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Examining the Socioeconomic Factors on the Double Burden of Undernutrition and Obesity across Sub-Saharan African Countries

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EXAMINING THE SOCIOECONOMIC FACTORS ON THE DOUBLE BURDEN OF UNDERNUTRITION AND OBESITY ACROSS SUB-SAHARAN AFRICAN COUNTRIES

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ABSTRACT

Malnutrition exists in multiple forms when a person has an imbalanced intake of food and or vitamins. We include nutrition related illness such obesity and undernutrition in our understanding of malnutrition. The obesity pandemic has historically been associated with developed countries, however processes of globalization have led to socioeconomic development, higher incomes and urbanization which have contributed to the increasing prevalence of obesity in Sub-Saharan African countries. The nutrition transition theory has been used to discuss the major shift in diet and activity patterns at the population level. However, these changes are accompanied by a country's economic and demographic shifts. This paper examines the obesity rates in 39 Sub Saharan African countries. This paper reviews four macro environmental predictors; Gross National Income (GNI), urban population, current health expenditures, and basic sanitation service in urban areas, on obesity rates in 39 Sub-Saharan African countries. The analysis found a strong correlation between GNI and obesity rates and a strong correlation between Urban Population and obesity rates in my analysis. The impact of higher incomes and higher urban population on obesity rates in these countries is a public health concern because of the associated risks for non-communicable diseases such as diabetes and heart diseases.

INTRODUCTION

In the wake of the global pandemic of obesity, extreme hunger and undernutrition have remained a problem in developing countries. Globally, 11% of the population is undernourished (FAO, IFAD, UNICEF, WFP and ,WHO, 2017) and in Sub-Saharan Africa the undernourishment rate stands at 23% (United Nations Development Program, 2018). Undernutrition is related to a combination of social, environmental, and economic factors including, but not limited to, poverty, inadequate food intake, healthcare and sanitation, and gender relations (Müller and Krawinkel, 2005). In 2015 "Ending hunger, achieving food security and improving nutrition, and promoting sustainable agriculture" was adopted as the second Sustainable Development Goal for the year 2030 (United Nations Development Programme, 2018). This goal was aimed at addressing global malnutrition, which refers to a deficit or imbalanced intake of macronutrients and/or micronutrients and manifests as undernutrition or overnutrition (FAO, IFAD and WFP , 2013). Undernutrition is a deficiency of micronutrients and calories and can lead to stunted growth, and wasting (Black et al., 2013). Overnutrition is an excess intake of dietary requirements and increases an individual's likelihood of becoming obese and developing other health risks such Diabetes and Heart Disease. Therefore, malnutrition encompasses not only undernutrition but also obesity.

Obesity has historically been associated with high socioeconomic status and localized to wealthier regions primarily the United States and Europe. However, over the past 40 years the obesity pandemic has spread to both developed and developing countries which has raised public health concerns on the possible risk factors for increasing rates of obesity (Prentice, 2005). Obesity exists as a global issue (Bloem & de Pee, 2017), however there are studies showing that Low and Middle Income Countries (LMICs) undergoing rapid development, have the fastest rate of increase in obesity prevalence (Popkin, 1994, 2007). There are studies (Prentice 2005, Mendez, Monteiro, & Popkin, 2005) showing an increasing prevalence of overweight and obesity in Sub-Saharan countries. Kelly, Wang, Chen, Reynolds and He (2008), conducted a pooled analysis to estimate the overall prevalence and absolute burden of overweight and obesity in the world and to project the global burden in 2030, and found that compared to developed regions, developing regions are projected to have a much larger proportional increase in the number of overweight and obese individuals between 2005 and 2030.

Growth in population size, population aging, urbanization and changes in lifestyle including increases in total calorie intake and reductions in physical activity, all contribute to the increase of obesity rates in developing regions (Kelly, Yang, Chen, Reynolds, & He, 2008). Caballero (2007) states that of the multiple causal factors associated with the rise in obesity in developing countries, urbanization and globalization of food production and marketing play a significant role. Therefore, we can assess increasing rates of obesity as an outcome of socioeconomic processes demonstrated through a "nutrition transition", which refers to major shifts in diet and activity patterns at the population level (Popkin, 2006), and a socioeconomic transition, which refers to shifts from lower socioeconomic status to higher socioeconomic status and globalization (Misra and Khurana, 2008). Popkin & Gordon-Larsen (2004) indicate that the nutrition transition and its relationship to increasing obesity rates is accompanied by a country's economic, demographic and epidemiological changes. The epidemiological changes are reflected in the population's health status, which demonstrate an increasing prevalence of non-communicable diseases (NCDs), such as diabetes, coronary heart disease and other nutrition-related illnesses (Du et al. , 2004). Demographic changes are evident in rural to urban shifts such that issues with adequate caloric and nutrient intake remain in many LMICs, which are also experiencing a nutrition transition that has led to an increase in overweight and obesity in both rural and urban populations. The nutrition transition and its effect on redefining dietary trends and consumption is increasingly fostering an environment with diets based on higher intakes of high calorie foods and edible oils (Popkin, 2006). Factors influencing this shift include technological advancements in food processes, marketing and distribution (Dearth-Wesley et al., 2011). Economic changes are reflected in higher incomes and urbanization. Dietary changes have been influenced by free market trade policies and higher incomes, which have made foods with higher animal fat, sugar and oils more affordable and accessible to a larger number of people (Du et al., 2004). (Popkin & Gordon-Larsen, 2004)) showed that all measures of caloric sweetener increase significantly as gross national product (GNP)- however currently referred to as gross national income- (GNI) per capita of the country and urbanization increase. Therefore, the interaction between income growth and urbanization is important for understanding the increasing rates of obesity in developing countries.

The purpose of this study is to explore the effect of Gross National Income (GNI) - which is the total domestic and foreign output claimed by residents of a country, on obesity rates in Sub Saharan African countries. Given that the scholarship examining the twin burdens of undernutrition and obesity finds socioeconomic patterning of nutritional levels (Kulkarni, Kulkarni, & Gaiha, 2017), I posed this research question; **To what extent does GNI affect the likelihood that a country in Sub-Saharan Africa will experience high obesity rates.**

Hypothesis: Countries with a high GNI will have high obesity rates.

LITERATURE REVIEW

Nutrition Transition

The shifts in dietary patterns have been associated with the rise of obesity and Non-Communicable Diseases (NCDs) such as diabetes and heart disease in developing countries (Du et al. 2004). The concept nutritional transition has been used to describe the major shift in diet and activity patterns at the population level, specifically shifts in dietary patterns and trends to more Western pattern diets with high intakes of animal-source food, partially hydrogenated fats, and sugar, and lower intakes of fiber and cereal (Popkin 1993, 2006). Caballero (2007) reports that globally the major contributors in calorie intake have been refined sugars and vegetable oils due to the increase in their availability and affordability. Free market practices and economies of scale have promoted certain foods, such as vegetable oils and other fats as well as animal sourced foods in the market, with relatively low and competitively advantageous prices, thus extending their affordability to people in various income brackets (Du et al., 2004). The increase in food options materialized in fast food outlets and street food in low income settings; this has fostered an obesogenic environment, shifted food trends, and increased consumption of processed, energy dense foods (Kimani-Murage et al., 2015; Steyn & Mchiza, 2014).

Studies in China have shown a shift away from traditional Chinese foods of low energy-density high-fiber foods toward more meat, oil and other higher-energy-density foods. Popkin, Lu, and Zhai (2002) found that by the late 1990's, a higher fat diet was consumed by over a third of Chinese adults aged 20-45, and over 60% of adults living in urban areas. Changing consumption trends in China are indicative of the nutrition transition present in other regions and explain the increasing obesity rates in China. Another case study found that more than one-quarter of the dietary energy available per capita was assigned to sugar, fat or alcohol in Mexico and South Africa (FAO, 2006). Kimani-Murage et al. (2015) report that among the Urban Poor Settings in Nairobi, Kenya, rapid changes in nutritional status marked by the nutrition transition also include epidemiological changes in health statuses as an increasing prevalence of NCDs such as diabetes, coronary heart disease and other nutrition related illnesses. Many developing countries undergoing a nutrition transition have experienced an increase in overweight and obesity in both rural and urban populations. MacIntyre, Kruger, Venter, & Vorster (2002) in the THUSA study in South Africa demonstrated a shift from the traditional high carbohydrate low fat diet to a diet associated with non-communicable diseases. They found that in both urban and rural settings maize meal and white sugar were consumed by almost, if not all, of the respondents. However, fruit and vegetable consumption were low, only showing an increase in the upper class urban group.

As countries undergo modernization, urbanization, and economic growth, Western diet patterns have been increasingly adopted and this presents as a risk for increasing obesity rates. The implications of this phenomena are significant when we consider that many Sub-Saharan African countries are beginning to experience obesity rates that are greater than undernutrition rates at the population level (Mendez, Monteiro, and Popkin, 2005). A growing body of research has shown that higher incomes, and faster rates of urbanization, which are markers of globalization, are creating lifestyle changes that contribute to a shift in food availability, access and preference. Popkin indicates that the nutrition transition and its relationship to increasing obesity rates is accompanied by demographic and economic changes. Therefore, it imperative that we consider the effects of socioeconomic development, urbanization and acculturation on understanding increasing obesity rates (Popkin, 2006).

Malnutrition in Developing Countries

Across the Sub-Saharan African region, food insecurity remains a challenge for population health and human development improvements, because undernutrition is still salient, particularly in vulnerable populations such as the urban poor (Bloem & de Pee, 2017). Countries in Sub Saharan Africa have the highest prevalence of undernutrition in the world (FAO, IFAD, UNICEF, WFP & WHO, 2017). Kimani-Murage et al. (2015) present a study on malnutrition in urban poor settings in Nairobi, Kenya; they found that the occurrence of maternal and child undernutrition is particularly high in East Africa, with a prevalence above 10% in mothers, and almost 50% of young children experiencing stunted growth. However, other studies show that there are a growing number of sub Saharan African countries facing both obesity and undernutrition (Mendez, Monteiro, and Popkin 2005) (FAO, IFAD, UNICEF, WFP, & WHO, 2017). Vorster, Kruger, & Margetts (2011) indicate that non- communicable, nutrition-related diseases such as diabetes are prevalent in Sub-Saharan Africa in low income populations that may still face under-nutrition. The occurrence of multimorbidity, defined as the coexistence of multiple illnesses, has been looked at in South Africa. Researchers found that 465 respondents from a sample of 11,638 adults had two or more chronic diseases, with diabetes ranking as the highest contributor to multimorbidity (Alaba & Chola, 2013). While this translates to 4% of the sample population, multimorbidity puts a strain on health care systems and health care resources that are already burdened communicable diseases such as HIV/AIDS.

Much of the literature cites the coexistence of obesity and undernutrition in the framework of a greater obesity to underweight prevalence. Whereby they provide a descriptive review on the general increase in obesity in most developing countries. A study by Mendez, Monteiro, & Popkin (2005) measures the double burden by using BMI. They calculated the overall prevalence of underweight (BMI < 18.5) and overweight (BMI ≥ 25) for women their sample of countries. They also calculated the ratio of overweight to underweight for each country to illustrate the relative magnitude of these two manifestations of malnutrition. Prevalence data were estimated for both urban and rural areas, and the urban and rural classifications were defined by using official criteria for each country (Mendez, Monteiro, & Popkin, 2005).

The THUSA (Transition and Health during Urbanization of South-Africans) study by Kruger, Venter, & Vorster, (2001) examined the relationship between anthropometric measures such as weight circumference (WC), BMI and skinfold measurements, and risk factors for NCDs in South African black women. Out of 1040 women, 28.6% were obese and the measures such as WC were associated with the risk for NCD such as high cholesterol (Kruger, Venter, & Vorster, 2001). Mendez, Monteiro, and Popkin (2005) conducted a comprehensive study of 36 developing countries, and found that the prevalence of overweight among urban women ranged from 10.3-69.9%. Kimani-Murage et al. (2015) found that malnutrition exists as undernutrition and obesity amongst the urban poor in Nairobi, Kenya. After examining 3,335 children and their mothers, the analysis showed a high prevalence of undernutrition in children in their early formative years. - 45.4% were stunted, 10.9% underweight, 2.4% wasted, whereas 8.8% overweight/obese. The various forms of malnutrition coexisting indicate that undernutrition and obesity may stem from the causes.

Developmental indicators

Using the theoretical framework of the social determinants of health we can examine the interplay between the individual choice, interpersonal networks, community and larger societal factors to understand the nutrition transition and rates of obesity in developing countries. Popkin

(1994, 2006) indicated that the nutrition transition and its relationship to increasing rates of obesity is accompanied by a country’s economic and demographic changes. Nutritional outcomes are therefore based off a series of determinants such as food security, maternal health, access to clean water, sanitation measures, food environment, lifestyle, culture and economics. Nutrition is a powerful indicator for health; however, this and other indicators are shaped by the amount of money, power, and resources that people have, all of which are influenced by policy choices and access (Alaba and Chola, 2013). Socioeconomic status measured as income and education influence food quality, quantity and consumption at multiple levels throughout a person's life which can put them at a higher risk for diseases such as heart disease. Alaba and Chola (2013) found that household income was strongly associated with multimorbidity, suggesting that persons from high income households were more likely to have two or more chronic diseases such as diabetes, high blood pressure and asthma. The socioecological model expands on factors such as income on amplifying a person’s risk for disease. The model demonstrates a complex interplay of behavioral, genetic, environmental, and social factors such that social and economic inequalities can hinder any incentive to improve health and may contribute to the onset of disease and illness related to obesity and undernutrition.

The coexistence of obesity and undernutrition exposes disparities prevalent in developing countries as they undergo structural changes in their economies and rising urbanization. Kelly, Yang, Chen, Reynolds, & He (2008) found a strong correlation between GNI and overweight and obesity prevalence in their analysis on the prevalence of overweight and obesity in 106 countries in 2005. The study conducted by Du et al. (2004) examines the impact of rapid income growth on diet behavior across different socioeconomic groups in China. In the wake of globalization and economic growth China has increased disposable income and elevated the national poverty rate from 80% in 1978 to less than 12% in 1998 (Du et al., 2004). They found changes in the Chinese diet from a traditional diet of rice and fiber to a diet in higher caloric foods, reflecting increases in income experienced between 1989- 1997 (Du et al., 2004). Popkin and Gordon-Larsen found that obesity starts to fuel health inequities in developing countries when the GNP (currently known as GNI) reaches a value of about US$2500 per capita (Popkin & Gordon-Larsen, 2004).

As an indicator of socioeconomic growth, urbanization in developing countries has been occurring over time. Countries in Africa and Asia have the fastest growing cities, where studies have also shown that malnutrition remains salient in these settings (Bloem & de Pee, 2017). Urbanization has been associated with changes in in diets now that people have access to processed food, animal products, and edible oils (Bloem & de Pee, 2017). Research by Mendez, Du and Popkin (2004) on dietary transition in China used a scale of "urbanicity", which considered access to health care, housing, communications and transport in urban and rural areas - and they found increasing intakes of animal source foods and edible oils in low “urbanicity” urban areas and more urbanized rural areas. Another study shows that the dual burden of obesity and undernutrition occurs in more urban areas in Brazil, China, Indonesia, United States and Vietnam (Doak, Adair, Bentley, Monteiro, & Popkin, 2005). Similarly, Mendez, Monteiro, and Popkin (2005) found that a high prevalence of overweight exists in developing countries with an urbanization threshold of 32%. Pawloski et al. (2012) demonstrated the coexistence of obesity and undernutrition in mothers and children using a geographical analysis in Kenya. In their study, they demonstrate the coexistence of overweight/obese mothers and stunted children using geographic location. There are variations of overweight prevalence in urban and rural settings based of GNI indices and urbanization. As urbanization and GNI increase, the difference in overweight /obesity prevalence in urban and rural decreases (Mendez, Monteiro, and Popkin 2005). The THUSA in South Africa demonstrated the link between urbanization and diet changes. MacIntyre, Kruger, Venter, & Vorster (2002) found that both total fat intake and the proportion of energy provided by fat increased with urbanization.

However, the burden of malnutrition is more evident in low income populations in developing countries (Bloem & de Pee, 2017). Du et al.'s (2004) findings show evidence to support the idea that the income effects adversely affect the poor. In China, the shift away from traditional foods, which were based off rice and wheat, in favor of higher intakes of edible oils and animal products is prevalent in low income groups. Furthermore, stir-fry as a cultural food item uses excessive amounts of oil, which has contributed to increased fat consumption. The poor are more vulnerable to the effects of prices changes for necessities such as food. Du et al. (2004) found that food demand was more price- and income-elastic, thus limiting the types of food those from a lower socioeconomic bracket could afford. However, lower food prices create an affordable market for more fat and high energy foods, as predictive of a nutrition transition. Animal products and edible oils have been shown to serve as indicators of cultural and socioeconomic capital suggesting that their consumption implies that an individual has the financial liberty to diversify and improve diet (Du et al., 2004). Consumption patterns show that it is the poor who bear the burden of the nutrition transition supporting studies that show higher BMIs in low socioeconomic groups. Social inequalities translate to health inequalities, such that the risk of becoming obese differs across different demographics and those who cannot afford more healthier and expensive food will be disadvantaged.

Another indicator of urbanization and socio-economic development is reflected in water, sanitation, and hygiene (WASH) improvements. Poor urban populations live in slums with poor water and sanitation facilities that indirectly contribute to poor nutrition because they cause illnesses such as diarrhea and inflammation, which reduce nutrient uptake and utilization (Dangour et. al., 2013). Poor water and sanitation affects not only households but also food safety within the food system that also rely on improved WASH amenities (Bloem & de Pee, 2017).

As Sub-Saharan African countries undergo urbanization, economic development, and increased incomes, the prevalence of obesity needs to be studied. Holmes et al. (2010) suggest that studies about the West's obesity epidemic cannot be applied to understand increasing rates of obesity in Africa. Therefore, this study aims to provide an understanding on the effect of socioeconomic drivers such as GNI on obesity rates, which will be crucial for shaping health policy and addressing population-wide health issues in countries undergoing development in Sub-Saharan Africa.

METHODS:

A. *Data set*

The data set for this study was collected from large online international databases, and then cleaned and re coded in excel with the help Jiebei Luo. The data on obesity and undernourishment were extracted from the World Health Organization (WHO), and the Food and Agricultural Organization of the United Nations (FAO).

a) The data on obesity was extracted from the WHO Global Health data repository - Body Mass Index. The WHO Global Database on Body Mass Index (BMI) was developed as part of WHO's commitment to implementing the recommendations of the WHO Expert Consultation on Obesity: Preventing and Managing the Global Epidemic (Geneva, 3-5 June 1997). The data are reported in a standardized manner using WHO recommended BMI cut-off points to produce internationally comparable results.

b) The data on undernutrition was extracted from the FAO Suite of Food Security Indicators as - Prevalence of undernourishment (%) (3-year average). The FAO makes its estimates on the prevalence of undernourishment from food balance sheets prepared by the FAO (that show trends on domestic food supply, food utilization, and food supply available for human consumption), National Household Surveys, and then coefficients on the distribution of food consumption within the population (FAO).

The data used to assess the socioeconomic explanatory factors were extracted from large databases from the World Bank and the World Health Organization.

c) **Gross National Income (GNI)** data was sourced from the World Bank national accounts data, and OECD National Accounts data files as: GNI per capita, Atlas method (current US$).

d) **Urban Population** Density data was sourced from The United Nations Population Division's World Urbanization Prospects under the World Bank Development Indicators.

e) **Current health expenditure (CHE) per capita** in US$ data was sourced from the World Health Organization under the Global Health Expenditure Database: Aggregate Indicators.

f) **Basic and safely managed sanitation services** data was extracted from the World Health Organization under the Global Health Repository to obtain the variable: Urban Population using at least basic sanitation services (%).

The unit of analysis for this study is countries. The true population is the total number of Sub-Saharan African countries (n=48). My sample consists of the 39 Sub- Saharan African countries that had complete data on the variables of interest. I decided to exclude eight countries from this study, because there was no available data. The FAO did not have data on the undernourishment prevalence variable in the following countries: Burundi, Comoros, Democratic Republic of Congo, Equatorial Guinea, Eritrea, Seychelles, and Somalia. The WHO reports that there was no available data for obesity rates for Sudan and South Sudan. Cases with no complete country level data were excluded from the analysis.

My sample of Sub-Saharan African countries includes: Angola, Benin, Botswana. Burkina Faso, Cameroon, Cape Verde, Central African Republic, Chad, Congo Rep. Cote d'Ivoire, Ethiopia, Gabon, Gambia, Ghana, Guinea, Guinea-Bissau, Kenya, Lesotho, Liberia, Madagascar, Malawi, Mali, Mauritania, Mauritius, Mozambique, Namibia, Niger, Nigeria, Rwanda, Sao Tome and Principe, Senegal, Sierra Leone, South Africa, Swaziland, Tanzania, Togo, Uganda, Zambia, and Zimbabwe.

B. Variables

1. Dependent variable**: High Obesity**

For this study the Dependent Variable is a High Obesity (HO) measure. I have operationalized High obesity as measure of prevalence rates of undernourished and obesity within in each country. The prevalence of overweight and obesity is defined based on an anthropometric measure of body-mass index (BMI) calculated by mass as measured in kilograms divided by the square of height measured in meters (kg/m^2) for adults which refers to individuals above the age of 18 years. This follows health standard conventions where obesity is defined by a BMI $\geq$ 30 in the adult population (Ng et al., 2014).

I have grouped the 39 countries into categories of a high or low obesity. Given that every country will have some degree of undernourishment and obesity, I have decided to create four groups of malnutrition possibilities. A country can have one of the following combinations: High obesity and high undernourishment **(HH**), high obesity and low undernourishment (**HL**), low obesity and low undernourishment **(LL**), and low obesity and high undernourishment (**LH**).

OBESITY: For this study I classify countries with a **prevalence rate of 7.5%** or higher as having high obesity (coded as 1). If a country has an obesity rate lower than 7.5% , they fail to meet our parameter of high obesity and are classified as having low obesity (coded as 0). (see figure 1 for explanation)

UNDERNOURISHED: For this study I classify countries with a **prevalence rate of 25%** or higher satisfy as having high undernourishment. If a country has an undernourishment rate lower than 25%, they fail to meet our parameter of high undernourishment and are classified as having low undernourishment (see figure 2 for explanation).

The sample group initially included all 48 Sub-Saharan African countries, therefore I based my cut off points of the descriptive statistics. I chose 7.5% as the high obesity cut off and 25% for the undernourishment threshold based of my median value for obesity and global rate of undernutrition.

2. Independent variable

a) Gross National Income (GNI) per capita calculates a country’s income, including both domestic and international income for a given population. This economic measure is given in U.S dollars but first calculated in national currency. The conversion to U.S. dollars is done with official exchange rates for comparisons across economies, although an alternative rate is used when the official exchange rate is judged to diverge by an exceptionally large margin from the rate applied in international transactions by the World Bank Atlas method (World Bank 2014).

For this study I classify countries with a **GNI per Capita 900US$** or higher as high GNI (coded as 1). If a country has a **GNI per capita less than 900US$,** they are classified as having a low GNI (coded as 0).

3. Control Variables

Urban Population Density refers to people living in urban areas as defined by national statistical offices. This variable gives us an indication of urbanization, globalization, and settlement into cities across Sub-Saharan Africa.

Current health expenditure (CHE) per capita in US$ reflects overall health expenditures by national governments relative to a country's population size.

Basic and safely managed sanitation services as the variable: Urban population using at least basic sanitation services (%), gives us an understanding of access to clean water and sanitation measures. Sanitation is a measure for progress against poverty, disease and mortality.

For this study I have kept the year (time frame) constant. I collected the most recent data from the year 2016 for all the variables, except for current health expenditure and urban population using basic sanitation services for which the most recent available data was from 2015. Descriptive statistics (means, medians, and standard deviations) were calculated for continuous variables. I created a dichotomous variable coded 1 for countries with the risk of High Obesity, High Undernourished (HH) AND High Obesity, Low Undernourishment (HL), and 0 for countries with the DB risk of Low Obesity, High Undernourishment (LH) AND Low Obesity, Low Undernourishment (LL) thus operationalizing and recoding the high obesity into a dummy variable. A correlation matrix showing the relationships between High Obesity, GNI per capita, Urban Population, Health Expenditure and Urban Sanitation were tested using the bivariate correlations procedure. Logistic regressions were then conducted. In our logistic regression with multiple independent variables, our coefficient tells us how much the High Obesity Variable is expected to increase when our independent variable increases by one, holding all the other independent variables constant. All statistical analyses were done in Excel and SPSS Software.

FINDINGS:

UNIVARIATE ANALYSIS

Dependent Variable: Obesity

Figure 1 illustrates the distribution of obesity prevalence rates in 2016 in 39 countries in Sub-Saharan Africa.

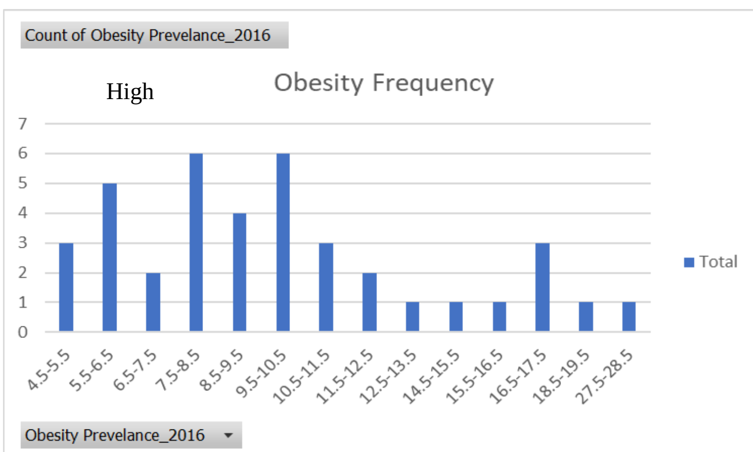


Figure 1

Figure 1 shows the obesity variable has a more normal distribution with prevalence rates ranging from a low of 4.5% to a high of 28.3%. For this study, I treat all cases above 7.5% as having high obesity rates given this distribution of the obesity rates for the 39 countries. This is because a rate of 7.5% is the first peak in the distribution that is closest to the median of 8.5%

from the original sample group of 48 Sub- Saharan Africa countries. It is also about halfway between 4.5% and 28%.

Figure 2 illustrates the distribution of undernourishment prevalence rates in 2016 in 39 countries in Sub Saharan Africa

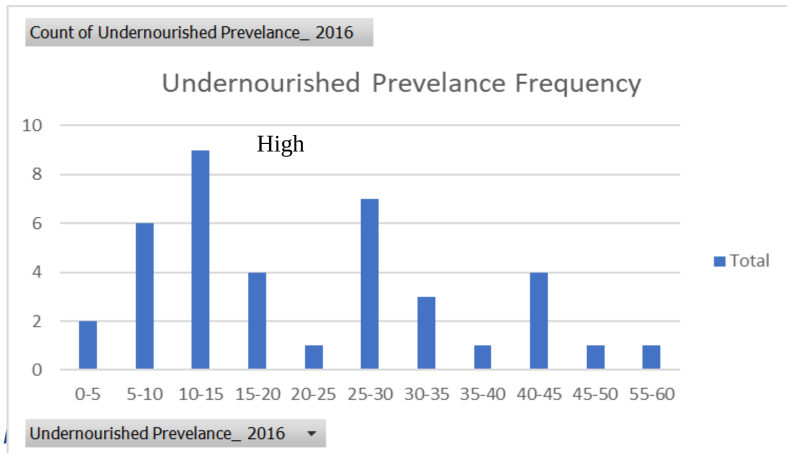


Figure 2 shows that for the undernourished variable, there was a significantly larger spread than for obesity. It ranges from a low of 4% to a high of 58.6%. Figure 2 shows two peaks at 10-15% and another 25-30%. For this study I treat all cases above 25% as high undernourishment prevalence in the 39 countries because the World Bank mean for undernourishment in Sub Saharan Africa is 23%. It is also about halfway between 4% and 59% and my mean for my sample of 39 countries in Table 1 is 22 %.

Table1. Means, Medians, and Standard Deviation for Variables (n = 39)

Variable	Mean	Median	S.D.
Obesity Prevalence (%)	10.22	8.90	4.691
High Obesity Dummy Variable	0.74	1.00	0.442
Undernourishment Prevalence (%)	21.92	19.20	13.957
GNI per Capita	1826.92	900.00	2158.240
GNI per Capita Dummy Variable	0.51	1.00	0.506
Urban Population	42.72	40.68	16.334
Current Health Expenditure per Capita in US$	106.66	58.79	126.996
Urban Population using Basic Sanitation (%)	45.28	46.00	17.721

Table 1 shows that for these 39 Sub-Saharan African countries the average rate of obesity is 10.22%. This mean indicates that on the average, 1 in every 10 people in these countries is obese. The High Obesity dummy variable indicates that of the 39 countries, 29 countries have an obesity rate higher than 7.5% which is 74% of the countries.

The table indicates that for all countries, the average undernourishment rate is 21.9%. About 1 in every 5 people experience extreme hunger and do not receive enough food and/or vitamins necessary for sustaining good health. The standard deviation for obesity is 4.691 and for undernutrition 13.957, which tells us that countries vary more on undernourishment rates than obesity rates.

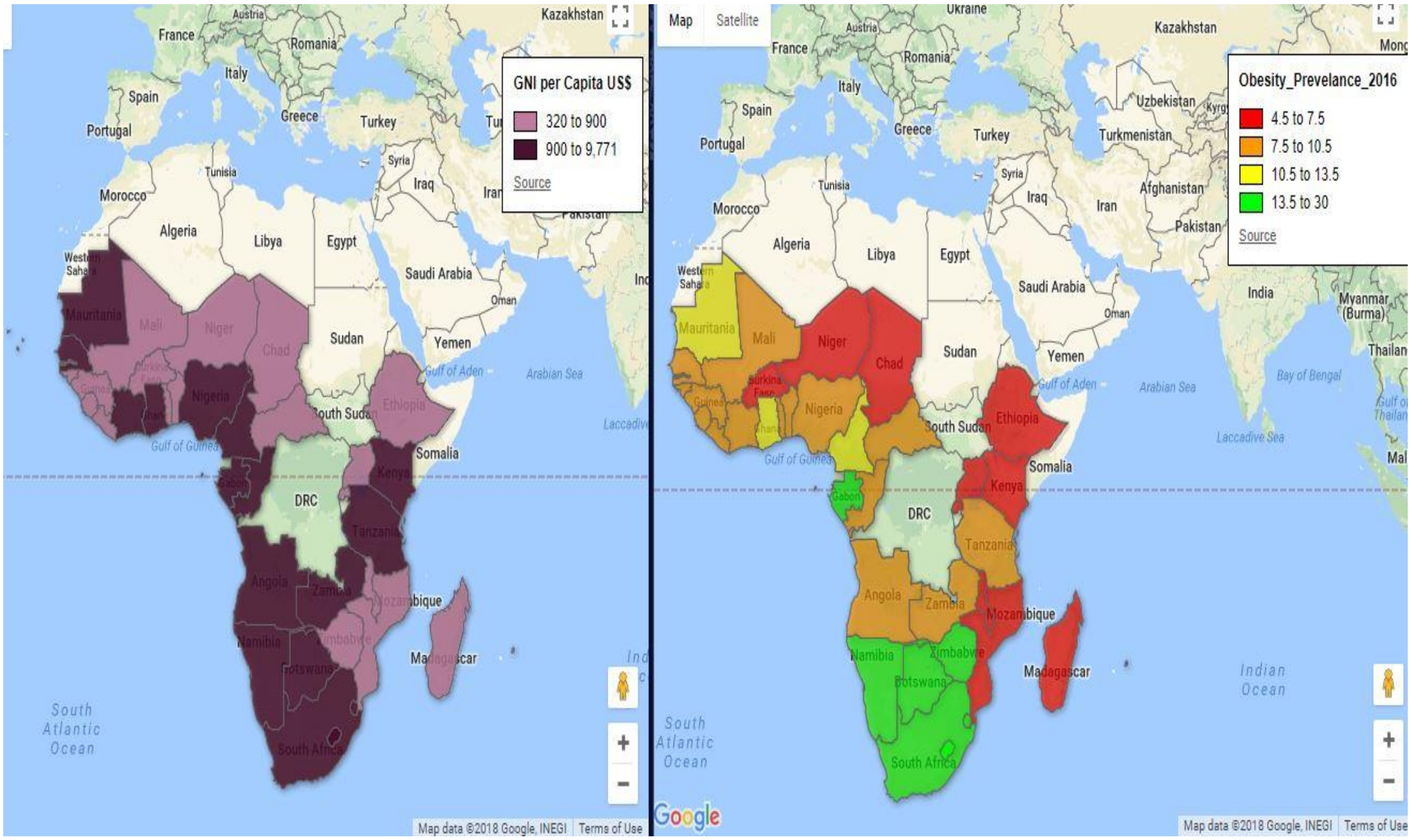
In 2016, for these 39 countries, the average Gross National Income (GNI) per capita in these Sub Saharan African countries was US$1826.92. The GNI dummy variable was coded 1 for countries with a GNI over the 900US$ (the median), and 0 for countries with a GNI less the 900US$. The mean for the GNI dummy variable is 0.51 which indicates that 51% of the 39 countries have a GNI over 900US$.

Furthermore, US$106.66 was the average amount spent on health care for each person in these 39 countries. On average 42.72% of the population in these Sub-Saharan African live in urban areas. On average, 45.28% of the urban populations in these countries have access to basic sanitation means.

Table 2: Cross tabulation of High Obesity Prevalence and High Undernourishment Prevalence (n=39)

	High Undernourishment	Low Undernourishment	Total	High Obesity Dummy Variable Coded
High Obesity	10	19	29	1
Low Obesity	7	3	10	0
Total	17	22	39	

According to Table 2, of the 39 countries 10 experience the coexistence of high obesity and high undernourishment (HH), 19 experience the coexistence of high obesity and low undernourished (HL); 3 experience the coexistence of low obesity and low undernourishment (LL), and 7 experience the coexistence of low obesity and high undernourished (LH). The dependent variable which is the high obesity dummy variable, codes all the high obesity countries as one, combining both the HH(n=10) and HL (n=19) cases. These 29 countries with high obesity are: Angola, Benin, Botswana, Cameroon, Cape Verde, Central African Republic, Republic of Congo, Côte d'Ivoire, Gabon, The Gambia, Ghana, Guinea, Guinea-Bissau, Lesotho, Liberia, Mali, Mauritania, Mauritius, Namibia, Nigeria, Sao Tome and Principe, Senegal, Sierra Leone, South Africa, Swaziland, Tanzania, Togo, Zambia, and Zimbabwe. Of the 29 high obesity countries, the 10 experiencing the coexistence of high obesity and high undernourishment are: Botswana, Central African Republic, Congo Rep. Guinea-Bissau, Liberia, Namibia, Sierra Leone, Tanzania, Zambia, and Zimbabwe. The countries coded as zero on the High Obesity Dummy Variable are: Burkina Faso, Chad, Ethiopia, Kenya, Madagascar, Malawi, Mozambique, Niger, Rwanda, and Uganda. These are countries that have obesity rates lower than 7.5%. A visual representation of the obesity prevalence rates, and the GNI dummy variable is shown in Map 1.



The map shows the variables GNI per Capita and obesity for the 39 Sub-Saharan African countries in my sample. The map on the left shows the independent variable where light purple indicates National income below 900US$ and dark purple shows a national income above 900U$. The map on the right shows our dependent variable of obesity rates. Orange, yellow and green countries with a rate of 7.5% or higher. Comparing the two maps we see a pattern of obesity rates above 7.5% and GNI greater or equal to 900US$ where dark purple corresponds with orange, yellow and green countries. There are 21 of the 39 countries have a GNI greater or equal to 900US$, and are high obesity countries. One example is of South Africa which has current GNI of US$5480 and an obesity prevalence of 28%.

BIVARIATE ANALYSIS

Table 3. Correlation Matrix between High Obesity and Socioeconomic Variables (two-tailed test, n = 39)

Variable	GNI per Capita Dummy	Urban Population	Urban Population using Basic Sanitation (%)	Current Health Expenditure per Capita in US$
High Obesity Dummy	0.485**	0.648**	0.261	0.324*
GNI per Capita Dummy		0.484**	0.444*	0.502**
Urban Population			0.171	0.317*
Urban Population using Basic Sanitation (%)				0.616**

* p < 0.05 ; ** p < 0.01

Table 3 provides the Pearson correlation coefficients between the main variable of interest- high obesity (a dummy variable that has a value of 1 for countries that have an obesity prevalence above 7.5% and a value of 0 for countries with an obesity prevalence rate less than 7.5%), and the independent variable - GNI and the control variables- urban population, urban sanitation, and health expenditure. The matrix illustrates the relationships between all of the variables of interest. The correlation between high obesity and GNI per Capita (r= 0.485; p<.01) indicates a moderate, positive relationship. This suggests that countries with GNI of 900US$ or higher are more likely to have high obesity rates. High obesity has a strong, positive relationship to Urban Population (r = 0.648; p<.01), which indicates that the greater the urban population, the more likely the country has high obesity rates. The correlation between high obesity and urban population using basic sanitation (r=0.261) is not statistically significant therefore urban sanitation has no relationship to obesity. The correlation between high obesity and health expenditure ($r = 0.324$; $p<.05$) indicates a weak, positive relationship. This suggests that the higher the health expenditure the more likely the country has high obesity rates. However, the causal deduction of this relationship is difficult to discern as it could be argued that increased health expenditures results from the NCDs associated with higher obesity rates.

GNI has a moderate positive relationship to Urban Population ($r=0.484$; $p<.01$), which indicates that countries with GNI above 900US$ are more likely to have a higher urban population. GNI has a moderate, positive relationship to Urban Population Using Basic Sanitation ($r=0.444$; $p<.01$). This suggests that countries with GNI above 900US$ are more likely to have a higher urban population using basic sanitation. Table 3 also demonstrates a moderate, positive relationship between GNI and Health expenditure ($r=0.502$; $p<.01$), which means that countries with higher average incomes are more likely to have higher health expenditures.

Table 3 shows a weak, positive relationship between Urban Population and Health Expenditure and ($r=0.317$; $p<.05$). Similarly, the correlation between Urban Population and Urban Population Using Basic Sanitation ($r=0.171$) not statistically significant. Lastly, health expenditure has a strong, positive relationship to Urban Population Using Basic Sanitation ($r=0.616$; $p<.01$). This suggests that countries with higher expenditures are more likely to have higher rates of urban population using basic sanitation.

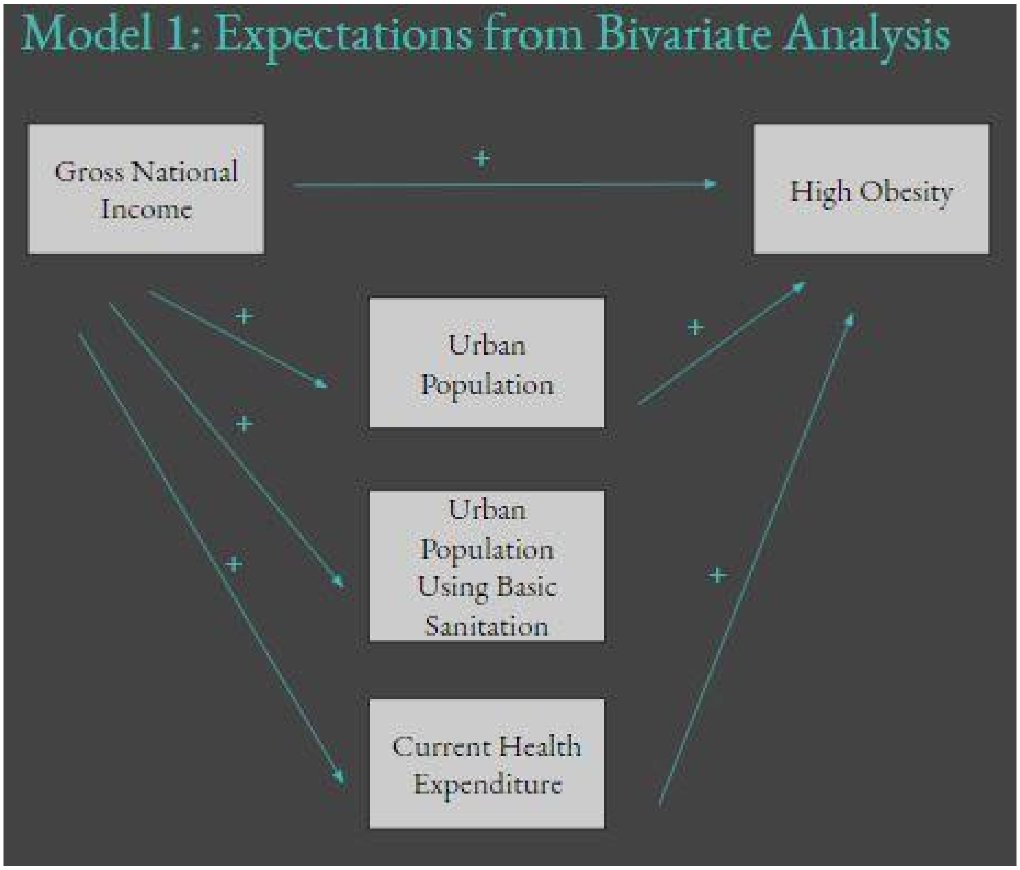


Figure 3: Model showing expectations derived from the bivariate relationship in Table 3

Figure 3 shows how the bivariate relationships inform my expectations on high obesity rates because GNI is statistically significant with all three of the other possible predictors. The positive relationship between the urban population and health expenditure on obesity led me to believe that this relationship is strengthened when a country has a GNI per Capita above 900US$. The logistic regression models will show the effect of GNI per Capita mediated by the three other predictors.

MULTIVARIATE ANALYSIS

Table 4: Logistic Regression of High Obesity on all predictors with GNI per Capita Dummy (Urban population, Urban Population using basic sanitation, and Current Health Expenditure) (n=39)

Variable	Model 1	Model 2	Model 3	Model 4
	Exp(B)	Exp(B)	Exp(B)	Exp(B)
GNI per Capita Dummy	17.100*	106.746^{+}	14.234*	5.198
Urban Population		1.494*		
Urban Population using Basic Sanitation			1.014	
Current Health Expenditure per Capita in US$				1.029
Cox & Snell R^2	0.230	0.558	0.233	0.285

$^{+}p< 0.1$; * $p < 0.05$; ** $p < 0.01$

Table 4 provides four logistic regression models that show the effect of GNI per Capita on the probability of high obesity rates in these 39 countries, when we control for other variables, using the Cox & Snell R^2 to assess the effectiveness of the model. The dependent variable- high obesity is a dummy variable that is coded 1 for countries that have an obesity prevalence above 7.5% and coded 0 for countries with an obesity prevalence rate less than 7.5%. GNI per Capita is also a dummy variable coded 1 for countries with a GNI > 900US$, and coded 0 for countries with a GNI < 900US$.

Model 1 predicts that the gross effect of GNI per Capita when a country goes from below 900US$ to above 900US$ is associated with a 10% ($p<.05$) increase on the likelihood that a country will have high obesity rates. Model 2 tells us that holding constant GNI (is greater than or less than 900US$) for the 39 countries, the higher the Urban Population, the higher the probability that they are a high obesity country. The 106.74 Exp B indicates that an increase in GNI per Capita by 74% is the relative risk of being a high obesity country. If two countries have a GNI above 900US$, this model indicates that the country with a higher Urban Population will be the one more likely to have high obesity. Model 3 tells us that holding constant GNI (is greater than or less than 900US$) for the 39 countries, the higher the Urban Population Using Basic Sanitation, the higher the probability that they are a high obesity country. The 14.237 Exp B indicates that an increase in GNI per Capita by 23%, is the relative risk of being a high obesity country. If two countries have a GNI above 900US$, this model indicates that the country with a higher Urban Population using Basic Sanitation will be the one more likely to have high obesity. Model 4 tells us that holding constant GNI (as greater than or less than 900US$) for the 39 countries, the higher Current Health Expenditure, does not indicate a higher the probability that they are a High Obesity country. The 5.198 Exp B is not statistically significant which indicates that the GNI per Capita relationship to high obesity does not hold up for these 39 countries when controlled for Health Expenditure. The analysis shows that GNI increases the odds that a country will have high obesity for all but one model 4.

DISCUSSION:

The analysis indicates that income and urbanization are significant in increasing the odds that a country will have high rates of obesity. The correlation matrix showed that GNI per Capita, Urban Population, Urban Population using Basic Sanitation, but not Health Expenditure have statistically significant correlations with high obesity. This informed my expectations for the multiple regressions because the matrix also showed that GNI has a statistically significant correlation with all three of the other possible predictors. I expected the logistic regression to show the effect of GNI per Capita mediated by all three of the other possible predictors. The strongest of these correlations was Urban Population. GNI per Capita as a dummy variable categorized countries as either high GNI (above 90US$) or low GNI (less than 900US$). The first model indicated that the relationship between GNI per Capita and high obesity holds. When I added the other possible predictors, I observed that the relationship that income has when controlled for Urban Population and Urban Population using Basic Sanitation, also too holds. Furthermore, if two countries both have income at 900US$, the one with the higher Urban Population will be more likely to have an obesity rate above 7.5%. Therefore, the hypothesis that countries with a high GNI will have high obesity rates holds. The findings suggest that income serves as both an input and outcome of urbanization, and this affects the probability of a country having a high obesity rate.

Popkin & Gordon-Larsen's study found that obesity starts to fuel health inequities in developing countries such as South Africa, when the GNP (currently known as GNI) reaches a value of about US$2500 per capita (Popkin & Gordon-Larsen, 2004). Their study supports these findings where this also hold this true with South Africa and its current GNI of US$5480 in 2016. I found that 21 of the 39 countries have a GNI greater or equal to 900US$. All but Kenya are high obesity countries. There are ten countries in this analysis that present an obesity rate higher than 7.5% and an undernourishment rate above 25% simultaneously. Interestingly of the 20 countries with high obesity and high GNI per Capita; Botswana, Namibia, Republic of Congo, and Zambia also have high Undernourishment. It is interesting to note that these are geographically localized in the southern and western part of Africa. Botswana, Namibia, Zambia, and Zimbabwe all border South Africa which has the highest obesity rate of 28%. In these four countries we observe the two extreme ends of malnutrition, and the paradox of the double burden of malnutrition, where obesity and undernutrition and obesity coexist at high rates.

Previous studies have found that lifestyle changes as an outcome of urban development have been linked to the global obesity pandemic (Caballero, 2007). The built environment fosters economic growth for the entire country, because as people migrate from the rural areas to the cities they become involved in the remittance economy, which refers to income sent home from family members who have migrated to the urban areas or abroad (Prentice, 2005). Studies have found that as economic development brings some characteristics of urban lifestyle to rural communities, these populations also begin to show increasing rates of obesity, particularly among women (Caballero, 2007). When holding GNI constant in model 2 showed that the more urban the country, the higher the probability that it is a country with an obesity rate of 7.5% or higher. Thus, the relationship that income has on high obesity in the 39 Sub Saharan African countries, when we control for urban population, holds. This indicates that a combination of high income and high urban population in these countries plays an important role obesity prevalence. We can assess this further by evaluating how the built environment plays an important role in fostering an obesogenic environment (Caballero, 2007). Features of urban environments that contribute to the obesity epidemic in low- and middle-income countries are increased access to high calorie food. Globalization has a role in creating markets, and influencing costs. Therefore, it is important to highlight the socioeconomic impact that arises when people have higher disposable incomes. Thus, the adverse effect of national income increases and subsequently urbanization can be observed as a risk for increasing high obesity. On average only half of the urban population in the 39 countries have basic sanitation amenities. This is important when we consider that diseases related to poor sanitation such as cholera affect an individual's ability to retain nutrients and maintain a healthy weight- thus contributing to undernourishment rates.

The effect of Urban Population on obesity is not solely dependent on income, but also on food consumption, caloric intake and expenditure, and access to food. The context of globalization on the type of food available to South Africa's neighboring countries needs to be examined further. South Africa has surpassed the stages where two extreme ends of malnutrition exist, and now demonstrates the western world diet and nutrition health concerns of obesity rates greater than undernourished rates. Changing diets and reduced physical activity are important factors contributing to this health transition of increasing rates of obesity. The nutrition transition, economic development and demographic changes, vary across the 39 Sub-Saharan countries with consequent variations in the outcomes of obesity and undernourishment rates. There are negative implications for healthcare systems in developing countries that are already burdened with communicable diseases such as HIV & AIDS and Tuberculosis.

CONCLUSIONS:

Increasing research has shown that high incomes and faster rates of urbanization as forces of macro level factors such as globalization, are creating lifestyle changes that contribute to the shift in food availability, access and preference. I set out to explore if the relationship between the independent variable, national income and the dependent variable, obesity rates in 39 Sub-Saharan African countries holds. I classified a country as high obesity if they had an obesity rate equal to or greater than 7.5%. Similarly, I classified a country with a Gross National Income (GNI) equal to or greater than 900US$ as high GNI. Thus, leading to the hypothesis "Countries with a high GNI will have high obesity rates". I included Urban Population, Urban Sanitation, Health Expenditure as control variables in the analysis, and conducted a bivariate analysis to illustrate the relationship between all the variables of interest. The matrix showed a significant correlation between countries with high obesity and high GNI, and a significant correlation between high obesity and Urban Population. This informed the expectations for the logistic regression. The four models in the logistic regression showed the effect of GNI on the probability of high obesity in the 39 when I controlled for the other variables. I concluded that the analysis shows that GNI increases the odds of being a high obesity country for all but model 4 which controlled for Health Expenditure. This suggests that the combination of high incomes and high urban population increases the likelihood that a country will have high obesity rates.

The built environment plays an important role in fostering an obesogenic environment by creating access to calorie dense food and reducing physical activity. Popkin indicates that the nutrition transition and its relationship to increasing obesity rates is reinforced by the economic and demographic changes in a country. The adverse effect of national income increases and subsequent urbanization can be observed as a risk for increasing obesity rates which people at a higher risk for NCDs. The results of this study suggest that, in the absence of policies to shift current trends, continued economic development and urbanization in developing countries will likely be accompanied by increased prevalence of obesity and strain on current health systems.

The limitation of this analysis includes missing data for all 48 Sub-Saharan African countries. Furthermore, it does not address food consumption and dietary patterns which are the direct causes of nutrition imbalances. The analysis is limited in its attempt to explain the extent to which cultural differences, food availability, and infectious diseases such as HIV/AIDS explain the differences in obesity patterns across countries with different levels of economic growth and demography.

A more detailed quantitative and qualitative analysis is needed to better understand the macro and micro level causes of obesity patterns that exist in Sub-Saharan African countries undergoing development. Therefore, future research needs to look into the relationship between caloric intake and rates of obesity in Sub-Saharan Africa. Another relationship to be explored is between gender and education on obesity rates, given that obesity rates in West Africa were found to be twice as a high in women than in men (Zeba, Delisle, Renier, Savadogo,& Baya, 2012). To better understand how nutritional status at the population level is changing as countries develop and are influenced by the processes of globalization, more data is needed on the changing food patterns and availability for both urban and rural areas, and on the tracking of nutritional status from childhood into adulthood. As development remains an economic goal, Sub-Saharan African countries cannot neglect the nutritional need of their population to ensure its people benefit from development.

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Appendix:

Table 5: Individual Logistic Regressions of High Obesity on all predictors with Urban Population (GNI per Capita Dummy, Urban Population Using Basic Sanitation, and Current Health Expenditure) (n=39)

Variable	Model 1	Model 2	Model 3	Model 4
	Exp(B)	Exp(B)	Exp(B)	Exp(B)
Urban Population	1.265**	1.494*	2.452^{+}	1.311*
GNI per Capita Dummy		106.746^{+}		
Current Health Expenditure per Capita in US$			1.139	
Urban Population using Basic Sanitation				1.077
Cox & Snell R^2	0.474	0.558	0.617	0.505

* $p < 0.05$; ** $p < 0.01$; $^{+}p < 0.1$