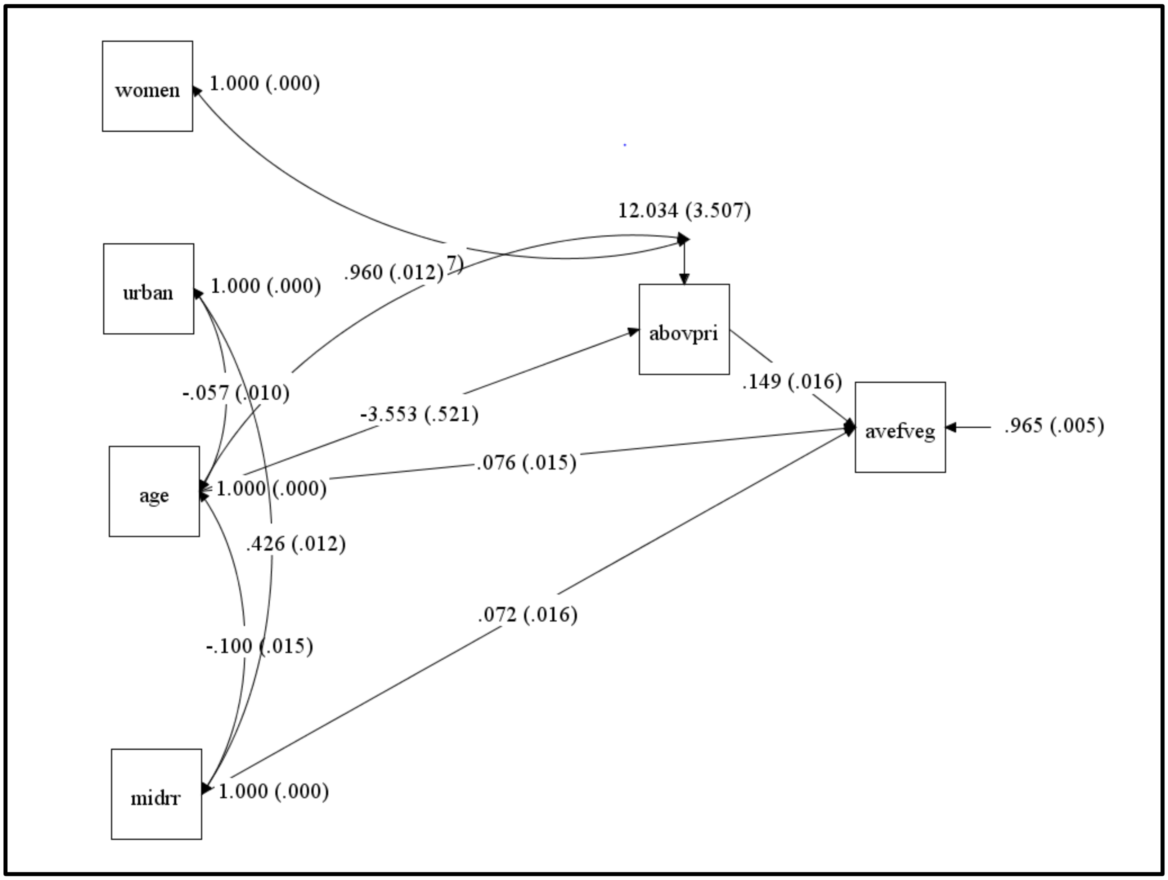


Note: age=age as a continuous variable, women=sex with men as reference, midrr=being in middle wealth category or higher, urban=region with rural as reference, abovpri=completing primary education or higher, overobse=being overweight or obese, hbp=hypertension, hgluc=type 2 diabetes (T2D).

Model 3: Fruit and Vegetable and Socio-demographic factors

A model examining direct and indirect pathways between average FV consumption and demographic characteristics was analyzed. A series of models were computed and modified as a result of utilizing existing literature supporting socio-demographic factors associated with FV consumption in Kenya and similar LMICs (Bloomfield et al., 2013; Ruel, Minot, & Smith, 2005) as well as through examining modification indices. A final model with a χ^2 = 38.317 ($p \leq 0.05$), RMSEA = 0.035, CFI = 0.983, TFI = 0.961 and WRMR = 0.019 with 14 degrees of freedom demonstrated that the model was a good fit. Positive direct significant pathways with average FV included age (standardized estimate = 0.076, $p \leq 0.05$), completing primary education or more (standardized estimate = 0.149, $p \leq 0.05$) and being in the middle or higher wealth category (standardized estimate = 0.072, $p \leq 0.05$). Overall, 3% ($p \leq 0.05$) of the variance in average FV consumption was explained by socio-demographic characteristics. Figure 3.5 demonstrates the model explaining significant standardized pathways between average FV consumption and demographic characteristics

Figure 3.5: Average fruits and vegetables and demographic factors



Note: avefveg=average fruit and vegetables consumed, age=age as a continuous variable, women=sex with men as reference, midrr=being in middle wealth category or higher, urban=region with rural as reference, and abovpri=completing primary education or higher.

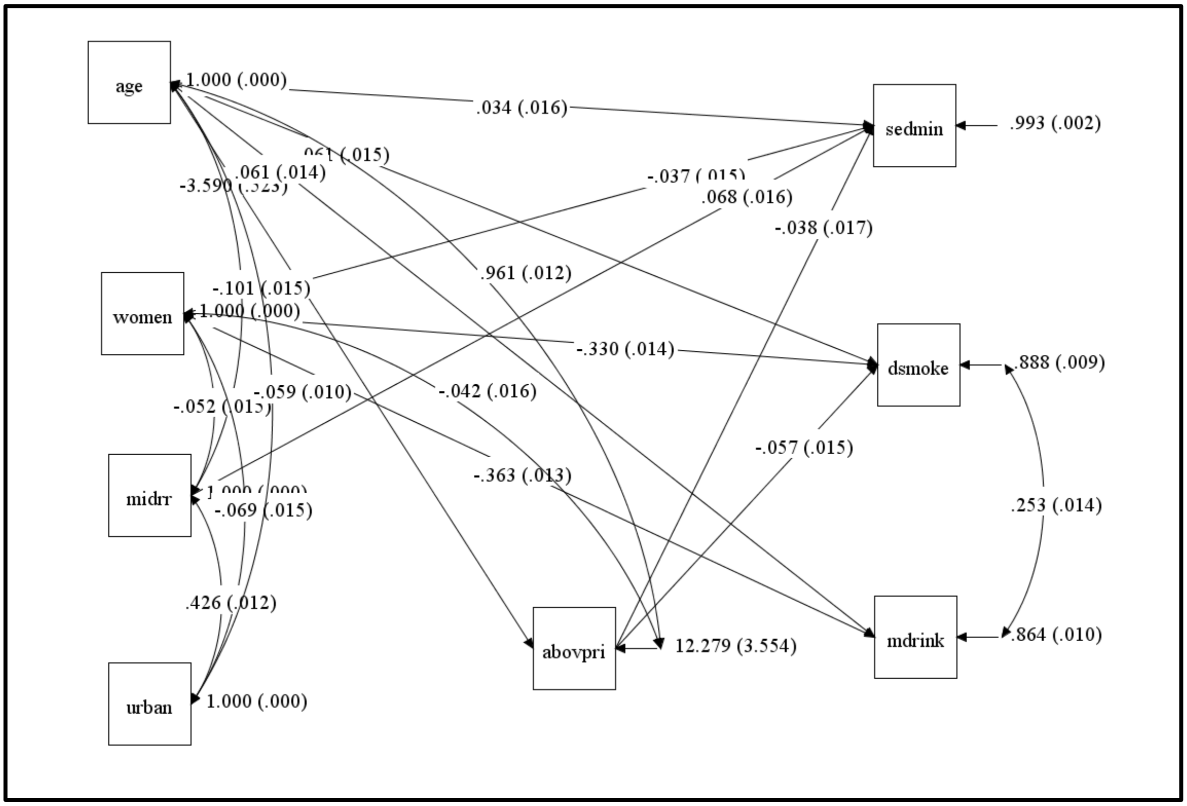
Model 4: Behaviors and Socio-demographic Factors

Models examined the pathways between health behaviors (e.g., sedentary activity, daily smoking, and being a current drinker) and socio-demographic characteristics as informed by literature in Kenya demonstrating the relationship between socio-demographic characteristics and the health behaviors (Bloomfield et al., 2013; Kinoti, Jason, & Harper, 2011; Lo et al., 2013) as well as examining modification indices. A final model with an χ^2 = 16.808 ($p \leq 0.05$), RMSEA

= 0.027, CFI = 0.995, TFI = 0.97 and SMRM = 0.007 with 14 degrees of freedom demonstrated that the model was a good fit.

Positive direct significant pathways between sedentary minutes (standardized estimate = 0.034, $p = 0.030$) and age and being middle wealth income or higher (standardized estimate = 0.068, $p \leq 0.05$) was found. Negative significant direct effects were found between average sedentary minutes per day and women (standardized estimate= -0.037, $p = 0.015$) as well as individuals who completed primary education or more (standardized estimate = -0.038, $p = 0.025$). Daily smoking had a negative direct effect on women compared to men (standardized estimate = -0.330, $p \leq 0.05$) and individuals with completed primary education or higher (standardized estimate = -0.057, $p \leq 0.05$). Age had a significant effect on daily smoking (standardized estimate = 0.061, $p \leq 0.05$) as well as current drinking (standardized estimate = 0.061, $p \leq 0.05$). The direct pathway between being a current drinker and women was negative and significant (standardized estimate = -0.363, $p \leq 0.05$), completing primary education or more (standardized estimate = -0.012, $p = 0.435$), and being in the middle wealth category or higher (standardized estimate = -0.012, $p = 0.440$). Overall, 0.07% ($p \leq 0.05$) of the variance in sedentary minutes, 11.2% ($p \leq 0.05$) of the variance in daily smoking, and 13.6% ($p \leq 0.05$) of the variance in being a current drinker was explained by socio-demographic characteristics. Figure 3.6 illustrates the model explaining significant standardized pathways between health behaviors and socio-demographic characteristics.

Figure 3.6: Health behaviors and socio-demographic factors

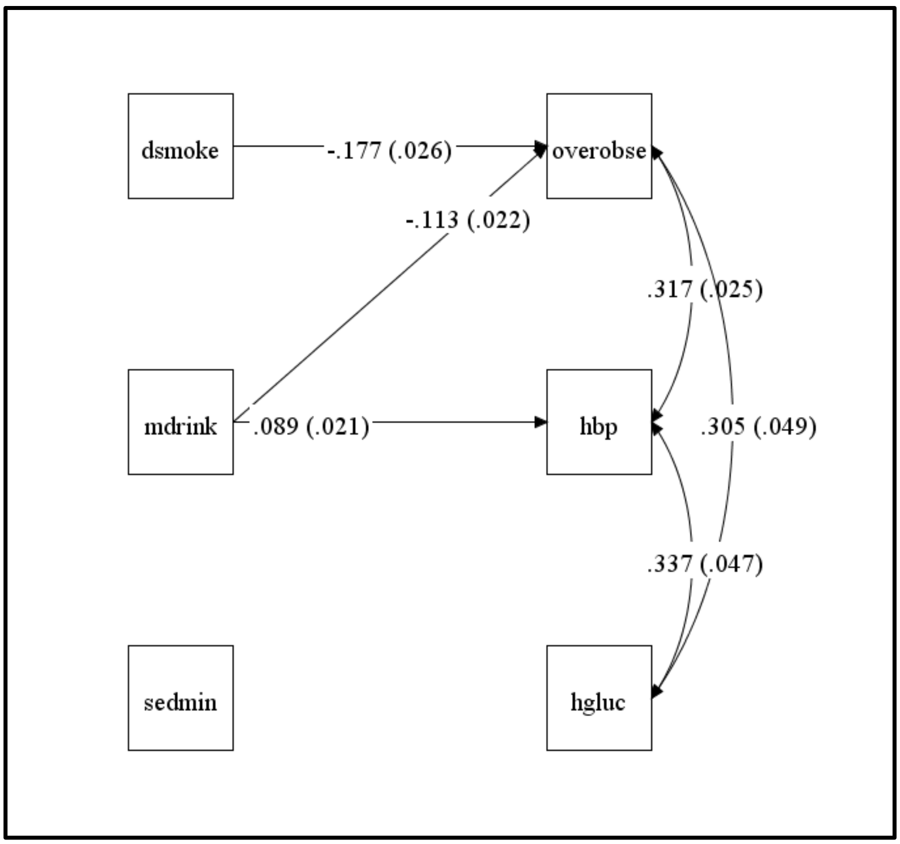


Note: age=age as a continuous variable, women=sex with men as reference, midrr=being in middle wealth category or higher, urban=region with rural as reference, abovpri=completing primary education or higher, dsmoke=daily smoker, mdrink=consuming alcohol in the past month, and sedmin=average sedentary minutes.

Model 5: Health Behaviors and NCDs

The model with a $\chi^2 = 0$ ($p \leq 0.05$), RMSEA = 0.00, CFI =1, TFI = 1 and WRMR = 0.010 with 12 degrees of freedom demonstrated that the model was not identified. Consuming alcohol in the last month (standardized estimate = -0.113, $p \leq 0.05$), and being a daily smoker age (standardized estimate = -0.117, $p \leq 0.05$) were negatively and significantly associated with overweight/obese. Hypertension has a positive significant pathway with currently consuming alcohol (standardized estimate = 0.089, p≤0.05) and sedentary minutes (standardized estimate = 0.049, p≤0.05). None of the behaviors had significant pathways with T2D. Figure 3.7 illustrates the model explaining significant standardized pathways between health behaviors and NCDs.

Figure 3.7: Health behaviors and NCDs



Note: dsmoke=daily smoker, mdrink=consuming alcohol in the past month, sedmin=average sedentary minutes, overobse=being overweight or obese, hbp=hypertension, hgluc=type 2 diabetes (T2D).

Final Model

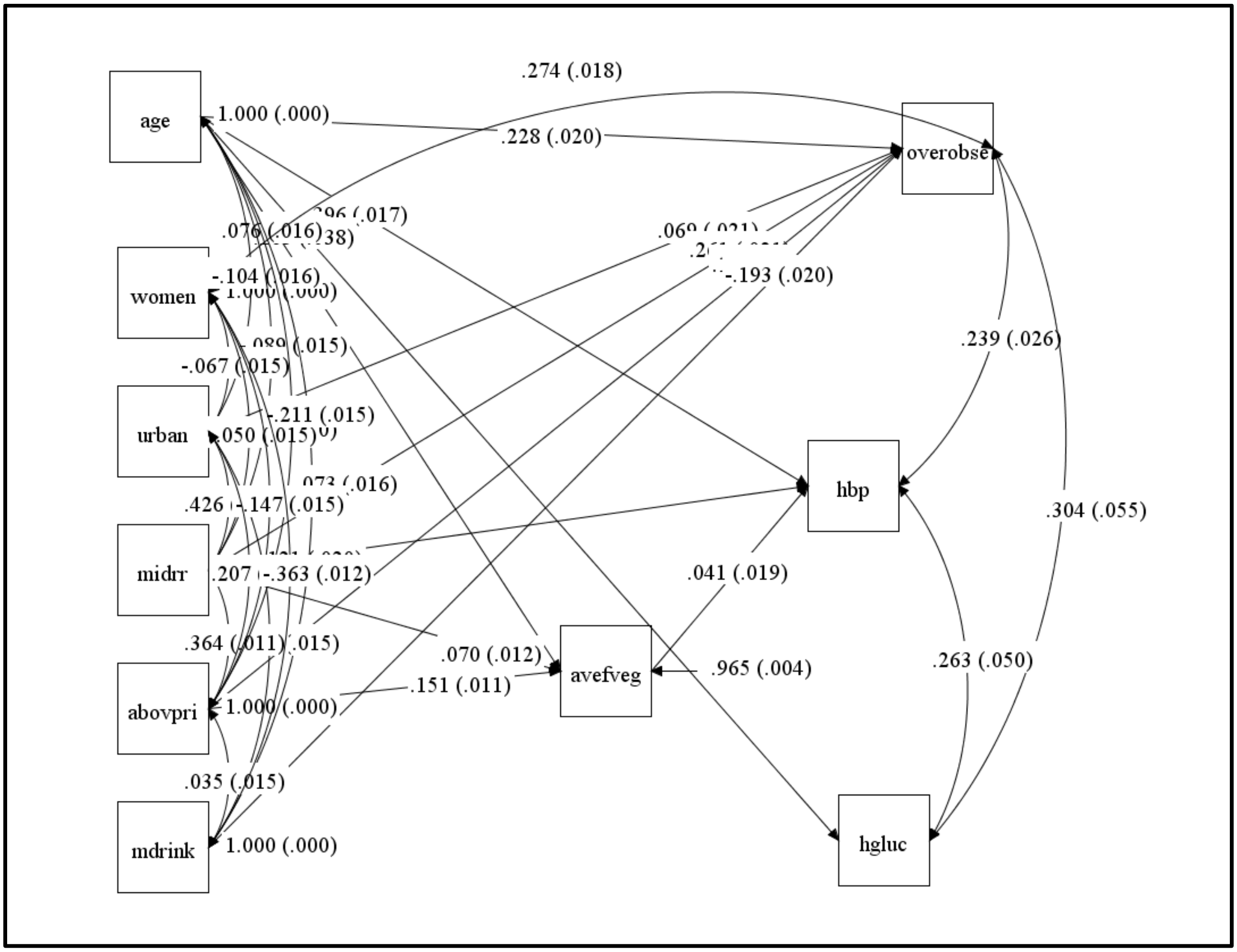
A series of models were computed that examined the direct and indirect effects between average FV consumption and NCD outcomes controlling for the effects of socio-demographic characteristics and health behaviors. The serious of models (Model 1 – Model 5) were referenced when making pathways for the final model. After running a series of models and using modification indices as well as referring to literature to support model modification, a final model with acceptable fit indices which was most parsimonious was identified. Table 3.4 summarizes previous models ran and modified to reach a model with an acceptable fit that is theoretically supported by the literature. The final model is bolded**.**

Table 3.4: Summary Fit Statistics of modified models.

Model	X^2 (df)	RMSEA (CI)	CFI	TLI	WRMR
1	239.064 (25)	0.044 (0.039-0.050)	0.903	0.826	2.063
2	119.073 (19)	0.035 (0.029 -0.041)	0.979	0.950	1.397
3	88.831 (18)	0.030 (0.024-0.036)	0.985	0.963	1.198
4	**51.558 (11)**	**0.029 (0.021-0.037)**	**0.992**	**0.968**	**0.861**

The final model had an χ^2 value of 51.558 (n = 4,350, df = 11, $p \leq 0.05$). The χ^2 indicated an absence of perfect fit. The chi-square, however, the χ^2 is sensitive to sample size (Hu & Butler,1999) thus other indices were examined to assess model fit. The model had an RMSEA = .029. Indicating good fit, a CFI = .992 indicating good fit, a TLI = .968 indicating good fit and a WRMR of 0.861 also indicating good fit. Figure 9 illustrated the final model with significant standardized pathways.

Figure 3.8: Final model of FV consumption, demographic characteristics and NCDs.



Note: age=age as a continuous variable, women=sex with men as reference, midrr=being in middle wealth category or higher, urban=region with rural as reference, abovpri=completing primary education or higher, dsmoke=daily smoker, mdrink=consuming alcohol in the past month, and sedmin=average sedentary minutes, hbp=hypertension, hgluc=type 2 diabetes (T2D).

The final model's standardized results indicated that average FV intake was not a significant predictor of overweight or obese (standardized estimate = 0.033, p = 0.056) or T2D (standardized estimate = 0.050, p = 0.297). Average FV intake was a significant positive predictor of hypertension (standardized estimate = 0.041, p = 0.028). Other direct paths that were significant with average FV consumption included age (standardized estimate = 0.08, $p \leq 0.05$), being middle to richest wealth (standardized estimate = 0.07, $p \leq 0.05$), completing primary education or more (standardized estimate = 0.15, $p \leq 0.05$). In the model, 19.4% of the variance in overweight or obese, 16.7% of the variance in hypertension, 7.3% of the variance in T2D was explained by average FV consumption.

Discussion

This study aimed to understand the pathways between FV consumption in Kenya and NCDs controlling for socio-demographic characteristics and health behaviors. Descriptive analysis revealed that only 6% of the nationally representative sample consumed adequate amounts of FV.The final model indicated that average FV intake was a significant positive predictor of hypertension. Socio-demographic variables such as age, biological sex, residence, education, and wealth had a significant direct pathway with average FV consumption. In Kenya, individuals who are overweight or obese typically consumed lower FV (Demmler et al., 2018; Kimani-Murage et al., 2015). Initiatives aimed to increase consumption of FV have the potential to curb both malnutrition and NCDs in the country.

The results of this study align with previous studies in Kenya demonstrating low FV intake (Bloomfield et al., 2013; Hulzebosch et al., 2015; Muchira et al., 2015). The proportion of sufficient consumption of average FV (five or more servings) was 6.7% among the sample, much lower compared to 17.3% and 16.3% reported by previous studies in Kenya (Bloomfield et al., 2013; Hulzebosch et al., 2015). The findings of this study support global trends of low FV consumption in both high and LMICs (Msambichaka et al., 2018; Peltzer & Pengpid, 2015; Vereecken et al., 2015).

Low FV consumption in Kenya may be influenced by the global nutrition transition which is characterized by shifting population-level dietary patterns due to improvements in socioeconomic status, urbanization, and increased processed food production and distribution trends (Allen et al., 2017; Lopez, Loopstra, McKee, & Stuckler, 2017; Tschirley, Reardon, Dolislager, & Snyder, 2015; Zhou et al., 2015). In East and Southern Africa, middle-class individuals was found to have higher food expenditure and consume more amounts of processed foods (70 – 80 percent) compared to (44 – 55 percent) of fresh perishable foods (Tschirley et al., 2015). The nutrition transition is driven by the globalization of processed, affordable, and easily accessible foods (Baker & Friel, 2014; Rischke et al., 2015). For example, the nutrition transition reported in several LMICs has been characterized by the increase in processed foods that are high in sugar, sodium, and fats (Baker & Friel, 2014; Popkin, 2017). In Kenya, the availability of processed foods is due to the emergence of supermarkets in small towns. These supermarkets have been associated with the increased consumption of high caloric processed foods which are easily accessible and affordable (Rischke et al., 2015).

The results of this study found that the average daily consumption of vegetables was higher compared to fruit. The findings of higher vegetable consumption are similar to results from a study conducted in South-Eastern Tanzania that found that 44.2% of participants reported daily vegetable consumption compared to 15.5% who reported daily fruit consumption (Msambichaka et al., 2018). The consumption of vegetables compared to fruits may be influenced by factors such as availability and dietary preferences as vegetables are typically a staple incorporated in meals (Ng’endo, Bhagwat, & Keding, 2016). For example, in Kenya, starches such as maize (cornmeal) or rice are typically accompanied by leafy greens such as spinach, kale, and other native leafy greens (Ng'endo et al., 2016). Bloomfield and colleagues, however, cautioned counting cooked vegetables in Kenya as part of a healthy diet as they are typically cooked for long periods of time before digestion (Bloomfield et al., 2013), and cooking vegetables has been shown to decrease nutritional content (Jiménez-Monreal, García-Diz, Martínez-Tomé, Mariscal, & Murcia, 2009; Pellegrini et al., 2010).

The findings of this study, however, contradict Bloomfield and colleagues' (2013) results who found higher fruit consumption (average of 3 per day), compared to vegetables (average of 1.6 per day) in Western Kenya. Differing consumption patterns may be explained by variation in accessibility of FV whether due to seasonal availability or affordability (Menezes, Costa, Oliveira, & Lopes, 2017; Miller et al., 2016; Ruel et al., 2005). More studies are needed to understand facilitators and barriers to FV consumption in Kenya. The findings of low FV consumption have implications for the prevention of both malnutrition and NCDs. The consumption of FV is associated with both increased intake of necessary nutrients to curb malnutrition as well as the prevention of overweight and obesity and NCDs (Lock, Pomerleau, Causer, Altmann, & McKee, 2005; Ochieng et al., 2018; Troesch et al., 2015). Individuals who consume adequate FV may also be more likely to adhere to healthier diets thus reducing their NCD risk.

This study found significant positive pathways between average FV consumption being in the middle or higher wealth categories and having higher than primary. Globally, studies support findings of disparities associated with FV consumption by SES status with individuals who are from higher socioeconomic consuming more FV (Landais et al., 2015; Mayén, Marques-Vidal, Paccaud, Bovet, & Stringhini, 2014). This study, however, contributes to contradicting evidence of FV by social status in Kenya as studies show low consumption across all SES groups (Kimani-Murage et al., 2015; Muchira et al., 2015; Ongosi, Gericke, Mbuthia, & Oelofse, 2014). It is important to note that despite findings of higher FV intake among higher SES, participants did not consume adequate amounts (i.e., 5 or more servings). Increasing socioeconomic status, as well as ecological factors including changes in lifestyle such as the advent of supermarkets in Kenya due to urbanization, have been associated with consumption of less fruit and vegetables (Neven, Reardon, Chege, & Wang, 2006; Steyn, Nel, Parker, Ayah, & Mbithe, 2012). Individuals who typically shop at supermarkets in Kenya have been found to purchase lower amounts of FV compared to processed foods (Rischke et al., 2015). Moreover, adults who shop at supermarkets have been found to significantly have a higher probability of being overweight (Kimenju et al., 2015).

The only significant pathway between FV consumption and NCDs (hypertension, T2D, and overweight/obesity) was with hypertension and the pathway was positive meaning, increased FV was associated with increased hypertension. This study contradicts other research that found no significant association between hypertension and FV consumption in Kenya (Olack et al., 2015; van et al., 2013). FV, however, have been found to act as a protective factor for hypertension and related conditions (Borgi et al., 2016; L. Wu, Sun, & He, 2016), more studies with objective measure of FV instead of self-report should be conducted to re-examine the relationship. The results of this study should be taken with caution as the methodology used (SEM) was meant to provide a model that supports theory and results from existing studies. The results should not be interpreted as causal.

Strengths and Limitations

The cross-sectional nature of this study limits ability to study trends over time. The data used for this study, however, was the first to collect data on FV consumption using a nationally representative sample in Kenya. National longitudinal surveys that are conducted in Kenya, such as the Kenya Demographic and Health Survey, should incorporate the examination of consumption patterns so that nutritional trends could be examined. There are limitations to the use of secondary data analysis. First, the measure of FV consumption was a function of participants being asked to recall the number of times and the amount of FV consumption in a typical day. Recall bias may have affected the quantity of FV consumption reported. Enhanced surveys of consumption patterns such as repeated 24-hour dietary recall may have allowed for more accurate estimation of FV consumed in a typical day (Burkholder-Cooley et al., 2017).

Despite limitations, our study has some strengths. The study uses a nationally representative sample to explore determinants of FV consumption in Kenya. Furthermore, the study aids to fill the gap in the literature in understanding behavioral factors associated with chronic disease risk. The use of structural equation modeling is a strength as this study attempts to provide a foundation in examining factors that influence FV. This study is timely as NCDs are increasing in Kenya and LMICs thus contributing to examining trends and risk factors that could be applied to prevention and management initiatives. The use of the WHO STEPwise survey is also a strength of this study as the methods are widely recognized in examining NCDs and risk factors (Houehanou et al., 2015; Moradi-Lakeh et al., 2015; Riley et al., 2016).

The consumption of adequate amounts of FV is widely recognized as a significant health protective behavior for disease prevention (Hartley et al., 2012; Li, Fan, Zhang, Hou, & Tang, 2014; Wang et al., 2014; World Health Organization, 2017b). Among this nationally representative sample, only 6.12% of participants reported consuming at least five servings of FV on a typical day. The high prevalence rate of inadequate FV calls for action from both researchers and public health practice. In Kenya, insufficient studies have examined FV intake (Bloomfield et al., 2013; Hulzebosch et al., 2015; Kimani-Murage et al., 2015; Oti et al., 2013). Among the studies, very limited studies exclusively focus on FV consumption as the outcome of interest (Iannotti & Lesorogol, 2014). Studies ascertaining drivers and determinants of FV in Kenya are needed.

The government of Kenya recognizes that consumption patterns are imperative to maintaining and improving good health outcomes. The Kenya National Food and Nutrition Security Policy's (Section 4.4) states that the government plans to "*support efforts to prevent NCDs through the promotion of the consumption of healthy foods and diet, and physical activity and exercise.*" (Agricultural Sector Coordinating Unit, 2011,pg.31). In National Nutrition Action Plan 2012-2017, outlined priority areas (Strategic Objective 6 and 10) include increasing public awareness of prevention and control of NCDs, strengthening coordination of healthy diet and lifestyle programs, and conducting needs-based research that will inform policy and program design and implementation (Ministry of Public Health and Sanitation, 2012). The policy, however, is broad and do not explicitly mention FV intake as an avenue of intervention for prevention of NCDs. Given the results of this study of finding low consumption of FV in Kenya, interventions and education efforts are needed to increase FV intake.

Conclusion

This nationally representative study found that a majority of the Kenyan sample did not consume adequate amounts of FV. Significant positive pathways included age and being of higher SES (e.g., completing primary education and being in the middle or higher wealth bracket). Only hypertension was significant with average FV in the final model with socio-demographic characteristics and health behaviors. There is a need for initiatives aimed at increasing FV consumption in Kenya. Research is needed to understand facilitators and barriers of FV consumption among Kenyans.

CHAPTER IV

USING SYNDEMIC THEORY TO IDENTIFY INDIVIDUALS WITH MULTIPLE NON-COMMUNICABLE DISEASE RISK FACTORS.

Introduction

Non-communicable disease in Kenya

Non-communicable diseases (NCDs) are the leading cause of death worldwide (World Health Organization, 2017c). An estimated 70% of all global deaths, 39.5 million, were attributed to NCDs in 2015 and three-quarters of those deaths, 30.7 million, occurred in low- and middle-income countries (LMICs) (World Health Organization, 2017c). In Kenya, an LMIC, there is increasing evidence of high burden of NCDs (Ayah et al., 2013; Githinji et al., 2017; M. D. Joshi et al., 2014; Olack et al., 2015). Currently, strokes and heart disease are among the top ten leading causes of death in Kenya (Ministry of Health, 2015a). By the year 2030, the Kenya Ministry of Health reports that deaths from cardiovascular disease, stroke, and cancer will eclipse the number of deaths from malaria and tuberculosis (Ministry of Health, 2015a).

Data from several studies demonstrate high overweight and obesity prevalence in Kenya, a leading NCD risk factor (Ayah et al., 2013; Jayne et al., 2011; M. D. Joshi et al., 2014; Kimani-Murage et al., 2015). The Kenya STEPwise survey for non-communicable diseases, the first to measure body weight for men and women, reports that 27% of Kenyans are overweight or obese (overweight/obese). The obesity rate among women was 38.5% and 17.5% for men (Ministry of Health, 2015b).

Risk factors for NCDs are well established in the literature as studies demonstrate that sedentary activity, inadequate consumption of healthy foods such as fruits and vegetables, consumption of alcohol, and tobacco use increase risk for NCDs (Gakidou et al., 2017; Handschin & Spiegelman, 2008; Hung et al., 2004). In Kenya, there is a growing body of literature that is exploring behavioral factors associated with NCDs. Several cross-sectional studies suggest that moderate sedentary activity (Mbochi et al., 2012; Olack et al., 2015), low fruit and vegetable consumption (Kimani-Murage et al., 2015; Mbochi et al., 2012), alcohol (Mbochi et al., 2012; Olack et al., 2015), and tobacco use (Ayah et al., 2013; M. D. Joshi et al., 2014; Olack et al., 2015) are significantly associated with NCDs such as obesity, hypertension and type 2 diabetes (T2D).

In addition to risk behaviors, existing research recognizes the critical role that socio-demographic characteristics play as risk factors for NCDs. Factors such as aging and socioeconomic status have been demonstrated to increase NCDs risk worldwide (Allen et al., 2017; Arokiasamy et al., 2017; Stringhini & Bovet, 2017). In Kenya, evidence suggests that increasing age increases the risk of NCDs such as hypertension, T2D, and overweight and obesity (Christensen et al., 2016; M. D. Joshi et al., 2014; Kaduka et al., 2012; Olack et al., 2015). Similarly, increasing socioeconomic status demonstrated by wealth is recognized as a socio-demographic risk factor for NCDs in Kenya (Kaduka et al., 2012; Mbochi et al., 2012; Olack et al., 2015), however some researchers provide contradictory evidence as they report high prevalence rate of NCDs among low-income Kenyans (Ayah et al., 2013; Ettarh et al., 2013; M. D. Joshi et al., 2014).

Syndemic Theory

Syndemic theory, first proposed by Singer (1994), was developed based on the observation that low-income, oppressed, ethnic minorities and marginalized individuals living in poverty-stricken cities in the United States were most vulnerable to the HIV/AIDs crisis (Singer, 1994). The prefix, *syn*, is the Greek term for “working together” and *demos* refers to people (Singer, 2000). Therefore, the term syndemic refers to “*a set of closely intertwined and mutual enhancing health problems that significantly affect overall health status of a population within the context of a perpetuating configuration of noxious social conditions*” (Singer, 2000, pg.13). Singer (2000), conceptualized the syndemic epidemic of HIV in the poverty-stricken inner cities using the term SAVA, to stress the interrelationships between substance abuse, violence, and AIDS.

Fundamentally syndemic theory explicates that epidemics such as HIV share underlying social risks leading to the excess burden of the condition in a given population (Freudenberg, Fahs, Galea, & Greenberg, 2006). For example, HIV studies informed by syndemic theory have found significant relationships between (1) multiple epidemics (i.e., poly-drug use, depression, intimate partner violence, history of childhood sexual abuse, sexually transmitted infections); (2) psychosocial problems (i.e., poverty, discrimination, stress); and (3) HIV risk behaviors (i.e., sexual compulsiveness, unprotected sex, multiple partners, drug use) among high risk men who have sex with men (Herrick, Stall, Egan, Schrager, & Kipke, 2014; Mustanski et al., 2017; Parsons, Grov, & Golub, 2012; Starks, Tuck, Millar, & Parsons, 2016).

Syndemic theory and NCDs

Syndemic theory is increasingly being applied to non-communicable chronic disease research to understand the clustering of chronic diseases and adverse social conditions among populations (Everett & Wieland, 2012; Mendenhall, Kohrt, Norris, Ndetei, & Prabhakaran, 2017; Mendenhall et al., 2015; Ruiz & Egli, 2010). Recently, Spoer and Fullilove (2016) stressed the need for researchers to consider utilizing syndemic theory in obesity research. They advocate that syndemic theory’s focus on social and structural factors can be in can be integrated into obesity research to examine ecological factors influencing outcomes. Furthermore, the researchers suggest that syndemic theory can provide theoretical justification on how comorbidities (i.e., diabetes, and cardiovascular disease) are influenced by obesity and that synemic literature has the potential to provide methods and measures pertaining to the synergistic interactions that influence obesity and health related outcomes such as NCDs (Spoer & Fullilove, 2016). For example, Spoer and Fullilove (2016) proposed that obesity research examining the influence of multiple comorbidities and social determinants of health (i.e., poverty, discrimination, and racial disparities) could benefit from syndemic theory as the co-occurrence of comorbidities and risk factors has been demonstrated by previous research (Bratanova, Loughnan, Klein, Claassen, & Wood, 2016; Cozier et al., 2014).

In Kenya, syndemic theory was recently utilized to understand the experiences of individuals with type 2 diabetes (Mendenhall et al., 2015). Participants of the study reported living with concurrent infections, anxiety, depression, along with financial challenges while dealing with T2D (Mendenhall et al., 2015). As a result of the influence of socioeconomic condition on health, Mendenhall (2015) extended the syndemics terminology by introducing the term *syndemic suffering* to capture the interactions of social problems and health challenges.

Study Aim

There is a significant gap in the literature in utilizing syndemic theory as a lens to examine co-occurring conditions and risk behaviors associated with NCDs. Several studies suggest that obesity is a common risk factor for NCDs (Commodore-Mensah et al., 2014; Hall et al., 2014; Jensen et al., 2014; Kengne et al., 2017; Ligibel et al., 2014). Additionally, both NCDs and obesity share common risk factors such as sedentary activity, inadequate consumption of fruit and vegetable intake, and alcohol consumption (Allen et al., 2017; Mozaffarian, 2016;

World Health Organization, 2017b). Moreover, there is an existing body of literature that has identified groups of individuals living with multiple co-morbidities and who also exhibit high-risk NCD related behaviors (Fine, Philogene, Gramling, Coups, & Sinha, 2004; Lochner & Shoff, 2015; Ward, Schiller, & Goodman, 2014).

As growing literature in Kenya continues to recognize the increasing burden of NCDs, it is imperative to examine if there are populations who are experiencing comorbid NCDs (ie. Overweight/obesity, T2D, hypertension) and how socio-demographic factors and health behaviors are associated with NCDs. The aim of this study is to examine syndemic relationships of NCD risk factors (i.e., obesity, hypertension, and diabetes) and health behaviors (i.e., sedentary activity and fruit and vegetable consumption) from a nationally representative sample of Kenyans.

Methods

Sample

Secondary data from the 2015 Kenya STEPwise Survey were analyzed. The 2015 Kenya STEPwise Survey was led by the Kenya Ministry of Health in partnership with the World Health Organization, the Kenya National Bureau of Statistics and other national and multinational organizations (Ministry of Health, 2015b). The survey is the first to collect comprehensive data on risk factors for NCDs and injuries in Kenya using a nationally representative sample. For the sample, adults 18 to 69 years of age were sampled and surveyed using the three-stage cluster sampling design of the Kenya National Bureau of Statistics, fifth National Sample Surveys and Evaluation Program (NASSEP V) master sampling frame (Ministry of Health, 2015b). Clusters were first selected by region (rural vs. urban), then households, individuals were then selected from households by age and gender. The study sampled 6,000 individuals to meet the national representation based on region, sex, and 12 year age groups (Ministry of Health, 2015b). Based on the eligibility criteria, 4,500 eligible adults, 18 to 64 years of age participated in the survey (Ministry of Health, 2015). More details of the sampling methods can be found in the 2015 Kenya STEPwise report (Ministry of Health, 2015b). For this study, a total of 4,350 participants were included. Participants below the age of 18 (n=14) and pregnant women (n=136) were excluded in this study

Chronic Disease Risk Factors

Overweight/Obese. Weight in kilograms and height in centimeters were recorded. Body mass index (BMI) was calculated by dividing the weight in kilograms by meters squared. The World Health Organizations' definition for BMI was used. A BMI lower than 18.5 kg/m^{2}was defined as underweight, 18.50 to 24.99 kg/m^2 were considered normal, and higher than 25.00 kg/m^2 was defined as overweight/ obese (World Health Organization, 2017d). A categorical variable was created (underweight=1, normal=2, overweight/obese=3).

Hypertension. Three blood pressure measurements using digital automated blood pressure monitors were collected as per WHO STEPwise protocol. The average of the last two blood pressure measurements was calculated according to the American Heart Association guidelines (American Heart Association, 2018). High blood pressure was defined as having an average systolic blood pressure of greater or equal to 140 mmHg and/or diastolic blood pressure of greater or equal to 90 mmHg or currently on blood pressure medication (World Health Organization, 2015). A dichotomous variable identifying whether an individual is hypertensive (0 = not hypertensive, 1 = hypertensive).

Type 2 Diabetes (T2D). Fasting blood glucose was collected according to WHO STEPwise protocol. High blood glucose was defined as a fasting plasma glucose value ≥ 7.0

mmol/L (126 mg/dl) or on medication for raised blood glucose (World Health Organization, 2006a). A dichotomous variable identifying whether an individual has T2D was created (0 = normal, 1 = T2D).

Health Behaviors

The following health behaviors were assessed: daily smoker (yes = 1, no = 0), alcohol consumption in the last 30 days (yes = 1, no = 0), and sedentary activity (minutes spent sitting or reclining on a typical day.

Fruits and Vegetable Consumption. Participants were asked, *1) In a typical week, on how many days do you eat fruit? 2) How many servings of fruit do you eat on one of those days? 3) In a typical week, on how many days do you eat vegetables? and 4) How many servings of vegetables do you eat on one of those days?* Participants were shown a nutrition card with examples of local fruits and vegetables and examples of servings size to define serving amount. A continuous variable was created by multiplying the number of days participants reported consuming fruit by the number of servings of fruit reported. The total days and servings of fruit consumption were then divided by seven to reflect the number of servings of fruit consumed on a typical day. The same formula was used to calculate the number of vegetables. The average number of fruit and the average number of vegetables on a typical day was then added to reflect typical consumption of fruit and vegetables in a day. A dichotomous variable was also calculate to determine proportion of participants who consumed five or more servings of FV as recommended by the WHO (World Health Organization, 2017b).

Demographic Characteristics

Participant demographic characteristics were assessed using the following items: biological sex (men = 1, women = 2), age as a continuous variable and a categorical variable divided into 10 year age groups (18 to 29, 30 to 44, 45 to 59, 60 to 69 years), education was coded as (less than primary complete=0, complete primary or more=1), marital status was categorized (married or cohabitating = 1, divorced or separated = 2, never married = 3, widowed = 4), residence (rural = 1, urban = 2), wealth quantile (poorest or poor = 1, middle = 2, rich or richest = 3).

Analysis

Descriptive analyses were conducted on STATA 14. Data were weighted to take into account complex sampling design. Latent class analysis groups individuals with similar characteristics by shared traits (Nylund, Asparouhov, & Muthén, 2007). The analysis allows for the estimation of the number of groups within a population based on shared characteristics and estimation of within-group characteristics based on similarity of responses of the variables included in the model (Nylund et al., 2007). The use of latent class analysis as a method allowed for the identification of underlying unobserved characteristics that result in clustering of individuals into classes based on the NCD risk factors and socio-demographic characteristics (Nylund et al., 2007). Latent class analysis allows for a series of models starting with a 1-class model to be examined to determine the model with the optimal number of classes (e.g., 2-class, 3-class). The analysis was conducted using a stepwise approach where an increasing number of classes were specified at each step (e.g., 1-class model analysis, then 2-class model analysis) (Nylund et al., 2007).

Latent class analysis was conducted using MPLUS using maximum likelihood to determine the model with the best number of latent classes. First, models were run to examine whether NCD risk factors and behaviors had cumulative relationships. The models were run using the following characteristics: BMI categories (underweight, normal, overweight/obese), hypertension, T2D, the average daily intake of fruits and vegetables, daily smoker status, consuming alcohol in the last month and average sedentary minutes per day. The series of models demonstrated that NCD risk behaviors and risk factors, did in fact, co-occur. Risk factors significantly associated with NCD risk in Kenya (i.e., age, sex, education, wealth status, and residence) were entered in the model (Ayah et al., 2013; Christensen et al., 2016; M. D. Joshi et al., 2014; Mbochi et al., 2012; Ploubidis et al., 2013).

Education and wealth performed similarly between classes; therefore, education was removed in the model and wealth was used as an indicator of socioeconomic status. Wealth status has been shown to have a significant impact on chronic disease risk in Kenya and other LMICs (Bovet et al., 2002; Chowdhury, Uddin, Haque, & Ibrahimou, 2016; Kaduka et al., 2012).

The final LCA model included the following characteristics; age, sex, wealth, residence, smoking, alcohol intake, hypertension, T2D, and BMI categories. The best model was assessed by analyzing indices used for optimal model selection such as the Bayesian Information Criterion (BIC), the Akaike Information Criterion (AIC) relative to other models, Chi-square X^2 statistic, the Lo-Mendell-Rubin Likelihood Ratio Test (LMR-LRT), standardized residuals and entropy (quality of classification) (Nylund et al., 2007). The best-fitting model was identified based on decreasing indices as well as interpretably.

Results

Demographic Characteristics

A total of 4, 350 participants were analyzed in this study. The mean age of the sample was 34.66 (SE. = 0.44), 45.03% of participants were between the ages of 18-29 years. The sample was evenly distributed by sex (male = 50.40% men and female = 49.60%). The majority, 64.75% of participants were married, completed at least primary school education (64.25%) and resided in rural Kenya (61.47%). The sample consisted of 39.83% participants who were either in the poor or poorest wealth category, 18.3% were middle wealth, and 41.87% were either in the rich or richest wealth category.

The proportion of smokers was (8.68%), and less than a fifth (19.84%) reported consuming alcohol within the last 30 days. The average fruits and vegetables consumed each day were 2.10 (S.E. = 0.08), and the average sedentary time reported per day was 152.59 (S. E. = 3.83) minutes. The average BMI in the sample was 23.39 (SE. = 0.44). More than half of participants (59.75%) were categorized in the normal BMI range, 11.85% were underweight, 18.90% were overweight, and 9.07% were obese. The prevalence of hypertension in the sample was 24.57%. The prevalence of T2D was 1.89%. Table 4.1 includes descriptive characteristics of participants.

Table 4.1: Demographic Characteristics

	Proportion	SE	[95% Conf. Interval] LL	UL
Age				
Mean	34.66	0.44	33.79	35.53
18-29	45.03%	0.02	0.41	0.49
30-44	32.87%	0.01	0.31	0.35
45-59	16.56%	0.01	0.15	0.18
60-69	5.54%	0.00	0.05	0.07
Sex				
Men	50.40%	0.01	0.48	0.53
Women	49.60%	0.01	0.47	0.52
Marital Status				
Married/Cohabiting	64.75%	0.01	0.62	0.68
Divorced/Separated	5.82%	0.01	0.05	0.07
Never married	23.72%	0.02	0.21	0.27
Widowed	5.71%	0.01	0.05	0.07
Education				
No Formal School	12.18%	0.02	0.09	0.16
Less than Primary	23.57%	0.02	0.21	0.27
Primary Complete	32.50%	0.02	0.29	0.36
Secondary or More	31.75%	0.03	0.27	0.37
Wealth Status				
Poor-Poorest	39.83%	0.03	0.33	0.47
Middle	18.30%	0.02	0.15	0.22
Rich-Richest	41.87%	0.04	0.34	0.50
Urban Rural				
Rural	61.47%	0.04	0.53	0.69
Urban	38.53%	0.04	0.31	0.47
Daily Smokers	8.68%	0.01	0.07	0.11
Current Drinkers	19.84%	0.01	0.17	0.23
BMI				
Mean BMI	23.39	0.22	22.95	23.83
Underweight	11.90%	0.01	0.10	0.14
Normal	60.00%	0.01	0.57	0.63
Overweight/Obese	28.09%	0.02	0.25	0.31
High Blood Pressure				
High Glucose	1.89%	0.00	0.01	0.03
Average FV consumption	2.10	0.08	1.94	2.25
Sedentary (minutes/day)	152.59	3.83	145.04	160.15

Latent Class Analysis Results

A series of models were run to explore whether there were latent groups who experienced shared NCD characteristics. All models had entropy values of above 0.80 demonstrating that the models could distinguish and had good separation of identifying groups for all the models (Hagenaars & McCutcheon, 2002). After examining models, a four-class model was identified as the best fitting model. Specifically, this model had the most meaningful interpretable results that supported existing NCD literature in Kenya and LMICs. The model also had the lowest adjusted BIC and acceptable entropy. Although the LMR LRT value was not significant, the model was the most interpretable and supported existing literature on the scope of NCDs in Kenya. Table 4.2 summarizes model fit information for the five latent class models.

Table 4.2: Best Fitting Model

Model	Adjusted BIC	AIC	p-Value	Entropy
1	123811.294	123753.688		
2	121785.349	121673.337	0.259	0.868
3	120575.324	120408.906	0.138	0.929
4	**119548.242**	**119327.418**	**0.593**	**0.912**
5	118583.580	118308.351	0.499	0.833

Class 1 is best described as young with highest NCD risk. The class comprised of (5%) of the sample. Participants in this class were made up of (52%) adults between 18-29 years. This class had a higher chance of being in the rich-richest wealth category (49%) and (32%) chance of being poorest-poor. This class had slightly higher chance of being rural (56%) compared to urban (44%). The class had the lowest chance of being daily smokers (4%) and (20%) chance of consuming alcohol in the last month. This class had the highest chance of hypertension (31%) and the highest chance of having T2D (6%). The mean average standardized estimate for average sedentary activity per day was 5.67 (S.E. = 0.30) making it the class with the highest sedentary activity. The standardized estimate for average fruit and vegetable consumption was 1.67(S.E. = 0.13) was also the highest compared to the other three classes.

Class 2 is best described as poor rural adults with lower NCD risk and comprised of (50.54%) of the sample. The probability of being a rural resident was (90%), and the chance of being in the poor-poorest wealth category was (73%) for participants in this class. The chances of being in the 18-29 year and 30-44-year age groups were (38%) and (36%) respectively. This class had slightly more than half, (54%) chance of being women. Participants assigned to this class had highest chance (65%) of being in the normal weight category and had (19%) chance of being overweight/obese. The participants had 1% chance of T2D and (25%) chance of having hypertension. The class had a high chance of daily smokers as class participants had (9%) chance of being daily smokers. This class had the lowest chance (17%), of being current alcohol consumers. The mean average standardized estimate for average sedentary activity per day was 1.39 (S.E. = 0.09) and 1.40 (S.E. = 0.05) for average fruit and vegetable consumption.

Class 3 is best described as rural with high NCD risk and comprised of (3.82%) of the sample. The probability of being rural in this class was (80%). This class had a higher probability of being male (55%), and similar to class 2 with (37%) and (36%) chance of being in the 18-29 year and 30-44-year age groups respectively. This mostly rural class had even distribution of probabilities by wealth category with (38%) chance of being poorest or poor, (31%) chance of being middle, and (31%) chance of being in the rich or richest wealth categories. This class had the highest probability of being daily smokers (10%), and also had the highest probability of consuming alcohol within the past month (29%). Participants assigned to this class had (28%) chance of being overweight/obese, (2%) chance of T2D, and the second highest chance, (28%) of having high blood pressure. The mean average standardized estimate for average sedentary activity per day was 1.50 (S.E. = 0.11). This class had the highest standardized estimate for average fruit and vegetable consumption 6.02 (S.E. = 0.34).

Class 4 is best described as rich young urban dwellers with high NCD risk behaviors. Class 4 comprised (41.2%) of the sample. The class had the highest chance of being either in the 18-29 years (53%) or 30-44 years (30%) age categories. The chance of being in the rich to richest wealth category was (92%) in this class. The chances of being male were more than half, (55%) and participants had a (75%) chance of being urban residents. The chances of being daily smokers and current drinkers in this class were (9%) and (22%) respectively. This class had the highest chance of being overweight/obese, (40%). Participants had (2%) chance of T2D and (23%) chance of hypertension. The mean average standardized estimate for average sedentary activity per day was 1.54 (S.E. = 0.07), and the standardized estimate for average fruit and vegetable consumption was 1.50 (S.E. = 0.05). Table 4.3 outlines result from the 4 - class latent class model and probability scale results for each class.

Table 4.3: Probability scale results

	Young with high NCD Risk (Class 1)	Poor Rural with Lower NCD Risk (Class 2)	Rural with High NCD Risk (Class 3)	Rich Young Urban with High NCD Risk (Class 4)
Class Prevalence	4.84%	50.18%	3.82%	41.16%
Age				
18-29	0.518	0.382	0.371	0.534
30-44	0.217	0.359	0.358	0.302
45-59	0.171	0.186	0.193	0.137
60-69	0.094	0.073	0.078	0.027
Sex				
Men	0.510	0.464	0.548	0.549
Women	0.490	0.536	0.452	0.451
Wealth				
Poor-Poorest	0.323	0.731	0.382	0
Middle	0.183	0.259	0.305	0.078
Rich-Richest	0.494	0.010	0.313	0.922
Residence				
Rural	0.560	0.900	0.796	0.253
Urban	0.440	0.092	0.204	0.747
Smoker				
No	0.963	0.910	0.901	0.914
Yes	0.037	0.090	0.099	0.086
Drinker				
No	0.798	0.826	0.710	0.781
Yes	0.202	0.174	0.290	0.219
High Blood Pressure				
No	0.693	0.750	0.722	0.770
Yes	0.307	0.250	0.278	0.230
High Glucose				
No	0.943	0.987	0.984	0.979
Yes	0.057	0.013	0.016	0.021
BMI				
Underweight	0.13	0.160	0.105	0.069
Normal	0.562	0.652	0.619	0.539
Overweight/Obese	0.308	0.188	0.276	0.391

Discussion

This study aimed to explore whether syndemic relationships between NCDs and NCD risk behaviors exist in a nationally representative sample of Kenyan adults. A four-class solution was identified as the model with the best fit. The following classes emerged: class 1 was identified as young adults with high NCD risk, class 2 was identified as poor rural adults with lower NCD risk, class 3 was identified as rural adults with high NCD risk, and class 4 was identified as rich young urban adults with high NCD risk.

In South Africa, results from a nationally representative survey demonstrated that 73% of adults with diabetes had an additional cardiovascular related chronic illness (Mutyambizi et al., 2017). In Kenya, very few studies have examined multiple co-morbidity for chronic disease, thus to the best of our knowledge, this study is the first to examine co-occurring NCDs and risk behaviors in Kenya using nationally representative survey. The results of this study supported the hypothesis that some groups may have co-occurring NCD as well as also exhibit co-occurring risk behaviors as demonstrated in other regions (Folb et al., 2015). As proposed by Spoer et al. (2015), this study found supporting evidence that syndemics theory is indeed appropriate and applicable to obesity and NCD research. Overall, this study found that syndemic or co-occurring NCD risk factors were clustered similar to previous studies that used latent class analysis to examine co-occurring NCD risk (Kang et al., 2014; Kim, Barreira, & Kang, 2016; Larsen, Pedersen, Friis, Glümer, & Lasgaard, 2017; Leventhal, Huh, & Dunton, 2014). Classes shared similar risk to NCDs, for example class 2, the poor rural adults with low NCD risk had a 25% chance of being hypertensive, 1 % chance of T2D and 19 % chance of overweight/obesity compared to class 3 which was made up mostly of rural wealthier adults with 28 % chance of hypertension, 2% T2D and 28% overweight or obesity.

As the chance of engaging in risk behaviors increased so did the chance of having an NCD (T2D, hypertension or overweight/obesity). As found in previous research in Kenya, this study found that groups with higher chance of NCDs also exhibited a higher chance of engaging in risky behaviors (Haregu, Oti et al., 2016). The classes with the highest chance of overweight or obese, hypertension as well as T2D also had low fruit and vegetable consumption, higher sedentary activity time per day, the highest chance of being daily smokers, and highest chance of currently consuming alcohol. In Kenya, Heregu and colleagues (2016) found that 17.6% of participants in their study had more than 2 NCD risk behaviors and the combination of unhealthy diet and insufficient physical activity was the most common. In this study, the chance of engaging in smoking and drinking were much higher in high NCD risk classes compared to lower NCD risk classes. For example, among wealthy young adults with high NCD risk (class 4), the group with the highest overweight/obesity probability, there was high chance of being current alcohol consumers, highest sedentary activity, as well as low consumption of fruit and vegetable intake. These findings are also supported by previous research showing clustering of health risk behaviors and high risk of NCD globally (Barile et al., 2015; Fine et al., 2004; Padrão et al., 2015; Van Remoortel et al., 2014).

Tobacco smoking is also widely recognized as a leading contributor to NCD risk especially cardiovascular disease risk (Allen et al., 2017; World, 2017). Overall, 8.68% of the sample were daily smokers similar to other studies in Kenya (Bloomfield et al., 2013; M. D. Joshi et al., 2014; Lo et al., 2013). Class 2, class 3, and class 4 had a 9%, 10%, and 9% chance of being current smokers. In Kenya, studies have reported significant associations between smoking and hypertension (M. D. Joshi et al., 2014; Olack et al., 2015). Alcohol consumption is associated with 5% of the global disease burden and is associated with increased risk of NCD and overweight and obesity risk (Ng et al., 2014).

The prevalence of current alcohol consumption in this study was 19.84%. Studies in Kenya report prevalence as high as 31.7% (Takahashi et al., 2017) and as low 9.2% (Jenkins et al., 2015). In Kenya, alcohol has also been demonstrated to increase NCD and overweight/obesity risk (M. D. Joshi et al., 2014). Although the probability of smoking was similar among the three classes, class 3 which had the highest chance of having daily smokers had the highest chance of current drinkers 29%. There is substantial evidence demonstrating that adults are highly likely to both smoke and drink (Meader et al., 2016; Noble, Paul, Turon, & Oldmeadow, 2015; Schuit, van Loon, A Jeanne M, Tijhuis, & Ocké, 2002). The combination of a high chance of smoking and drinking may have contributed to class 3 having the second highest hypertension and T2D chance despite having a high probability of normal weight individuals being 62%. Smoking and alcohol consumption may mask protection from NCD risk for non-overweight and obese individuals.

The World Health Organization (WHO) reports that 1.7 million deaths globally are attributable to inadequate consumption of fruits and vegetables (WHO, 2018). The WHO recommends that adults consume 5 or more servings of fruits and vegetables each day (WHO, 2004). In this study, less than 10% of adults consumed 5 or more fruits and vegetables a day supporting findings in Kenya and other LMICs showing low consumption of fruits and vegetables (Bloomfield et al., 2011; Haregu et al., 2016; Zaman et al., 2015). The classes with low rates of fruits and vegetable consumption in the results had a high chance of overweight or obese as well as underweight and NCDs. Additionally, high consumption of fruit and vegetables was observed among rural participants with a high probability of being in the middle or rich-

richest wealth categories with urban dwellers and rural poor participants consuming fewer fruits and vegetables.

The rural poor class also had the highest (16%), the chance of being underweight in this study. Rural dwellers have been shown to have better dietary diversity compared to urban residents in Kenya (Steyn et al., 2012) thus the findings show disparities by a socioeconomic study. The double burden of both malnutrition and overweight and obesity has been demonstrated in Kenya, and low fruit and vegetable consumption are associated with both malnutrition and over nutrition by previous studies in Kenya (Hulzebosch et al., 2015; Kimani-Murage et al., 2015). Increasing consumption of fruit and vegetables in Kenya has the potential to both influence malnutrition and overweight and obesity.

Sedentary activity is increasingly being identified as an essential factor influencing NCD risk (Biswas et al., 2015; Owen et al., 2009; Schmid, Ricci, & Leitzmann, 2015). In Kenya, studies show conflicting evidence as to whether physical activity influences chronic disease risk. Some studies show that physical activity is a significant factor associated with NCD risk (Olack et al., 2015) and others do not report significant results (M. D. Joshi et al., 2014). In Tanzania, physical activity influenced NCD risk (Zack et al., 2016). Because of the conflicting evidence, this study used the sedentary activity as a measure in order to attempt to gain a better understanding of the relationship between activity and chronic disease risk. The class with the highest sedentary activity was class 1 who were young with the high risk of NCDs. In Kenya, the majority of the population has been found to report work-related physical activity (Groot & Muthuri, 2017; Haregu et al., 2016) thus the young population may be subjected to lengthy sedentary work-related activity.

Residence (rural vs. urban) was a common factor that separate classes in this study. The class with the highest chance of being overweight or obese were urban adults (Class 4). The results of this study align with previous studies in Kenya and other LMICs showing higher overweight or obese and NCD risk among urban dwellers compared to rural (Aryal et al., 2015; Kavishe et al., 2015; Ogah et al., 2016). The results were impressive; however, as class 4, the young adults with high NCD risk had highest hypertension probability had a higher chance of being rural (55%) compared to urban (45%).

The results demonstrate that high rates of NCDs may not be exclusively a function of residence (rural vs. urban). This hypothesis is both demonstrated by results of this study as well as findings of the high prevalence of NCDs in studies conducted in rural environments in Kenya and other LMICs (Chege, 2016; Hendriks et al., 2012; Pastakia et al., 2013). The high rates of hypertension in the group may be explained by having the highest current drinking chance as well as highest smoking. Rural adults may have lower overweight and obesity risk, but participation in high-risk behaviors may put them at high risk of NCDs.

Wealth category also influenced class membership in this study. In Kenya and other LMICs, individuals who are wealthy have been found to have a higher risk of NCDs compared to their poor counterparts (Olack et al., 2015; Ploubidis et al., 2013). In this study, class 2, rural poor adults had much lower chance of all NCD risk (hypertension, T2D, and overweight or obesity) compared to class 3 who had a higher chance of being in the middle or higher wealth categories. Among urban adults, class 4 which had 92% chance of being in the rich or richest wealth category had the highest overweight or obese chance among all classes. Wealthy adults in this study were most represented among classes with a higher chance of NCDs as well as risk behaviors.

Unlike high income countries where poverty is associated with high risk of NCDs and engaging in behaviors that increase NCD risk (Menke, Casagrande, Geiss, & Cowie, 2015; Saydah et al., 2014; Walker & Druss, 2017), the findings of this study align with studies In Kenya and other LMICs that report higher NCD prevalence among wealthy individuals (Dinsa, Goryakin, Fumagalli, & Suhrcke, 2012; Olack et al., 2015; Ploubidis et al., 2013). Traditional public health initiatives and programs that aim to improve education and behaviors may need to focus on ecological and systems-based interventions to reduce risk.

In this study, wealth was used as a proxy for socioeconomic status as education performed similarly to wealth categories when inserted into the model. The overall model improved by removing education. Health promotion efforts typically use education as a tool for NCD prevention, for example educating individuals on health risk and health protective behaviors (Lins, Jones, & Nilson, 2010; Nugent et al., 2018; World Health Organization, 2011). In Kenya however, since higher socioeconomic individuals tend to have a higher risk, it is imperative to further explore drivers of health outcomes in order to identify impactful leverage points for disease prevention appropriately. In Kenya for example, preference for larger body size has been documented in Kenya thus one area of focus may be examining the influence of culture on weight management (Appiah et al., 2016; Ettarh et al., 2013; Renzaho, 2004).

Strengths and Limitations

This study has some limitations. First, the cross-sectional nature of this study limits examining trends over time. The use of secondary data is also challenging due to limits of the type of available data and variables. For example, the measure of fruit and vegetable consumption might be influenced by recall bias since participants were asked to share how much fruits and vegetables they consumed and frequency during the past week. A 24 – 48 dietary recall measures may have resulted in a more productive measure of dietary intake. Additionally, more objective measures of physical activity such as wearable trackers may result in the better measurement of physical activity.

Despite limitations, this study has strengths. First, to the best of our knowledge, this is the first study to use a nationally representative sample to examine syndemic NCDs and risk factors in Kenya. The use of the WHO Kenya STEP Wise survey is a strength as the survey is widely used and has been found to have reliable measures of NCD risk and behaviors (Bonita et al., 2003; Janghorbani et al., 2007; Riley et al., 2016). The use of latent class analysis is also a strength of this study as it allowed for the identification of high-risk groups which may inform targeted interventions. Last but not least, this study is timely and responds to the growing burden of NCDs in Kenya.

Conclusion

Overall, the results of this study demonstrate that wealth and residence (rural vs. urban) are strong predictors of co-occurrence of NCD risk and risk behaviors in Kenya. Latent class analysis results demonstrated the high probability of both NCD risk and health behaviors among specific groups calling for targeted and tailored interventions in reducing NCD risk and risk behaviors.

CHAPTER V

CONCLUSIONS

The purpose of this dissertation study was to examine the national prevalence and predictors of NCDs in Kenya. This study provides insight on the national prevalence of NCDs (e.g., overweight, obesity, hypertension, and T2D) and associated socio-demographic factors and related health protective behaviors (e.g., sedentary activity, FV consumption, smoking, and alcohol consumption) in Kenya.

Implications for research

Three independent studies of adults over the age of 18 years were conducted using data from the 2015 Kenya WHO STEPwise Survey. The studies (1) utilized logistic regression to examine the national prevalence of overweight/obesity and socio-demographic and health behaviors (Chapter II); (2) investigated the relationship between average FV consumption and NCDs and socio-demographic factors using structural equation modelling (Chapter III); and (3) utilized syndemic theory as a guide to quantitatively determine risk profiles of NCDs on health behaviors and socio-demographic characteristics (Chapter IV).

The results of the first study examining prevalence and risk factors for overweight and obesity in Kenya reported the obesity prevalence rate of 27.94%. Socio-demographic factors associated with increased overweight and obesity risk were being a woman, being older, having more than a primary education, being in the middle wealth category or higher, and residing in an urban environment. Contrary to expectations, this study did not find significant relationships between overweight or obesity and health behaviors (e.g., alcohol consumption, physical activity, FV consumption or sedentary activity). The insignificant findings of the relationship between overweight or obesity and health behaviors call for future studies to further explore behaviors using objective measures as opposed to self-reported measures used for this study. In addition to collecting objective measure, qualitative studies are needed to understand perceptions of health behaviors and associated NCDs such as overweight or obesity in order to understanding of the scope of NCD risk in Kenya. For example, despite studies showing a strong link between physical activity and overweight/obesity, studies in Kenya show high levels of physical activity (Ayah et al., 2013; Bloomfield et al., 2013; R. Joshi et al., 2014).Thus, it is imperative to extend and tailor the lens at which risk factors are conceptualized, as they may be different in Kenya.

The results of this study support evidence that overweight/obesity is a challenge among women, older age groups, urban dwellers, highly educated individuals, and wealth in LMICS (Allen et al., 2017; Arokiasamy et al., 2017; Dalal et al., 2011; Lloyd-Sherlock, Beard, Minicuci, Ebrahim, & Chatterji, 2014). Future studies should seek to examine risk factors among these high risk populations. Overall, this study closed a significant gap in the literature, the absence of a nationally representative study examining prevalence and risk of overweight/obesity among both men and women. Several studies examining overweight and obesity in Kenya are gender-specific (e.g., women) (Mbochi et al., 2012; Mkuu et al., 2018; Pawloski et al., 2012; Steyn et al., 2011) or focused on specific regions (Ettarh et al., 2013; Kimani-Murage et al., 2015; Mbochi et al., 2012). Future studies should examine perceptions of weight and weight management behaviors to identify intervention opportunities in Kenya.

The major findings of the study examining FV consumption and NCDs were that only 6.15% of the sample consumed adequate amounts (5 or more servings per day). The study also found that only hypertension had a significant pathway with FV among the NCDs examined (overweight/obesity and T2D). Older individuals, completing primary education or more, those in the middle-wealth category or higher had significant positive pathways with FV consumption. The findings have major implications for research as very few studies in Kenya have exclusively examined FV intake and associated factors (Ruel et al., 2005).To date, the studies that include FV are typically examining its relation to NCD outcomes such as overweight or obesity, hypertension or T2D (Hulzebosch et al., 2015; Kimani-Murage et al., 2015; Oti et al., 2013). To the best of the author's knowledge, no study has examined FV exclusively. There is a large gap in the literature in providing a foundation for the level of perceptions of FV consumption, and facilitators and barriers to FV consumption in Kenya. Future studies seeking to examine FV consumption should also consider objective long-term measurements as opposed to relying on self-report measures to reduce the potential for recall bias.

The results of the study examining syndemic relationships between NCDs and health behaviors (e.g., smoking, alcohol consumption, sedentary activity and FV consumption) and socio-demographic factors identified that NCDs and risk behaviors did cluster. Latent class analysis derived a set of four classes that reflected patterns of NCDs and risk factors: 1)young adults with high NCD risk, 2) poor rural adults with lower NCD risk, 3)rural adults with high NCD risk, and 4) rich urban adults with high NCD risk. Classes demonstrating high engagement in risk behaviors also had high risk for NCDs. Classes with high chance of urban dwellers had higher chances of overweight/obesity. Classes with high risk of NCDs also had higher chances of having younger individuals 18-44 years. The findings support current research regarding the clustering of NCDs and risk behaviors (Bratanova et al., 2016; Cozier et al., 2014; Marley & Metzger, 2015), as well as increased chance of NCDs among urban and individuals of higher SES status in LMICs (Allen et al., 2017; Oyebode et al., 2014). Our class of rural adults with high NCDs, however, was evenly distributed by chance of wealth category membership (i.e., poor and poorest, middle, rich and richest). The rural adults with high NCD risk class had the highest chance of having current drinkers and daily smokers when compared to other classes. The results suggest that rural individuals who are typically less likely to have NCD risk increase risk by engaging in high-risk health behaviors. More studies are needed to understand urban and rural drivers of NCD risk behaviors.

The scientific premise of this dissertation rests on the lack of research identifying national prevalence and risk factors for NCDs in Kenya. The studies bridge a gap in understanding the national scope of determinants of NCDs through the utilization of diverse statistical analysis techniques. As with the studies in this dissertation, the literature status quo on NCDs in Kenya has mainly focused on cross-sectional studies emphasizing prevalence and providing a foundation for understanding the scope of NCDs. More studies are needed to solidify understanding of prevalence and risk factors. Moreover, there is also a need to vertically shift research NCD research towards longitudinal studies to identify trends over time as well as intervention research to determine evidence-based interventions to advance NCD prevention in the country.

Implications for policy and practice

The Kenya Health Policy 2014-2030 outlines the government's plan to ensure improvement in the health status of Kenyans (Ministry of Health, 2014). The policy focuses on committing to meet two obligations; first, that health is a human right which is enshrined by the Constitution of Kenya 2012 and second, that health contributes to economic development and necessary to reach goals envisioned in Kenya Vision 2030(Ministry of Health, 2014). In the Kenya Health Policy 2014-2030, NCDs are explicitly recognized as an emerging threat to gains and investments made in improving infectious diseases and medical services. Furthermore the policies goals are to, “*halt and reverse the rising burden of non-communicable conditions”* (Ministry of Health, 2014, pg 32). Based on the study findings, the strategies most appropriate to meet the objectives are promoting universal access to interventions addressing NCDs; strengthening advocacy and health-promoting activities aimed at preventing NCDs; putting intersectoral NCD prevention and control programs in place; and designing and implementing integrated health services that are comprehensive control of NCDs (Ministry of Health, 2014).

The results from this dissertation provide evidence for policies and interventions focused on NCD prevention and control. For example, the results illustrate that NCD interventions should be focused on urban individuals and individuals engaging in risky behaviors such as consumption of alcohol and smoking. Additionally, results show clustering of NCDs and risk factors among specific groups, namely affluent individuals and urban dwellers, thus supporting the proposed strategy for comprehensive and integrated NCD services. Moreover, findings in this study found that majority of Kenyans do not consume adequate amounts of FV could also be addressed through policies and interventions. The commitment of the government to provide universal interventions to address NCDs could involve providing education on benefits of FV consumption to the public.

The Kenya National Strategy for the Prevention and Control of Non-Communicable Diseases 2015-2020 aims at “attaining the highest possible standard of health in a manner responsive to the health needs of the population” (Ministry of Health, 2015a). The policy provides strategic directions towards reducing the burden of NCDs in Kenya including promoting healthy lifestyles to tackle unhealthy diets, physical inactivity, harmful alcohol use and tobacco use as well as promoting and conducting research and surveillance to prevent NCDs (Ministry of Health, 2015a). The strategies in the plan are adopted from the WHO Global NCD action plan 2013-2020, which have influenced other Kenya policies such as the Vision 2030 (Kenya Vision, 2013, 2018), Public Health Act Amendment (Republic of Kenya, 2017), Alcoholic Drinks Control Act 2010(National Council for Law Reporting, 2012b), the Tobacco Control Act the National(National Council for Law Reporting, 2012a), Nutrition Action Plan 2012-2017 (Ministry of Public Health,and Sanitation, 2012)and several other policies focused on NCD prevention. Table 5.1 provides a summary of health policies in Kenya on NCDs and how results from the findings of this dissertation pertain and contribute supporting evidence for the implementation of strategic priorities.

The results of this study directly pertain to the Kenya National Strategy for the Prevention and Control of Non-Communicable Diseases 2015-2020's objectives. The third objective of the policy is "*to promote healthy lifestyles and implement interventions to reduce the modifiable risk factors for non-communicable diseases: unhealthy diets, physical inactivity, tobacco use, and harmful alcohol"* (Ministry of Health, 2015a, pg12). Results of this study could inform effective strategies that are targeted and tailored to risk groups. One strategy outlined by the policy is to implement public awareness on healthy diets throughout the life course. The results highlighting inadequate consumption of FV in the country provide evidence for implementation of programs to increase awareness of healthy diets. The government of Kenya has included NCDs as a priority through outlining policies that seek to integrate NCD prevention, control, and management. This dissertation provides insight into the national scope of some of the determinants of NCDs and results from the study highlights some possible areas that targeted interventions should focus. Ensuring appropriate systems, services, and support for further research on NCDs as well as evidence-based targeted and tailored interventions have the potential to curb the growing NCD burden in Kenya.

Table 5.1: Health Policies related to NCDs in Kenya

Policy	NCD Objective/Goal (Verbatim)	Priority Strategies (Verbatim)	Policy recommendations based on study findings
Kenya Health Policy 2014-2030	<u>4.2.2 Policy objective 2:</u> Halt and reverse the rising burden of non-communicable conditions and mental disorders	• Promote universal access to interventions addressing priority NCD • Put in place intersectoral programmes for NCD prevention and control. • Strengthen advocacy for health-promoting activities aimed at preventing increased burden of NCDs. • Design and implement integrated health service provision tools, mechanisms, and processes, with a view to enhancing comprehensive control of NCDs.	• Promote universal access to interventions addressing low FV intake. • Put In place intersectoral program between ministries of health and agriculture to promote FV intake. • Advocate for increased resources to increase research and identification of factors that drive NCDs. • Include overweight and obesity as part of NCDs in health service provision.

Table 5.1: Health Policies related to NCDs in Kenya Continued

Policy	NCD Objective/Goal (Verbatim)	Priority Strategies (Verbatim)	Policy recommendations based on study findings
Kenya National Strategy for the Prevention and Control of Non-Communicable Diseases 2015-2030	3. Promote healthy lifestyles and implement interventions to reduce the modifiable risk factors for NCDs: unhealthy diets, physical inactivity, harmful use of alcohol, tobacco use and exposure to tobacco smoke. 8. Promote and conduct research and surveillance for the prevention and control of non-communicable disease.	• (3) Implementing public awareness programmes on healthy diets during the life course, in the framework of national and county strategic plans, and regulations. • (3) Implement effective use of tax and price measures for control of demand for tobacco products. • (3) Creating public awareness on the dangers of alcohol consumption and its related risks. • (8) Identify priority research areas on Non-communicable Diseases and their risk factors. • (8) Conducting baseline and periodic surveys on NCDs and their risk factors. • (8) Integrating NCD and their risk factors into the existing national household surveys.	• (3) Focus on promoting consumption of FV as avenue for increasing healthy diets during the life-course. • (3) Increase taxes on tobacco and alcohol as well as increase awareness on dangers of products to reduce use. • (8) Results show FV consumption may be a priority area for NCD prevention. • (8) Conducting periodic surveys on NCDs as well as integrating NCDs and risk factors into existing national household surveys will allow for examination of trends overtime.

Table 5.1: Health Policies related to NCDs in Kenya Continued

	NCD Objective/Goal (Verbatim)	Priority Strategies (Verbatim)	Policy recommendations based on study findings
National Nutrition Action Plan 2012-2017	1. To improve the nutritional status of women of reproductive age (WRA) (15-49 years). 3. To reduce prevalence of micronutrient deficiencies in the population. 6. To improve prevention, management and control of diet related to NCDs.	• (1) Promote healthy dietary practices among WRA. • (1) Promote adequate micronutrient intake. • (3) Advocate and create awareness on food fortification, supplementation and dietary diversification. • (6) Review, develop and implement comprehensive strategy and guidelines for prevention, management and control of diet related to NCDs. • (6) Strengthen coordination mechanisms for healthy diet and lifestyle programs at national and county level.	• (1) Increasing FV consumption through promoting and creating awareness. • (6) Comprehensive strategies and guidelines of programs at all levels should emphasize consumption of FV.

Table 5.1: Health Policies related to NCDs in Kenya Continued

Policy	NCD Objective/Goal (Verbatim)	Priority Strategies (Verbatim)	Policy recommendations based on study findings
Alcohol Drinks Control Act 2010.	The object and purpose of this Act is to provide for the control of the production, sale, and use of alcoholic drinks.	• Inform and educate the public on the harmful health, economic and social consequences of the consumption of alcoholic drinks; • Promote research and dissemination of information on the effects of alcoholic drink consumption, in particular the health risks that may arise therefrom.	• Increase education on harmful use and consequences of alcohol. • Increase resources for the researchers to ascertain alcohol consumption determinants, behaviors, and risks.
Tobacco Control Act 2012	The object and purpose of this Act is to provide a legal framework for the control of the production, manufacture, sale, labelling, advertising, promotion, sponsorship and use of tobacco products, including exposure to tobacco smoke	• Inform, educate and communicate to the public the harmful health, environmental, economic and social consequences of growing, handling exposure to and use of tobacco and tobacco products, and tobacco smoke; • Promote research and dissemination of information on the hazardous effects of tobacco production and use including exposure to tobacco products and tobacco smoke, in particular the health risks including addictive characteristics of tobacco consumption and exposure to tobacco smoke.	• Increase education on harmful use and consequences of tobacco. • Increase resources for the researchers to examine tobacco consumption behaviors, determinants and risks.

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