Blood Pressure and its Correlates in Children and Adolescents in Urban Nigeria

by

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DEDICATION

I would like to dedicate this thesis to my mother, sisters, brother, brother-in-law and nephew for their selfless and invaluable support throughout my course of study, and also to the loving memory of my father.

ACKNOWLEDGEMENTS

I am most indebted to my supervisors, Professor Aileen Clarke, Professor Margaret Thorogood, and Dr Kandala Ngianga-Bakwin for their assistance throughout my project, who in spite of their tight schedule and commitments, sacrificed time to offer constructive criticism at every stage of the project.

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DECLARATION

I hereby declare that this thesis is all my own work except where I have otherwise stated and that this thesis has not been submitted for a degree at any other University.

Ogboye, Oluwatoyin Apeke

October, 2012

ABBREVIATIONS

ANOVA	Analysis of variance
BMI	Body mass index
BP	Blood pressure
CVD	Cardiovascular disease
DBP	Diastolic blood pressure
DHS	Demographic and Health Survey
K1	First Korotkoff sound phase
K4	Fourth Korotkoff sound phase
K5	Fifth Korotkoff sound phase
MDGs	Millennium Development Goals
NCDs	Chronic non-communicable diseases
PCA	Principal components analysis
SBP	Systolic blood pressure
S.D	Standard deviation
SEC	Socio-economic characteristics
UN	United Nations
USA	United States of America
WC	Waist circumference
WHO	World Health Organisation

ABSTRACT

Background: A substantial increase in the incidence of chronic non-communicable diseases (NCDs) and a decline in communicable diseases and poverty-related diseases are occurring in developing countries (including Nigeria) as a result of an epidemiological transition. Given the burden and poor outcomes of NCDs related to hypertension or high blood pressure (BP) in adulthood, there is an urgent need for the identification of high risk individuals in early life. High BP has already been reported amongst young people worldwide, including Nigeria. High BP in childhood is predictive of high BP in adulthood. There is very little information available on the distribution of blood pressure in children and adolescents, and the factors which determine its distribution in Nigeria.

Objectives: To determine the association between: socio-economic characteristics and blood pressure, pubertal maturation status and blood pressure, and anthropometric measures of adiposity and blood pressure in children and adolescents in Nigeria; and also to determine the overall prevalence of hypertension in the population of secondary school aged children and adolescents in Nigeria.

Methods: A school-based stratified randomised cross-sectional survey of students aged 11 to 18 years was carried out in the urban area of Lagos, Nigeria. Blood pressure, body weight, height and waist measurements of the participants were obtained. A self-complete validated questionnaire was used to obtain socio-demographic information, health-related information, socio-economic characteristics (including living circumstances and parent/carer education level) and pubertal maturation status of the participants. Data analysis was carried out using descriptive statistics and multiple regression analysis.

Results: 1086 students (538 males and 548 females) participated in the study, giving a total response rate of 90.5%. The overall mean systolic and diastolic blood pressure was 105.23±12.63mmHg and 57.87±8.09mmHg, respectively. The overall prevalence of hypertension was 2.5%. Socio-economic characteristics, pubertal maturation status, body mass index and waist circumference were statistically significantly associated with systolic and diastolic blood pressure ($p<0.05$).

Conclusion: This study suggests that the epidemiological transition exists and is having measurable effects in school children in Nigeria. The findings highlight the presence of hypertension, and also the need for investigation of factors associated with blood pressure in children and adolescents so as to guide health policy, public health preventive interventions and health practice for child and adolescent hypertension. This study has long term implications for an extra burden of chronic non-communicable diseases related to hypertension in Nigeria.

CHAPTER 1: INTRODUCTION

1.0 INTRODUCTION

In this chapter, I will present the important information underpinning the basis of the present study. I will also describe the origin of my interest in the research topic, and the structure of the thesis.

1.1 INTRODUCTION

"We cannot afford to say, 'we must tackle other diseases first – HIV/AIDS, malaria, tuberculosis – then we will deal with chronic diseases'. If we wait even 10 years, we will find that the problem is even larger and more expensive to address"

– President Olusegun Obasanjo, former President of Nigeria

(World Health Organisation, 2005: ix).

Globally, disease profiles are altering dramatically (Raj and Kumar, 2010). In the new millennium, the epidemiological transition is presenting in the form of a shift toward an increase in prevalence of chronic non-communicable diseases (NCDs) (cardiovascular disease (CVD), cancer, injuries and metabolic disease such as diabetes) and a decline in communicable diseases (excluding HIV/AIDS), and poverty-related disease (maternal and perinatal conditions, and nutritional deficiencies), collectively (Tharkar and Viswanathan, 2009).

This transition has been linked to the current socio-economic development, socio-cultural transitions, rapid urbanisation, globalisation and westernisation experienced globally (Longo-Mbenza *et al*., 2007), which are taking place alongside lifestyle changes towards unhealthy diets and more sedentary lifestyles. Most notably the epidemiological transition is penetrating the developing countries; first amongst the wealthy middle-aged adults during the initial stage of transition but gradually affecting deprived populations with continuing socio-economic transitions (Suchday *et al*., 2008; Mendez *et al*., 2003; Colhoun *et al*., 1998). Nigeria, like other developing countries, is experiencing an epidemiological transition phenomenon. This study was set in Lagos State, a fast growing megacity in Nigeria, with the characteristic of a rapidly developing society, where diseases of poverty and wealth coexist (Ben-Bassey *et al*., 2007).

Until recently, in many developing countries, chronic non-communicable diseases were not considered to be public health challenges (Tang *et al*., 2007). The developing countries have found themselves having to tackle the new epidemic of non-communicable diseases (NCDs) while the scourge of communicable diseases, maternal and perinatal conditions, and nutritional deficiencies are far from disappeared (World Health Organisation, 2005). The consequences of chronic non-communicable diseases are expected to be worse in the developing countries, where health system capacity to cope with the disease condition is lax (Yach *et al*., 2004). A global action has recently been taken on the prevention and control of chronic non-communicable diseases, with primary concentration on developing countries. In late 2011, a political declaration was adopted by the United Nations General Assembly during its High-Level meeting on chronic non-communicable diseases (World Health Organisation, 2011a).

Cardiovascular disease (CVD) is the leading cause of death from chronic non-communicable diseases (NCDs), and a major contributor of the disease burden from chronic non-communicable diseases (NCDs), worldwide (World Health Organisation, 2005). The emerging epidemics of cardiovascular disease in developing countries form the core of the phenomena of epidemiological transition (Raj and Kumar, 2010), hitting these countries hard, as cardiovascular disease mortality is occurring more prematurely (under 70 years of age) (World Health Organisation, 2012; Abegunde *et al*., 2007). The increasing burden of cardiovascular disease in developing countries reflects the increasing prevalence of cardiovascular disease risk factors, and specifically hypertension (Ejike *et al*., 2008; Moura *et al*., 2004).

Hypertension is a major public health challenge for societies in epidemiological transition, and contributes to 7.5 million deaths worldwide every year (World Health Organisation, 2011a). Hypertension is a silent threat to the health of people worldwide (Tesfaye *et al*., 2009), as it is most often asymptomatic (Anand and Tandon, 1996). According to the World Health Organisation (2012), the mean blood pressure has decreased remarkably in almost all developed countries, while it has remained unchanged or increased in most developing countries. The morbidity and mortality of adult hypertension is well established, and there is now a substantial body of evidence from prospective studies indicating that blood pressure in adulthood may have its origin in childhood and adolescence – the phenomenon of “tracking” (Chen and Wang, 2008). This indicates that in order to investigate the early stage of the epidemiological transition, it may be preferable to focus on the determinants of the health of children rather than on those of adults.

Children and adolescents are an important segment of the society, as their health is paramount. It can be used to represent the general health status of a society (Ramzan *et al*., 2008). Interest in blood pressure assessment in children and adolescents has increased, since its emergence in the 1960s, with the first recommendations on blood pressure evaluation in children and adolescents in the 1970s (de Araujo *et al*., 2007). Once considered relatively rare, primary or essential hypertension in children is more common among apparently healthy children, and is the main cause of increased blood pressure levels in children, as compared to the past notion that increased blood pressure levels in children was mainly secondary hypertension (caused by a disease condition) (Sorof and Daniels, 2002). Hypertension is increasingly recognised among children and adolescents throughout the world, including Nigeria (Mijinyawa *et al*., 2008); however, the specific prevalence of child and adolescent hypertension is unknown.

Many factors that may account for population level blood pressure variations have been established (Monyeki and Kemper, 2008). According to Ejike and Ugwu (2010), the identification of attributes associated with higher blood pressure in children and adolescents (in developing countries) may be instrumental in the interruption of cardiovascular disease risk factors (such as hypertension), in order to counteract both the risk of cardiovascular disease in adulthood and the impending burden on the health systems of developing countries. In Nigeria, where the epidemiological transition is well established, little is known about the distribution of blood pressure at younger ages and its relationship to other characteristics in this society.

This study was carried out to provide epidemiological information on the association between: socio-economic characteristics (school fee level, parent education level, and household wealth index) and blood pressure, pubertal maturation status and blood pressure, and anthropometric measures of adiposity (body mass index (BMI) and waist circumference (WC)) and blood pressure in children and adolescents in Nigeria (the conceptual framework for these relationships is shown in Figure 1); and also to determine the overall prevalence of hypertension using internationally agreed guidelines, for the population of secondary school aged children. To the best of my knowledge, this study provides an original contribution to the relationship between pubertal maturation status and blood pressure in the African continent. It is expected that the findings of this study will help to guide the development of health policy and prevention strategies, and health practice that are essential to combat the cardiovascular disease epidemic in Nigeria in course of the epidemiological transition.

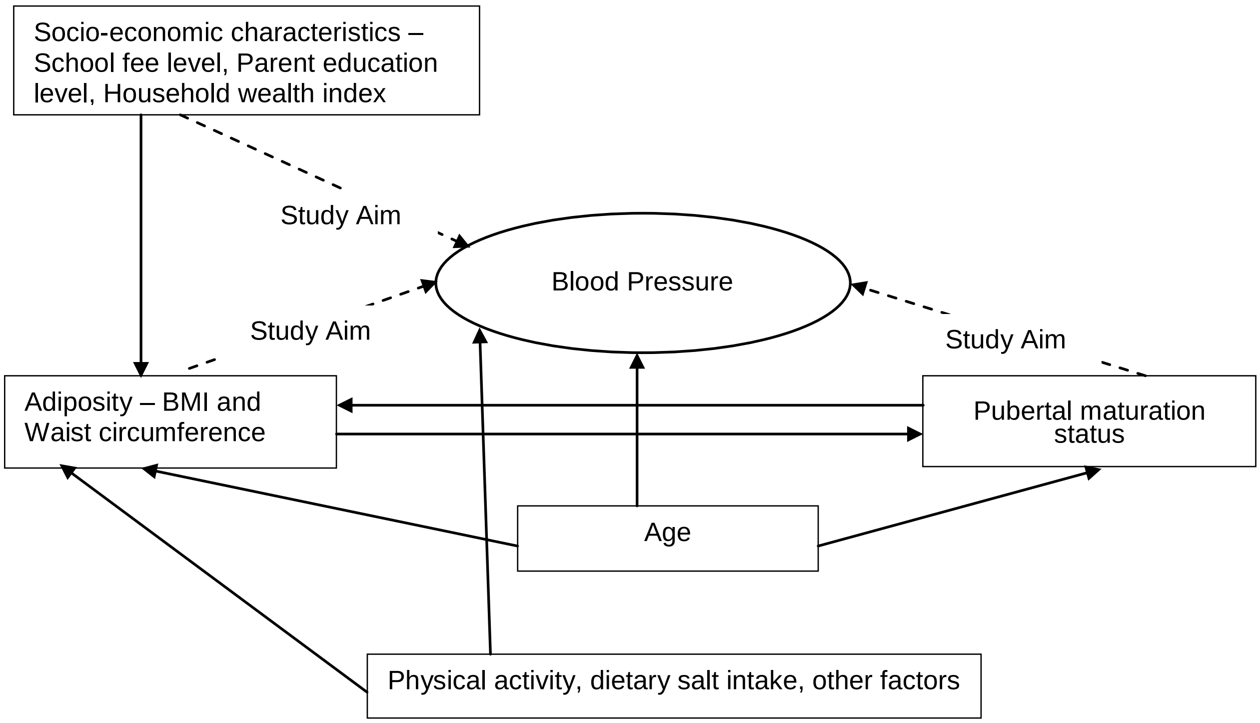


Figure 1: Conceptual Framework: Relationship between blood pressure and measures of socio-economic characteristics, anthropometric measures of adiposity or fatness and pubertal maturation status in children and adolescents.

1.2 ORIGIN OF MY INTEREST

This thesis was originally derived from my special interest in non-communicable diseases, and my motivation to contribute to the research expertise in developing countries. I am a Public Health Professional, with a background in Physiotherapy, and, experience of working in national and international health organisations, where I have had the opportunity to gain relevant knowledge on various health and developmental issues worldwide. I am from Nigeria, a developing country, where the epidemiological transition is evident in its urban cities, and I have knowledge of its medical and educational facilities and the health profile. Throughout my academic and professional life, most of my research projects have been centered on non-communicable diseases. From my experience in the hospital setting in Nigeria, I have provided treatment to many people with different medical problems, including chronic non-communicable diseases.

My interest in paediatric health started with my Masters in Public Health project where I carried out a systematic review about back-care education in children and adolescents. My interest in paediatric or child health is based on the fundamental rationale of a need for a preventive intervention to address health problems in early life – childhood, given the poor outcomes of clinical treatment and public health prevention programmes in adulthood because of the problems of correcting long standing lifestyle patterns or embedded social characteristics.

I decided to focus on hypertension and blood pressure (the most common risk factor for cardiovascular disease) because of my knowledge of the epidemiological transition occurring worldwide and the obvious effect on cardiovascular disease in developing countries. I felt it would be of value to apply the knowledge of this transition in the paediatric population, as they are the future adults, and future of the nation. I had a primary thought, “Is the epidemiological transition in the 21st century already having measurable effects on the younger population – the future of the nation?” With all these in mind I formulated my research questions.

1.3 OVERVIEW OF THE THESIS STRUCTURE

This thesis is comprised of eight chapters. In Chapter Two (Background Chapter), I describe my study area – Lagos State, Nigeria, in the first section. In the second section I present detailed important background information for the present study. I highlight the global status of disease patterns, putting Nigeria in perspective, describe the theoretical basis of the shift in disease profile worldwide, with relevance to Nigeria, and elaborate on chronic non-communicable diseases (NCDs) (including cardiovascular disease (CVD)) and hypertension (a main risk factor for CVD) and their global challenges. I also describe hypertension in children and adolescents, where I highlight the definition of hypertension, the aetiology of hypertension, associated factors for variations in blood pressure, and the tracking of blood pressure in children and adolescents.

In Chapter Three, I present a detailed review of published literature on the epidemiology of hypertension in children and adolescents in Nigeria and other parts of the world, the relationship between measures of socio-economic characteristics and blood pressure in children and adolescents, the relationship between anthropometric measures of adiposity or fatness and blood pressure in children and adolescents, as well as the relationship between pubertal maturation status and blood pressure in children and adolescents. I also highlight the justification for the study; which is followed by an itemised statement of my research questions, aims and objectives, and the null hypothesis of the study.

Chapter Four consists of the Methodological issues of the present study; where I discuss the rationale for choosing the methodological approaches used. In Chapter Five, I provide a detailed description of the pilot study carried out in a low-income secondary school in Lagos State, Nigeria, as a precursor to the main study. This is followed by the Methods Chapter (Chapter Six), where I describe aspects of the research methods used in this main study, including: setting, study design, sample size estimation, participant selection, data collection, data handling, data entry and cleaning, and data analysis. In Chapter Seven, I present the main findings of the study, which include both descriptive and inferential results.

Chapter Eight (the final chapter) of this thesis covers the discussion, recommendations for policy, practice and future research, as well as the conclusion. In this chapter, I summarise the main findings from each section of the thesis in relation to the original research questions, discuss the relationship between the findings and the results of previous research, highlight the strengths and limitations of the present study, discuss the implications for policy, practice and future research, and end with a broad conclusion.

SUMMARY

In this chapter, I have presented the introduction to this thesis and information underpinning the basis of the present study. I also presented the description of the origin of my interest in the research topic, and the structure of the thesis. In the next chapter, I will describe my study area – Lagos State, Nigeria, and background information for the present study in greater detail.

CHAPTER 2: BACKGROUND

2.0 BACKGROUND

2.1 SETTING OF STUDY

INTRODUCTION

In this section, I will describe my study area, including the country (Nigeria) and the precise study area – Lagos State.

2.1.1 COUNTRY PROFILE

Located in the west coast of Africa, Nigeria is bordered on the north by Niger, on the northeast by Chad, on the east by Cameroon, on the west by Republic of Benin, and on the south by the Atlantic Ocean (Demographic and Health Survey, 2008) (Figure 2). It is the fourteenth largest country in Africa with a land area of 924,000 square kilometres. Nigeria is grouped into six geopolitical zones – North-Central, North-East, North-West, South-East, South-South, and South-West, and is comprised of 36 states and a Federal Capital Territory (FCT) – Abuja (located in the centre of the country) (United States Department of State, 2011; Demographic and Health Survey, 2008) (Figure 3). Lagos State, the former capital of Nigeria from 1991, is located on the coast (Demographic and Health Survey, 2008). Nigeria has a tropical climate with temperature range between 25°C and 40°C, and two well defined seasons, rainy season (March to October) and dry season (November to February) (Demographic and Health Survey, 2008). Table 1 (page 30) shows selected demographic, health and socio-economic indicators of Nigeria.

Figure 2: The Map of Nigeria showing its location in Africa and also showing the Federal capital territory – Abuja and Lagos State (the study area).
Source: Demographic and Health Survey (2008)

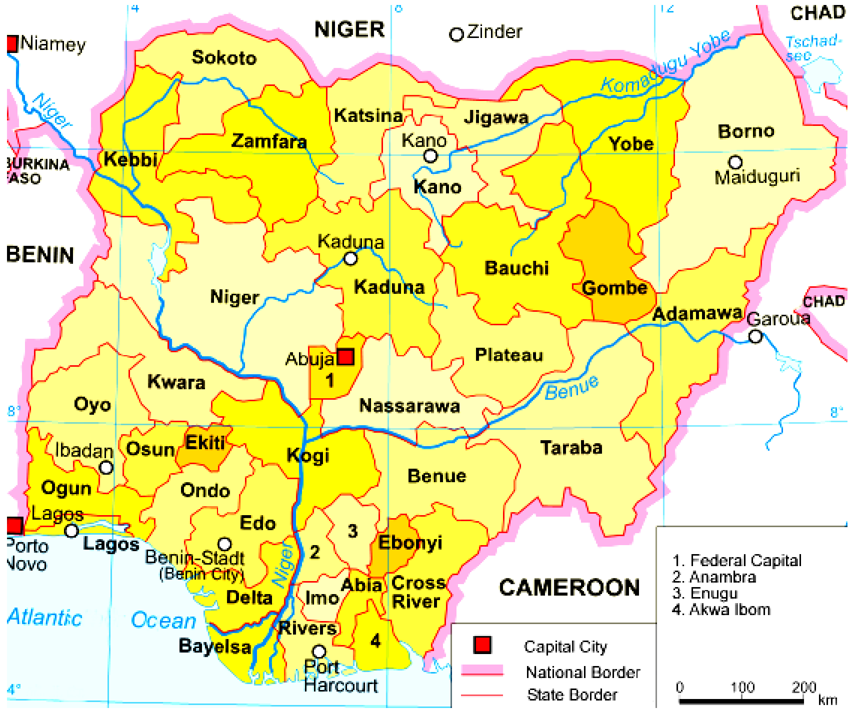


Figure 3: The Map of Nigeria showing the 36 States and the Federal capital territory – Abuja.
Source: Demographic and Health Survey (2008)

UNICEF (2011) estimates Nigeria's population at approximately 155 million in 2009, with an annual growth rate of about 2.7 percent. It is the most populous country in Africa (thus, referred to as the "Giant of Africa") (World Bank, 2011), and the seventh most populated country worldwide; it also accounts for approximately seventeen percent of the black population in the world and 47 percent of the population in West Africa (World Bank, 2011). The nation's population is largely young, with about 50% of the population under the age of 18 (Nigeria National Population Commission, 2006) (see Figure 4 for the population pyramid). The population is not uniformly spread across Nigeria (Demographic and Health Survey, 2008). Lagos and Anambra are the most densely populated states, while Yobe, Niger, and Taraba states are the most sparsely populated (Demographic and Health Survey, 2008) (Figure 5).

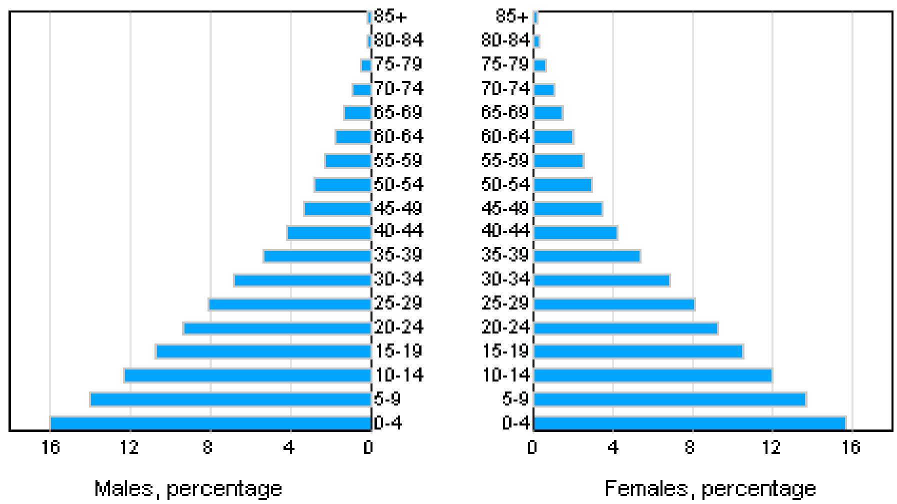


Figure 4: Population Pyramid, Nigeria, Census 2006
Source: Nigeria National Population Commission (2006)

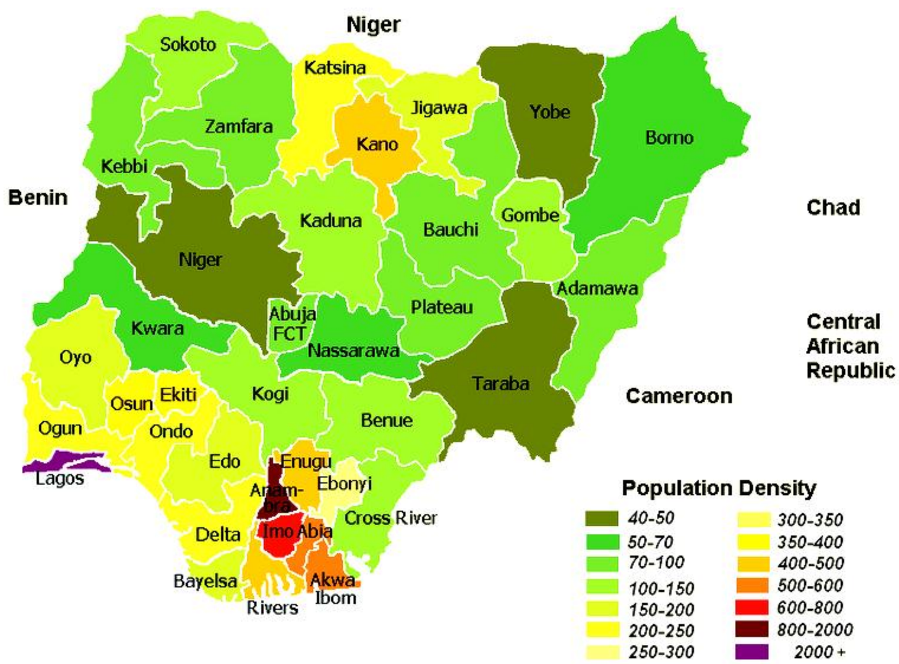


Figure 5: The Map of Nigeria showing the population density across the 36 States and the Federal capital territory – Abuja.
Source: Demographic and Health Survey (2008)

Nigeria has the highest number of large cities (that is, population of over one million) in Africa (Agunwamba *et al*., 2009). It is partly urbanised, with half the population living in urban areas, and a high average annual growth rate of urban population of 4 percent (UNICEF: State of the World's Children, 2011), which is greater than sub-Saharan Africa's urban population growth rate. Urbanisation is occurring rapidly in the country; in the next two decades, the percentage of the population living in urban areas is estimated to rise to about 64 percent (United Nations, 2007).

There are about 250 ethnic groups in Nigeria; but, the major ethnic groups are the Hausa-Fulani in the North region, the Igbo in the South-East region, and the Yoruba in the South-West region (United States Department of State, 2011). English is the official language in Nigeria; however, there are 500 native languages, and the widely spoken languages are Hausa-Fulani, Igbo and Yoruba languages (United States Department of State, 2011). While there are a wide range of religious beliefs in Nigeria, the most common ones are Islam and Christianity (United States Department of State, 2011). Islam is predominant in the north, while Christianity is predominant in the south (United States Department of State, 2011).

Nigeria is the largest oil producer in Africa, with the highest natural gas reserves (World Bank, 2011). In spite of the large returns obtained from oil wealth and natural resources, Nigeria is a low-income country, with a gross domestic product (GDP) per capita of only about US$1,118 (UNICEF: State of the World's Children, 2011). About half of the population live below the poverty line (less than 1.25 dollars per day) (UNICEF: State of the World's Children, 2011). The gross domestic product growth rate has doubled in the last decade in Nigeria (UNICEF: State of the World's Children, 2011). It accounts for 41 percent of sub-Sahara Africa's gross domestic product (GDP), representing the second largest economy in the region (World Bank, 2011). The southern region of the country is wealthier and more urbanised than the north. The North-East and North-Central region (comprising about half of the nation's population) are the poorest in the country, with the majority of nation's poor residing in these regions (Demographic and Health Survey, 2008).

The total expenditure on health as a percentage of gross domestic product (GDP) in Nigeria is 5.8 percent (World Bank, 2011). The general government expenditure on health as percentage of total expenditure on health (2008) is about 37 percent while private expenditure on health as percentage of total expenditure on health (2008) is about 63 percent (World Health Organisation, 2011b).

Table 1: Demographic, Health and Socio-economic indicators of Nigeria.

Indicator	Year	Estimate	Source
Demographic			
Total population	2009	154729000	UNICEF 2011
Life expectancy at birth (years), male	2009	53	UNICEF 2011
Life expectancy at birth (years), female	2009	54	UNICEF 2011
Population, under 18	2009	75994000	UNICEF 2011
Adolescents Population (aged 10-19)	2009	35386000	UNICEF 2011
Adolescents Population (aged 10-19), as a proportion of total population (%)	2009	23	UNICEF 2011
Population annual growth rate (%)	2000-2009	2.7	UNICEF 2011
Crude birth rate (births per 1,000 population)	2009	40	UNICEF 2011
Crude death rate (deaths per 1,000 population)	2009	14	UNICEF 2011
% of population urbanised	2009	50	UNICEF 2011
Average annual growth rate of urban population (%)	2000-2009	4	UNICEF 2011
Health			
Health System Performance ranking	2000	187	WHO, 2000
Physicians per 10,000 population	2009	4.0	WHO 2011b
Nurses and midwives per 10,000 population	2009	16.1	WHO 2011b
Total fertility rate (per woman)	2009	5.2	UNICEF 2011
Under-5 mortality rate (per 1,000 live births)	1990	212	UNICEF 2011
Under-5 mortality rate (per 1,000 live births)	2009	138	UNICEF 2011
Infant mortality rate (per 1,000 live births)	1990	126	UNICEF 2011
Infant mortality rate (per 1,000 live births)	2009	86	UNICEF 2011
Adult mortality rate (per 1,000 population)	2009	370	WHO 2011b
Adult HIV prevalence rate (aged 15-49) (%)	2009	3.6	UNICEF 2011
Proportional mortality (% of total deaths, all ages) • Chronic non-communicable diseases (NCDs) • Injuries • Communicable, maternal, perinatal, and nutritional conditions	2008	 28 5 67	WHO 2011c
Chronic non-communicable diseases			
Total NCD deaths (per 1,000 population)	2008	269.9	WHO 2011c
Total NCD deaths (percentage of all deaths)	2008	28	WHO 2011c
NCD deaths under age 60 (percentage of all NCD deaths)	2008	41.7	WHO 2011c
All NCDs (age-standardised death rate per 100,000)	2008	805.4	WHO 2011c
Cancers (age-standardised death rate per 100,000)	2008	94.1	WHO 2011c
Chronic respiratory diseases (age-standardised death rate per 100,000)	2008	95.3	WHO 2011c
Cardiovascular disease and diabetes (age-standardised death rate per 100,000)	2008	455.8	WHO 2011c
Hypertension (prevalence %)	2008	42.8	WHO 2011c
Mean systolic blood pressure (mmHg)	1990	130	WHO 2011c
Mean systolic blood pressure (mmHg)	2008	132	WHO 2011c
Overweight (prevalence %)	2008	26.8	WHO 2011c
Obesity (prevalence %)	2008	6.5	WHO 2011c
Mean body mass index (Kg/m^2)	1990	21	WHO 2011c
Mean body mass index (Kg/m^2)	2008	24	WHO 2011c
Socio-economic			
Gross National Income per capita (US$)	2009	1140	UNICEF 2011
GDP per capita (US$)	2009	1118	UNICEF 2011
GDP per capita average annual growth rate (%)	2009	5.6	UNICEF 2011
% share of household income, lowest 40%	2000-2009	15	UNICEF 2011
% share of household income, highest 20%	2000-2009	49	UNICEF 2011
Total adult literacy rate (%)	2005-2008	60	UNICEF 2011
Youth (15-24 years) literacy rate, female	2004-2008	65	UNICEF 2011

Source: The State of the World's Children, UNICEF (2011), World Health Statistics, World Health Organisation (WHO) (2011b) and NCD Country Profiles, World Health Organisation (2011c), and WHO, World Health Report (2000).

2.1.2 STUDY AREA - PROFILE OF LAGOS STATE

The study was carried out in Lagos Metropolis (also known as Lagos City), the urban area of Lagos State. Lagos State is one of the 36 states that constitute the Federal Republic of Nigeria (Nigeria National Population Commission, 2006). It is located in the South-West region of the country. Lagos State is bounded in the North and East by Ogun State, in the west by Republic of Benin and the south by the Atlantic Ocean (Oke *et al*., 2000) (Figure 3). It comprises twenty Local Government Areas (Fabamwo and Okonofua, 2010). Lagos State has the smallest land space (3577 square kilometres) in the country (Figure 3) (Fadare and Oduwaye, 2009), although it is the most populous state in Nigeria and also in sub-Saharan Africa, comprising a population of about 17.5 million. Lagos State has an annual growth rate of 3.2 percent and a population density of 4,193 persons per square kilometre (Lagos State Government, 2011).

Lagos is the most urbanised state of the Federal Republic of Nigeria (Fadare and Oduwaye, 2009). Lagos Metropolis, the urban area of Lagos state and Nigeria's largest urban area, covers about 40% of the land area of Lagos State, and constitutes approximately 90% of the total population of the state (Lagos State Government, 2011). It has an average population density of more than 20,000 persons per square kilometre (Lagos State Government, 2011; Fadare and Oduwaye, 2009). Lagos Metropolis, itself is the most populated city in Africa and the 14th most populated city worldwide. Globally, Metropolitan Lagos is one of the most rapidly growing cities, with a population rising ten times more rapidly than New York or Los Angeles (Lagos State Government, 2011). By 2020, it is expected to be the 7th most populated city worldwide (City Mayor Statistics, 2011).

The native people of Lagos State are the Yorubas, but there is also a wide socio-cultural mix of Nigerians from all over the country, people from other African countries as well as from other continents (Oke *et al*., 2000). There are a variety of religious groups in the state; however, the most common ones are Christians (71.8 percent) and Muslims (27.9 percent) (Demographic and Health Survey, 2008).

Lagos State is the economic and financial centre of Nigeria and also of West Africa (Fadare and Oduwaye, 2009). The state accounts for almost two-thirds of the nation's GDP (UN-HABITAT, 2006). As a result of the rapid urbanisation and population expansion in Lagos State, the poverty level in Lagos Metropolis is substantial, with about 65 percent of the population living below the poverty line (UN-HABITAT, 2006).

Figure 6: The Map of Lagos State showing the local government areas.
Source: Lagos State Government (2011)

2.1.2.1 THE EDUCATION SYSTEM

The schools (primary schools, secondary schools, universities and polytechnics) in Lagos State are owned by the public sector – government (Federal or State government) or private sector. There are about 1,000 public primary schools, 400 public secondary schools, 1,200 privately owned nursery/primary schools and 110 privately owned secondary schools, and 8 public universities and polytechnics in Lagos State (Oke *et al*., 2000). Both publicly (Federal or State government) and privately owned primary and secondary schools are almost evenly distributed all over the state. Lagos State government owned primary and secondary schools are grouped under 20 local education districts, grouped within five divisions (Oke *et al*., 2000). The Lagos State government owned secondary schools included in the present study were from the "Lagos State district IV".

Lagos State has the three-tier: 9-3-4 education system (created in 2006), which includes six years of primary education, three years of junior secondary education, three years of senior secondary education, and four years of university or polytechnic education (Uwaifo and Uddin, 2009). This system is used in all the states in Nigeria. The 9-3-4 system of education was created to align with the Millennium Development Goals (MDGs) and universal basic education goal (Uwaifo and Uddin, 2009). Following the Universal Primary Education (UPE) enacted in all states in Nigeria in 1976, which offered tuition-free primary education in State government owned public schools, Nigeria currently has the Universal Basic Education (UBE) system, implemented in all states in Nigeria in 1999 (Demographic and Health Survey, 2008). The Universal Basic Education (UBE) system makes it compulsory for every child to have access to equivalent tuition fee free comprehensive primary and secondary education in State government owned public schools (Demographic and Health Survey, 2008). Unlike the tuition fee free State government owned public primary and secondary schools, all Federal Government and privately owned schools are fee-paying schools.

Under the Universal Basic Education (UBE) system, distinct from the UPE, school attendance is compulsory; the UBE places the responsibility on parents and carers to register their children in school and ensure the completion of the primary and secondary education (Kazeem *et al*., 2010). The Universal Basic Education (UBE) system also has assigned legislated penalties for parents and carers who fail to perform this obligation (Kazeem *et al*., 2010).

The percentage of the Nigerian population that has received any education differs according to geopolitical regions (Demographic and Health Survey, 2008). The North-East and North-West regions have the highest percentage population with no education, the South-South region has the lowest percentage population with no education, and the South-West region has the highest percentage population with more than secondary education (Demographic and Health Survey, 2008). The 2008 Demographic and Health Survey (DHS) indicate that only 4 percent of the total population in Lagos State have no education, compared with 19 percent of the total population in Nigeria. In Lagos State, 2 percent have only some primary education, 10 percent completed only primary education, 16 percent have some secondary education, 43 percent have completed secondary education, and a further 25 percent have higher than secondary education (Demographic and Health Survey, 2008). The percentage of persons who have completed secondary education and the percentage of those with more than secondary school level of education in Lagos State are more than twice the national average.

Lagos State has the highest literacy rate in Nigeria (Nigeria National Population Commission, 2006). Data from the Nigeria National Population Commission (2006) indicated that 88 percent of the total population in Lagos State are literate, compared to the nation's 67 percent. Ninety four percent of the population aged 10 to 19 years in Lagos State are literate, while Nigeria overall has 75 percent literacy rate (Nigeria National Population Commission, 2006).

School attendance rate is relatively high in Lagos, compared to the national average. According to the Nigeria National Population Commission (2006), 94 percent of the population aged 10 to 14 years and 74 percent of the population aged 15 to 19 years are attending school in Lagos State. At national level, 74 percent of children aged 10 to 14 years and 68 percent of children and adolescents aged 15 to 19 years are attending school (Nigeria National Population Commission, 2006). Four percent of children and adolescents aged 10-19 years in Lagos State have never attended school, compared with the national average of about 22 percent (Nigeria National Population Commission, 2006).

SUMMARY

In this section, I have given an overview of my study area, including the geographic location, demographic, health, education, and socio-economic characteristics of the entire nation (Nigeria), as well as Lagos State, so as to provide knowledge of the study population features.

In the next section, I will provide the information which form the fundamental foundation for the present study. I will highlight the theoretical basis of the disease pattern worldwide and discuss the global status on disease pattern with relevance to Nigeria. I will then have a detailed look at non-communicable diseases (NCDs) (including cardiovascular disease (CVD) and hypertension (a main risk factor for CVD) and their global challenges, and subsequently locate my main focus in the context of blood pressure in children and adolescents.

2.2 STUDY BACKGROUND

INTRODUCTION

In this section, I will present the theory and epidemiological trends underpinning the basis of the present study. I will describe the theory of epidemiological transition and accompanying transitions. I will discuss the global status on disease pattern, placing Nigeria in perspective. I will then elaborate on chronic non-communicable diseases (NCDs) (including cardiovascular disease (CVD)) and hypertension (a main risk factor for CVD) and their global challenges. I will later explain the main focus of my study in the context of blood pressure in children and adolescents, under the following headings – definition of hypertension, the aetiology of hypertension, associated factors for variations in blood pressure, and the tracking of blood pressure in children and adolescents

2.2.1 THE THEORY OF EPIDEMIOLOGICAL TRANSITION AND ACCOMPANYING TRANSITIONS

The epidemiological transition refers to a distinct shift in the disease and mortality profile of a population (Omran, 1971). Omran first proposed the theory of epidemiological transition in 1971. The theory of epidemiological transition describes four sequential stages of changing patterns of disease and mortality in human society (Pearson, 1999). Omran (1971) proposed three stages of epidemiological transition in the process of modernisation: “the stage of pestilence and famine”, “the stage of receding pandemics” and “the stage of degenerative and man-made diseases”. A fourth stage was introduced by Olshansky and Ault (1986), as “the stage of delayed degenerative diseases” (see Table 2).

Countries in the world and states within a country at any point in time can be at different phases of epidemiological transition (Yusuf *et al*., 2001). According to Hill *et al* (2007), in the developing world, the majority of Africa (including Nigeria) and South Asian countries are in the initial stages of the epidemiological transition, while much of Latin America and East and Southeast Asian countries are in the later stages. In addition, populations from a homogenous origin at any point in time have been noted to be at different stages of epidemiological transition (Gillum, 1996). Six stages of the epidemiological transition of CVD among black people of sub-Saharan African origin (such as black populations in the West Indies and black Americans) have been proposed by Gillum (1996).

Table 2: Stages of the Epidemiological Transition

Stages of Epidemiological Transition	Mortality Rate	Birth Rate	Life Expectancy	Deaths attributed to CVD	Disease Patterns
Stage 1 - Stage of pestilence and famine	Very High	High	20-40 years	5-10%	Communicable diseases, famines and wars account for a major proportion; chronic non-communicable diseases e.g. CVD (Rheumatic heart disease, infections and nutritional cardiomyopathies) play a small role.
Stage 2 - Stage of receding pandemics	High	High	30-50 years	10-35%	Epidemic peaks of communicable diseases become less recurrent and there is an increase in the contribution of chronic non-communicable diseases e.g. CVD (Rheumatic heart disease, infections and nutritional cardiomyopathies, hypertensive heart disease and hemorrhagic stroke).
Stage 3 - Stage of degenerative and man-made diseases	Low	Low	>50 years	35-55%	Chronic non-communicable diseases e.g. CVD (Stroke, Ischemic heart disease) epidemic becomes fully expressed and occurs at relatively young ages.
Stage 4 - Stage of delayed degenerative diseases	Low	Lower	>70 years	<50%	Chronic non-communicable diseases e.g. CVD (Stroke, Ischemic heart disease) occur at older ages.

Source: Pearson (1999); Olshansky and Ault (1986); Omran (1971)

The shifts in disease and mortality patterns which characterise the epidemiological transition are closely related to two processes – the demographic transition and the nutrition transition (Popkin and Gordon-Larsen, 2004). The demographic transition describes a change in population dynamics (Amuna and Zotor, 2008). The theory of the demographic transition proposes a relationship between mortality and birth rate. The demographic transition is characterised by a gradual shift from a pattern of high mortality and birth rate, short life expectancy and low population growth to low mortality and birth rate, longer life expectancy and increased population growth (Lee, 2003) (see Table 1, page 30). Nigeria currently has an average life expectancy at birth of 54 years, a high birth rate of 5.2 births per woman and high infant and under 5 mortality rates of 86 and 138 per 1000 live births respectively, (UNICEF: State of the World's Children, 2011), with an adult mortality rate (probability of dying between 15 and 60 years) of 370 per 1,000 population (World Health Organisation, 2011b).

Population growth and ageing will augment a significant rise in the numbers of deaths from chronic non-communicable diseases, especially in developing countries. An eighteen percent rise in population growth has been projected for developing countries between 2005 and 2015 (Abegunde *et al*., 2007). Smith and Mensah (2003) highlighted that in the next three decades between 2000 and 2030, the population of elderly persons aged 65 years and older is projected to increase by two-fold in many Sub-Saharan African countries.

The nutrition transition refers to a shift in the patterns of diet and physical activity towards unhealthy foods higher in fat, sugar and energy, and low in fruit and vegetable and fibre, alongside more sedentary lifestyles (Popkin and Gordon-Larsen, 2004).

2.2.2 GLOBAL STATUS ON DISEASE PATTERN

Over the next two decades, the relative contribution of the major cause of death and total burden of disease in many developing countries (including Nigeria) is projected to alter significantly (Mathers and Loncar, 2006). A major decline in communicable diseases (except HIV/AIDS) and poverty-related diseases, and a substantial increase in the incidence of chronic non-communicable diseases (such as cardiovascular disease (a hypertensive-related disease), cancers, chronic respiratory diseases and diabetes) is expected worldwide (including in Nigeria) over the next few years (World Health Organisation, 2005) (Figures 7 and 8).

The World Health Organisation (2005) has predicted that although communicable diseases and poverty-related diseases will continue to be the leading causes of death in Nigeria over the next few years, deaths from chronic non-communicable diseases (including cardiovascular disease (CVD), cancers, chronic respiratory diseases and diabetes) will rapidly catch up (Figures 7 and 8). By 2030, chronic non-communicable diseases are predicted to surpass communicable diseases and poverty-related diseases in Africa (World Health Organisation, 2011a). Some developing countries such as India and Pakistan are already experiencing a predominance of chronic non-communicable diseases deaths (World Health Organisation, 2005) (Figures 7 and 8).

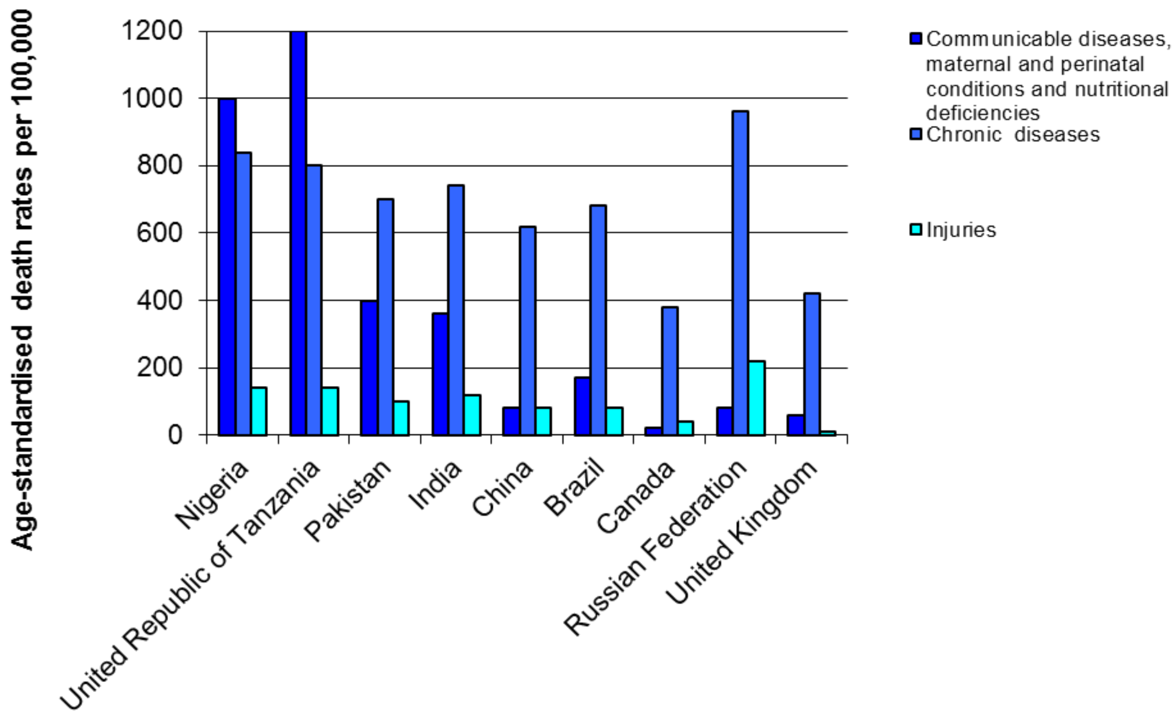


Figure 7: Projected Main Causes of Death in selected countries, all ages, 2005
Source: World Health Organisation (2005)

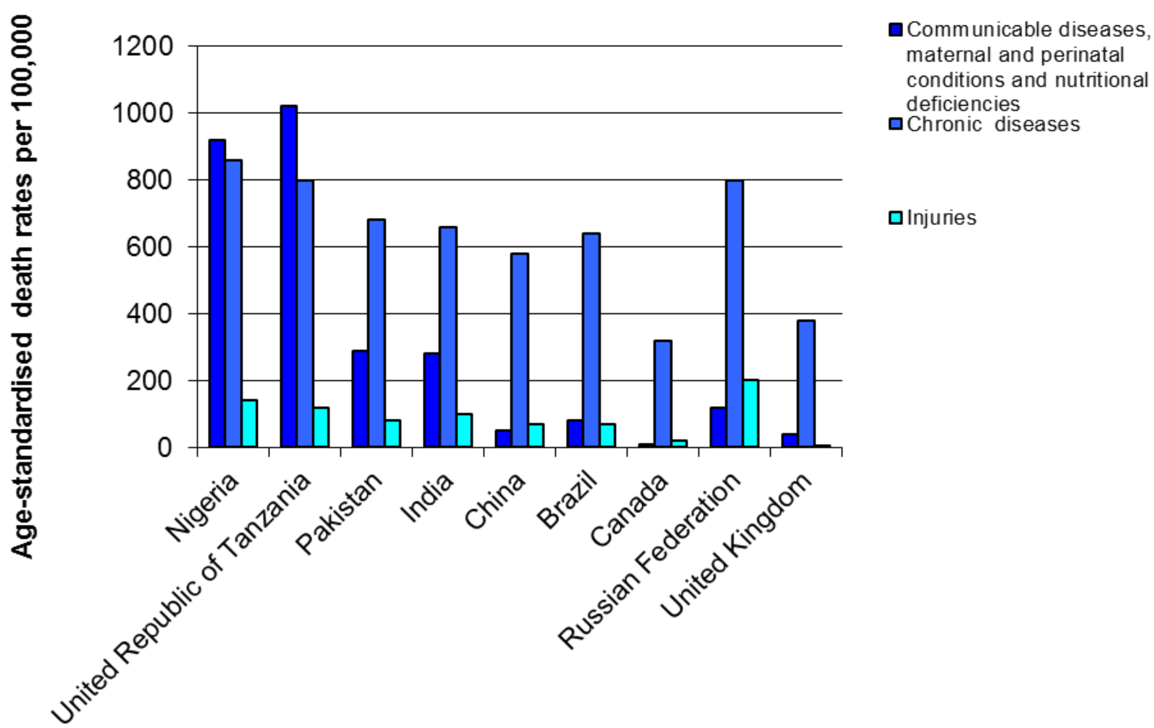


Figure 8: Projected Main Causes of Death in selected countries, all ages, 2015
Source: World Health Organisation (2005)

While communicable diseases and poverty-related diseases (such as HIV/AIDS, tuberculosis, malaria, maternal and perinatal conditions, and nutritional deficiencies) remain a threat in many developing countries, including Nigeria, the increasing prevalence of chronic non-communicable diseases (such as cardiovascular disease (a hypertensive-related disease)) has led to a “double burden of disease” (Yusuf *et al*., 2001). This double burden of disease has a grave public health impact as it places serious challenges on the health system (Yach *et al*., 2004), since the health system is still coping with the challenges of tackling communicable and poverty-related diseases with limited financial and human resources. BeLue *et al* (2009) highlighted that the management of chronic non-communicable diseases (such as cardiovascular disease) would be available for only a small number of people, resulting in high disease burden and mortality.

Nigeria alongside other developing countries is currently undergoing a process in modernisation known as “an epidemiological transition”, characterised by a progressive rise in the burden of chronic non-communicable diseases including cardiovascular disease and a decrease in the communicable diseases and poverty-related diseases (BeLue *et al*., 2009), associated with socio-economic development, urbanisation, industrialisation, globalisation and changing lifestyle factors (Kadiri, 2005). Many developed countries (especially European countries) passed through this transition in the first half of the 1900s (Hill *et al*., 2007). However, the epidemiological transition presently being experienced in developing countries is occurring in a shorter time frame than that experienced in the past by developed countries (Miranda *et al*., 2008).

2.2.3 CHRONIC NON-COMMUNICABLE DISEASES

Globally, chronic non-communicable diseases (NCDs) (mainly, cardiovascular disease, cancers, chronic respiratory diseases and diabetes) are currently the leading cause of death in the adult population. In 2008, about sixty percent of deaths (36 million) worldwide were due to NCDs; and this is predicted to increase by about 15% by 2020 (World Health Organisation, 2011a). NCDs (such as cardiovascular disease, cancers, respiratory diseases, diabetes and injuries) were estimated to account for 28 percent of all deaths in Nigeria in 2008 (World Health Organisation, 2011c). Because of the larger populations involved, the preponderant effects of chronic non-communicable diseases are falling increasingly on developing nations, with 80 percent of NCD deaths occurring in these countries and the highest percentage of these deaths occurring prematurely during working age (that is in people under 70 years of age) (World Health Organisation, 2011a).

In addition to the health impact associated with chronic non-communicable diseases, there is also a socio-economic and human development adverse impact, hindering progress (World Health Organisation, 2011a). Every 10% increase in NCDs is linked to a 0.5% decrease in the yearly rate of economic growth (World Health Organisation, 2011a). According to World Health Organisation (2005), the economic losses due to chronic non-communicable diseases (mainly cardiovascular disease and diabetes) in Nigeria, United Kingdom, India and China were 400 million dollars, 2 billion dollars, 9 billion dollars and 18 billion dollars, respectively, in 2005. By 2015, the accumulated amount of loss in national income as a result of deaths caused by chronic non-communicable diseases (mainly cardiovascular disease and diabetes) in Nigeria, United Kingdom, India, and China is expected to increase to 8 billion dollars, 38 billion dollars, 247 billion dollars, and 558 billion dollars, respectively (World Health Organisation, 2005).

Chronic non-communicable diseases (NCDs) were omitted in the United Nations (UN) Millennium Development Goals (MDGs) established in 2000. These goals were established to reduce poverty and improve human well-being (World Health Organisation, 2011a). Today, NCDs encompass a significant burden of disease and mortality worldwide; thus, it is inappropriate that they are not a part of the MDGs. There is an increasing global interest and action on chronic non-communicable diseases. In September 2010, the Millennium Development Goals Review Summit took place in New York, which highlighted NCDs as important issue for addition to the MDG successor goals in 2015 (United Nations, 2010). At the UN High-Level Meeting on prevention and control of chronic non-communicable diseases which took place in New York in September 2011, the significant rise of NCDs in developing countries was acknowledged, and it was agreed that chronic non-communicable diseases should be high on the global health agenda (United Nations, 2011). The strategies to respond to the issues of NCDs through a reduction in risk factors, strengthening of health systems, and improvement in surveillance and evaluation were also outlined at the meeting.

2.2.4 CARDIOVASCULAR DISEASE

Cardiovascular disease (CVD) is a leading cause of death and burden of disease from chronic non-communicable diseases in adults worldwide (World Health Organisation, 2005) (Figures 9 and 10). An estimated 17 million people die annually from cardiovascular disease conditions (such as stroke and coronary heart disease), with about 7 million of these deaths caused by coronary heart disease and 6 million by stroke (World Health Organisation, 2010). As stated previously, the poorer countries carry the heaviest burden from cardiovascular disease deaths, with 80 percent of the deaths occurring in these countries (World Health Organisation, 2005). In 2008, about half of NCD deaths worldwide were caused by cardiovascular disease (World Health Organisation, 2011a). In the same year, CVD contributed to 10 percent of overall all-cause mortality, and was responsible for almost half of the NCD deaths in Nigeria (World Health Organisation, 2011c).

Although the current high mortality and burden of CVD is in itself a sufficient rationale for attention, a bigger issue is the more premature mortality from CVD in developing countries compared with the developed countries (World Health Organisation, 2012; Abegunde *et al*., 2007), with almost half of these CVD deaths occurring prematurely (under 70 years) (Abegunde *et al*., 2007). This will have adverse effects on productivity and economic development, weakening the economies of countries (World Health Organisation, 2011a). Cardiovascular disease is expected to remain the single leading causes of death worldwide, with an estimated 23.6 million deaths by 2030, mainly because it will increase in developing countries (Mathers and Loncar, 2006).

Socio-economic differences exist in the distribution of cardiovascular disease within countries, worldwide. In developed countries, CVD has a greater impact on the poor (World Health Organisation, 2005); whilst in developing countries (such as Nigeria), CVD is commoner in those with a more “western” lifestyle. This lifestyle accompanies urbanisation, and may be more prevalent with rising socio-economic status (Ejike *et al*., 2008). As CVD epidemic progresses in developing countries, the disease prevalence will alter to the poorer population groups (World Health Organisation, 2011a). The present pattern observed in developing countries is similar to those found at the beginning of CVD epidemic in developed countries in the early 1900s, and it is classic for a population in epidemiological transition (Karaye *et al.*, 2009). Despite the fact that CVD affects mainly adults, its causes may begin in early childhood (Hulanicka *et al*., 2007).

The rise in CVD is mostly due to a rise in key risk factors, mainly hypertension or high blood pressure (BP) (Ejike *et al*., 2008; Moura *et al*., 2004). An increase in hypertension or high blood pressure heralds an increase in CVD (Ejike *et al*., 2008).

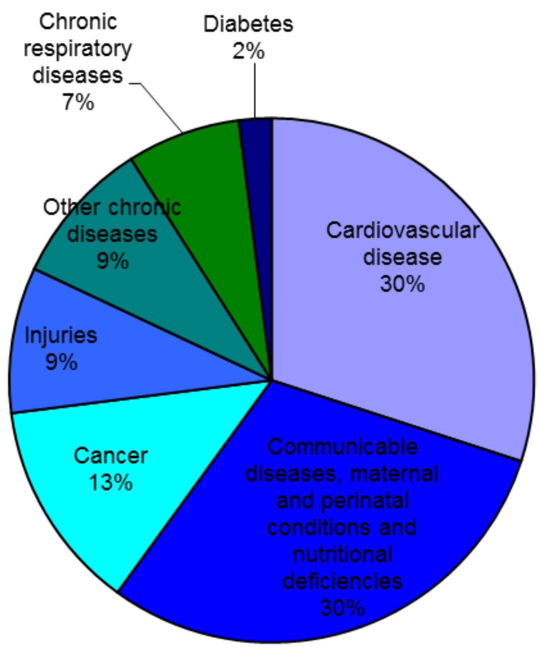


Figure 9: Projected Main Causes of Death, worldwide, all ages, 2005
Source: World Health Organisation (2005)

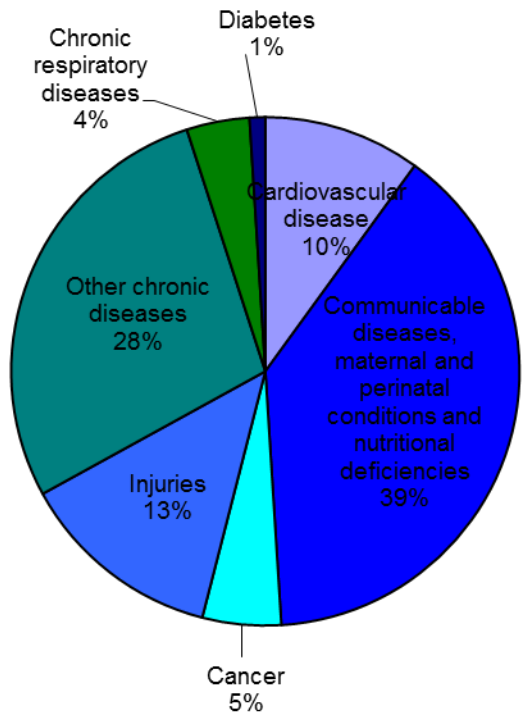


Figure 10: Projected Main Causes of Global Burden of Disease (DALYs), worldwide, all ages, 2005
Source: World Health Organisation (2005)

2.2.5 HYPERTENSION

Hypertension or High blood pressure is one of the leading cardiovascular risk factors that contribute to mortality worldwide, and the second major cause of global burden of disease following underweight in children (Lopez *et al*., 2006). Around 40% of the adult world population (aged 25 and above) was found to have hypertension in 2008 (World Health Organisation, 2011a), and this is predicted to have a 1.5 fold increase by 2025 (Kearney *et al*., 2005). Annually, hypertension causes approximately 13% (7.5 million) of total mortality (World Health Organisation, 2011a) and contributes to 57 million (3.7%) disability adjusted life years (DALYs) in adults worldwide (World Health Organisation, 2011a). It causes a considerable amount of incapacity and disability in adults worldwide (Mensah, 2008). It has been recognised as a major risk factor for the development of cardiovascular disease in adults (Sharma *et al*., 2010; Taksande *et al*., 2008; Luma and Spiotta, 2006; Thakor *et al*., 1998). It has been estimated that hypertension is responsible for half of stroke mortality and coronary heart disease mortality (World Health Organisation, 2012). Hypertension was once considered to be uncommon in adults in sub-Saharan Africa; however, the prevalence is rapidly increasing and it is quickly becoming an important medical and public health problem (Addo *et al*., 2007), as a result of increasing epidemiological transition.

The highest prevalence of hypertension (46%) in the adult population (aged 25 and above) was observed in the African Region in 2008 (World Health Organisation, 2011a). In 2008, it was estimated that almost half of the adult population in Nigeria had hypertension (World Health Organisation, 2011c). Hypertension accounted for about 5% of deaths in Nigeria in 2005 (World Health Organisation, 2005). Hypertension is known to occur with socio-economic differences within countries, worldwide (Colhoun *et al*., 1998). According to Ejike *et al* (2008), socio-economic characteristics (SEC) are likely to influence the pattern of distribution of hypertension in sub-Saharan Africa. The prevalence of hypertension in adults has been suggested to be highest in high-income populations in developing countries (including Nigeria), while the prevalence of hypertension is highest in the low-income population subgroups in industrialised societies (Cooper *et al*., 1998). This observed pattern of the influence of socio-economic characteristics on blood pressure in developing countries (including Nigeria) has been theorised (Mendez *et al*., 2003).

Mendez *et al* (2003) noted that an alteration in the relationship between socio-economic characteristics and blood pressure may occur with the gradient of the associations changing from positive to negative with increasing industrialisation and socio-economic development. It has been suggested that the socio-economic characteristics and blood pressure gradient observed in developing countries (including Nigeria) may be due to the fact that the affluent (commonly urban residents) are the first to adopt unhealthy lifestyles, such as more sedentary lifestyles, a high energy and fat diet and smoking (Ejike *et al*., 2008). The timing of the potential influence of socio-economic factors on blood pressure in Nigeria is uncertain. It is not known whether the pattern observed in adults is reflected in children and adolescents (Agyemang *et al*., 2005).

2.2.6 HYPERTENSION IN CHILDREN AND ADOLESCENTS

Hypertension in children and adolescents was once considered uncommon and was unacknowledged (Adedoyin *et al*., 2006); however, hypertension has been increasingly reported among children and adolescents worldwide (including Nigeria) in the last 30 years (see the Literature Review Chapter (Chapter 3) for further details on the epidemiology of hypertension in children and adolescents). Ejike *et al* (2008) noted that it is of concern that hypertension in childhood and adolescence is an indicator of morbidity and mortality in adulthood. Hypertension in children and adolescents over a prolonged period of time has been suggested to cause end-organ damage (such as left ventricular hypertrophy (LVH), kidney failure, hypertensive encephalopathy, seizures, cerebrovascular accidents and congestive heart failure), associated with high risk of premature mortality in adulthood (Gidding, 2008).

2.2.6.1 DEFINITION OF HYPERTENSION IN CHILDREN AND ADOLESCENTS

The definition of hypertension in childhood and adolescence varies in different reports. There has been a lot of interest in hypertension in childhood and adolescence over the past three decades; however, before 1977 there was no standardised definition of hypertension in children and adolescents (Falkner and Sadowski, 1995). There is no single cut-off point that defines hypertension in children and adolescents (Vogt, 2001). In the absence of a standardised definition of hypertension prior to 1977, the established blood pressure level of hypertension of 140/90mmHg used as the cut-off point for hypertension in adults was adopted for children and adolescents (Falkner and Sadowski, 1995). The children and adolescents identified as hypertensive using this value were frequently symptomatic and had what is now considered to be severely raised blood pressure. This led to a misconception that hypertension was due to known causes (secondary hypertension), and that primary or essential hypertension was absent in childhood and adolescence (Falkner and Sadowski, 1995). This now outdated criterion of hypertension is however still being utilised in studies of hypertension in children and adolescents (Mijinyawa *et al*., 2008; Adams-Campbell *et al*., 1987; Einsterz *et al*., 1982; Abdurrahman and Ochoga, 1977).

In the middle of the 1970s, a task force was appointed by the United States National Heart, Lung and Blood Institute to study hypertension in children and adolescents. The National Heart, Lung and Blood Institute through the National High Blood Pressure Education Program Working Group on Children and Adolescents published a first "Task Force Report on Blood Pressure Control in Children" in 1977. The Task Force defined hypertension as blood pressure of above the 95th percentile for appropriate age and gender. Age-gender-specific BP percentile curves were generated for United States children and adolescents, and presented in their report. Since 1977, the definition of hypertension has generally been based on a normal distribution of blood pressure in healthy children and adolescents (percentile rank), that is, threshold levels of blood pressure are identified which are said to distinguish those at risk for severe health outcomes from those who have no increased risk (Gulati, 2006). After the publication of the 1977 task force report, a “Second Task Force on Blood Pressure Control in Children” was released in 1987.

Following this, the National High Blood Pressure Education Program (NHBPEP) Working Group on Children and Adolescents released a 1996 report - “Update on the 1987 Task Force Report on High Blood Pressure in Children and Adolescents”. In both reports the description of hypertension was retained; however, the age-gender-specific BP percentile curves were revised. In the 1996 report, height-specific percentiles were added to the age-gender-specific BP percentile curves.

The fourth report of the National High Blood Pressure Education Program (NHBPEP) Working Group on Children and Adolescents (2004) is the most current report and updates the 1996 report. According to the NHBPEP Working Group on Children and Adolescents (2004), hypertension in children and adolescents is defined as systolic blood pressure (SBP) and/or diastolic blood pressure (DBP), that is greater or equal to 95^{th} percentile for given age, gender and height on repeated (3 or more) measurements. Because the difference between blood pressure at 95^{th} percentiles and 99^{th} percentiles (in the range of 7mmHg to 10mmHg) is not large enough to adequately differentiate between mild and severe hypertension and to aid a clinical treatment plan, the NHBPEP Working Group on Children and Adolescents (2004) classified hypertension into two stages: stage 1 hypertension – blood pressure that varies between the 95th percentile to 5mmHg above the 99th percentile, and stage 2 hypertension – blood pressure levels that are more than 5mmHg above the 99th percentile.

In addition, blood pressure between the 90th and 95th percentile, or greater or equal to 120/80mmHg (regardless of whether the BP is less than 90th percentile) in childhood and adolescence is considered “high normal” or “pre-hypertensive” (it is a pointer of increased risk of developing hypertension and for recommending change in lifestyle). Normal blood pressure is defined as systolic blood pressure and diastolic blood pressure that are less than 90th percentile of the population (for given age, gender and height) (NHBPEP Working Group on Children and Adolescents, 2004).

Based on data from a large United States (US) national database on normative BP levels during childhood and adolescence which has been growing significantly since the first “Task Force Report on Blood Pressure Control in Children” in 1977, the NHBPEP Working Group (2004) provided updated BP tables/standards based on age, gender and height including 50th, 90th, 95th and 99th BP and height percentiles that allow for consideration of different levels of growth in determining BP (see Appendix 1 and 2).

These blood pressure tables have been rigorously prepared and are good standard references for blood pressure levels in children and adolescents worldwide. However, the tables are based on normative data on blood pressure levels in American children and adolescents and may not be appropriate for other populations (including Nigerian children and adolescents). Standard reference tables are needed for other countries including Nigeria, as comparing Nigerian children and adolescents to US children and adolescents may not be suitable, and there may be important differences in blood pressure levels for different ages, gender and height.

2.2.6.2 AETIOLOGY OF CHILDHOOD HYPERTENSION

Hypertension can be classified into either primary (essential) or secondary hypertension (Gulati, 2006). Essential hypertension (primary) refers to high blood pressure in children and adolescents where no cause can be established (Luma and Spiotta, 2006), while secondary hypertension is due to an identifiable underlying disorder (Gulati, 2006). The most common causes of hypertension in childhood are summarised in Table 3.

Table 3: Common causes of Hypertension by age group

Age group	**Common causes**
< 1 month	Renal artery thrombosis, renal artery stenosis, congenital malformation, coarctation of aorta, bronchopulmonary dysplasia.
≥ 1 month to < 6 years	Renal parenchymal disease, coarctation of aorta, renal artery stenosis
≥ 6 years to < 10 years	Essential hypertension, renal artery stenosis, renal parenchymal disease.
≥ 10 years to ≤ 18 years	Essential hypertension (85-90%), renal parenchymal disease.

Source: Gulati (2006)

2.2.6.3 ASSOCIATED FACTORS FOR VARIATION IN BLOOD PRESSURE IN CHILDREN AND ADOLESCENTS

Several factors have been suggested to be associated with variability in blood pressure in children and adolescents, these include: age (Ejike *et al*., 2008), gender (Agyemang *et al*., 2005), physical inactivity (Leary *et al*., 2008), dietary intake (He and MacGregor, 2006), cholesterol (Monyeki and Kemper, 2008), salt intake (He and MacGregor, 2006), anthropometric parameters (Ejike *et al*., 2008), family history of hypertension (Kuschnir and Mendonça, 2007), pubertal or sexual maturation status (Chen and Wang, 2009), psychosocial stress, occupational stress, alcohol use, smoking, social stress (Monyeki and Kemper, 2008), urbanisation (Ejike *et al*., 2008), ethnicity (Daniels *et al*., 1996), socio-economic characteristics (Kulaga *et al*., 2010), and low birth weight (Lenfant, 2008). Stranges and Cappuccio (2007) highlighted that established correlates of blood pressure in adults are increasingly being recognised and are becoming an important public health concern in youngsters. The identification of factors which are potentially modifiable will allow for the introduction of preventive intervention strategies in childhood and adolescence with the aspiration that this may lead to a reduction in high incidence of hypertension in adulthood (Garcia *et al*., 2004).

The epidemiological transition, its associated influences (such as socio-economic development and urbanisation), and lifestyle changes (towards unhealthy diets and more sedentary lifestyles – a likely precursor for increased adiposity (obesity)) underline the necessity to investigate chronic non-communicable diseases (particularly high blood pressure, a main risk factor of CVD) in developing countries (such as Nigeria). The consequences of the epidemiological transition – the double burden of disease and the looming challenge on the health system in the developing countries, highlights the need to establish how the epidemiological transition is reflected on the young population (in particular, the impact on the blood pressure pattern observed in youngsters), so as to maximise health outcomes for future cohorts, as they grow into a world influenced by its associated environmental changes (such as socio-economic development and urbanisation) and lifestyle changes.

In the next chapter (Chapter 3), I will present a literature review of the associations between measures of adiposity (as a consequence of unhealthy diets and sedentary lifestyles) and blood pressure in children and adolescents; and socio-economic characteristics and blood pressure in children and adolescents.

In addition, certain physiological sexual maturation changes have been noted to take place in teenage populations (Meininger *et al*., 2004); this may have an impact on blood pressure (Mueller *et al*., 2001). As the study population includes children and adolescents, I considered it important to assess the association between pubertal or sexual maturation status and blood pressure. A literature review on pubertal or sexual maturation and blood pressure relationship children and adolescents will also be presented in the next chapter (Chapter 3).

2.2.6.4 TRACKING OF BLOOD PRESSURE IN CHILDREN AND ADOLESCENTS

There is convincing evidence from a high quality systematic review that the prevalence of hypertension in adults may be linked to blood pressure levels during childhood and adolescence as described by the concept of "tracking" (Chen and Wang, 2008). Using meta-analytic techniques, Chen and Wang (2008) assessed the evidence from 50 medium to high quality cohort studies with reported BP tracking correlation coefficients (Spearman or Pearson method), baseline ages of less than 18 years, and wide length of follow-up of between 6 months and 47 years. The majority of the studies (92%) included in the review were from developed countries (United States, Europe, Australia, Canada, Israel, and New Zealand); and the rest of the studies were from Asia.

Tracking has been used to explain how initial blood pressure measurement at the higher or lower end of the distribution of blood pressure in childhood is likely to be maintained relative to the rest of the cohort in later life (Gidding, 2008). Reported studies on tracking of blood pressure in Africa are unfortunately scarce and only one study from Africa (Adams-Campbell *et al* (1992)) has attempted to examine the trend over time for blood pressure in children and adolescents. This may be attributed to the extensive structural requirements for long-term longitudinal research and the fact that hypertension was once believed to be uncommon in Africans. Adams-Campbell *et al* (1992) observed a significant association between initial BP levels and follow-up BP, however, the study was carried out over a period of just 1 year. The long term outcomes of high BP detected in African children and adolescents is presently unknown as no data exist to relate childhood high BP to increased hypertension risk in adulthood. More longitudinal studies are needed to determine the extent and nature of blood pressure tracking in African children and adolescents relative to their peer group, so as to arrive at more generalisable findings.

SUMMARY

In this section, I presented the underlying standpoint of the present study. I provided details on the disease pattern worldwide, the theory of the epidemiological transition, its associated influences, and its accompanying transitions. I also provided details on chronic non-communicable diseases (NCDs) (including cardiovascular diseases (CVD)) and hypertension (a main risk factor for CVD) and their health and development challenges, and significance in the global health agenda. I have set my main focus on blood pressure childhood and adolescence. I have highlighted the definition of hypertension in children and adolescents, the causes of hypertension in children and adolescents, factors associated with blood pressure in children and adolescents, and the tracking of blood pressure patterns from childhood and adolescence to adulthood.

Some of the key information from the background section includes:

- The epidemiological transition, its associated influences (such as socio-economic development and urbanisation) and its accompanying transitions underline the necessity to investigate chronic non-communicable diseases (particularly CVD) worldwide, particularly in developing countries (such as Nigeria).
- In developing countries, NCDs compete with communicable and poverty-related diseases for health system funding and resources.
- There is a rapid growth and inequitable socio-economic distribution of chronic non-communicable diseases, worldwide.
- NCDs (such as cardiovascular disease (CVD)) have an impact on health and development, thus must be tackled if the global health and development agenda (including United Nations Millennium Development Goals (MDGs)) is to be achieved.
- Hypertension is a main risk factor for cardiovascular disease (CVD).
- Childhood hypertension is not as uncommon as previously thought.
- Primary hypertension (of unknown cause) is most common in children and adolescents aged 10 to 18 years.
- Persistent hypertension in childhood and adolescence over time is associated with a higher risk of premature mortality in adulthood due to end organ damage.
- It is unknown how the influence of the epidemiological transition and its environmental and lifestyle associated factors are reflected in the blood pressure pattern variability in children and adolescent population in Nigeria.

- An investigation of the relationship between blood pressure and pubertal or sexual maturation status in this study population may be important.
- The concept of tracking of blood pressure is almost non-existent in Africa, as it has received almost no research interest.
- Country-specific standard blood pressure reference tables are lacking in many countries, including Nigeria.

In the next chapter, I will present a broad literature review on the epidemiology of hypertension in children and adolescents. I will provide an extensive review of the associations between blood pressure and the recognised associated factors of the epidemiological transition (adiposity (as a consequence of unhealthy diets and sedentary lifestyles) and socio-economic circumstances) as well as pubertal or sexual maturation status. I will also present the justification or rationale of this study, and indicate my research questions, aims and objectives and the null hypothesis of the study.

CHAPTER 3: LITERATURE REVIEW

3.0 LITERATURE REVIEW

INTRODUCTION

In this chapter, I will present the review of literature based on my four research questions identified from the background information presented in the previous chapter as well as preliminary literature searches. I will also present the justification or rationale of this study, and state my research questions, aims and objectives and the null hypothesis of the study.

The literature review on my four research questions will be presented in four sections, including:

- Epidemiology of hypertension in children and adolescents.
- Socio-economic characteristics and blood pressure in children and adolescents.
- Adiposity and blood pressure in children and adolescents.
- Pubertal maturation and blood pressure in children and adolescents.

3.1 EPIDEMIOLOGY OF HYPERTENSION IN CHILDREN AND ADOLESCENTS

INTRODUCTION

In this section, I will present a review of literature on the prevalence of hypertension in children and adolescents.

The persistent elevation of arterial blood pressure beyond a level defined as normal is known as hypertension (Moura *et al*., 2004). Hypertension in adults remains a major public health problem in both developing and developed countries (Sharma *et al*., 2010). It has been recognised as a major risk factor for the incidence of cardiovascular disease and premature mortality in adults (Sharma *et al*., 2010; Taksande *et al*., 2008; Luma and Spiotta, 2006; Thakor *et al*., 1998). According to Mijinyawa *et al* (2008), hypertension was long considered to be uncommon among children and adolescents. However, it has been increasingly reported among children and adolescents throughout the world, including Nigeria. Numerous studies have provided considerable evidence that the origins of hypertension in adults may extend back to childhood and adolescence (Chen and Wang, 2008).

I undertook a narrative review of the prevalence of hypertension in children and adolescents. The studies included were identified through various search methods. A comprehensive literature search was undertaken using MEDLINE (OVID) database (from 1946 to June Week 2, 2012) (search terms used were children, adolescents, childhood, adolescence, paediatrics, blood pressure, systolic, diastolic, hypertension, cardiovascular disease, risk factors, Africa, Nigeria, school). Searches were carried out between January 2010 and June 2012. Papers obtained from Google Scholar, hand searches, scanning of reference list of publications and recommended papers from colleagues were also included.

Publications selected for further assessment fulfilled the following inclusion criteria: 1). studies characterised by cross-sectional study design; 2). studies published in English language; 3). studies that included male or female children and adolescents, 18 years or below; 4). studies that included participants with no identifiable, known pathology (e.g., infection, neoplasm, fractures); and 5). studies that reported overall hypertension prevalence (that is combined systolic and diastolic hypertension).

Table 4 presents studies that reported the prevalence of hypertension in children and adolescents from Africa (Nigeria, Egypt, Kenya, Tunisia, and Zaire); Europe; Asia (India); Middle East; South America; and North America. Two reports (Ekunwe and Odujinrin, 1989; and Johnson, 1971) from Nigeria comprised a population drawn from Lagos (my study setting). There were relatively more papers from Nigeria (my study setting) included in this review compared to other countries.

Almost all the studies were school-based, except Obika *et al* (1995); Akinkugbe *et al* (1990); M'buyamba-Kabangu *et al* (1986); Einsterz *et al* (1982); Alakija (1979); Johnson (1971); and Akinkugbe and Ojo (1968), which were community-based studies. Overall, the studies included in this review had sample sizes ranging from approximately 250 to 21,000 participants, with age ranging from 1 to 18 years. Only two studies had sample sizes of less than 300 participants (Adams-Campbell *et al*., 1987; M'buyamba-Kabangu *et al*., 1986). A few of the studies gave details of their sample size calculation (Abolfotouh *et al*., 2011; Durrani and Fatima, 2011; Cândido *et al*., 2009; Dinc *et al*., 2009; Mijinyawa *et al*., 2008; Taksande *et al*., 2008; da Silva *et al*., 2007; Harrabi *et al*., 2006; Moura *et al*., 2004; Ghannem *et al*., 2001; Ghannem *et al*., 2000).

The majority of the studies differed in the method of selection of population groups. Some studies selected participants using a random selection method, while some had volunteer participation (Merhi *et al*., 2011; Bayat *et al*., 2009; Kollias *et al*., 2009; Chiolero *et al*., 2007a; Chiolero *et al*., 2007b; McNiece *et al*., 2007; Fuiano *et al*., 2006; Jago *et al*., 2006; King *et al*., 2006; Urrutia-Rojas *et al*., 2006; Sorof *et al*., 2004; Akinkugbe *et al*., 1999; Obika *et al*., 1995; O'Quin *et al*., 1992; Akinkugbe *et al*., 1990; Balogun *et al*., 1990b; Abu-Bakare and Oyaide, 1983; Einsterz *et al*., 1982; Silverberg *et al*., 1975).

The method of participant selection was not specified in other studies (Sharma *et al*., 2010; Taksande *et al*., 2008; da Silva *et al*., 2007; Mohan *et al*., 2004; Sorof *et al*., 2002; Irgil *et al*., 1998; Anand and Tandon, 1996; Sinaiko *et al*., 1989; Epstein *et al*., 1981; Norero *et al*., 1981; Ayoola, 1979).

In studies where participation rates were indicated, participation rates were high, ranging from 75% to 100% (Durrani and Fatima, 2011; Merhi *et al*., 2011; Cândido *et al*., 2009; Dinc *et al*., 2009; Flores-Huerta *et al*., 2009; Kollias *et al*., 2009; Mijinyawa *et al*., 2008; Nur *et al*., 2008; Chiolero *et al*., 2007a; Chiolero *et al*., 2007b; McNiece *et al*., 2007; Harrabi *et al*., 2006; Kelishadi *et al*., 2006; King *et al*., 2006; Urrutia-Rojas *et al*., 2006; Pileggi *et al*., 2005; Ghannem *et al*., 2001; Ghannem *et al*., 2000; Muraguri *et al*., 1997; O'Quin *et al*., 1992; M'buyamba-Kabangu *et al*., 1986; Muñoz *et al*., 1980; Akinkugbe and Ojo, 1968). Non-respondents were not described in any of the studies.

A non-random participant selection, inadequate sample size, moderate to low participant response rates, and a notable selection bias (where there is a possibility of dissimilarity between non-respondents and respondents and those who remained in the studies) may reduce the generalisability of findings, and could even lead to biased hypertension prevalence rates.

The blood pressure level beyond which a child or adolescent could be considered hypertensive has been hard to establish, irrespective of country or region. There were disparities in the cut-off points for classification of hypertension reported (Table 4). However, the majority of the studies, and particularly more recent studies in the last two decades have used systolic and/or diastolic blood pressure greater or equal to (≥) the 95^{th} percentile for gender, age and height to define hypertension recommended from reports by the National High Blood Pressure Education Program (NHBPEP) Working Group on Children and Adolescents (see the Background Chapter (Chapter 2) (Definition of Hypertension section) for more details on the reports from the NHBPEP Working Group). A few studies did not use the most updated recommended cut-off values by the NHBPEP Working Group as at the time their research was published.

Other cut-off points of hypertension used in studies were systolic blood pressure (SBP) and/or diastolic blood pressure (DBP) of 2 or more standard deviations (SDs) above the mean; systolic ≥ 140mmHg and/or diastolic blood pressure ≥90mmHg; systolic ≥130mmHg and/or diastolic blood pressure ≥90mmHg; systolic ≥130mmHg and/or diastolic blood pressure ≥80mmHg; systolic ≥120mmHg and/or diastolic blood pressure ≥ 80mmHg; diastolic pressure > 97^{th} percentile; diastolic pressure > 95mmHg; systolic ≥ 150mmHg and/or diastolic blood pressure ≥ 90mmHg; systolic ≥ 150 mmHg and/or diastolic blood pressure ≥ 95mmHg; systolic ≥160mmHg and/or diastolic blood pressure ≥ 95mmHg; and systolic BP ≥ 160mmHg and/or diastolic BP ≥ 90mmHg.

Blood pressure measurement methods varied in many respects across studies (Table 4). The studies vary in instrument used in measuring blood pressure. The majority of the studies used the standard mercury sphygmomanometer. One study used the standard aneroid sphygmomanometer (M'buyamba-Kabangu *et al*., 1986). The automated blood pressure monitoring device was used in the other studies (Ejike *et al*., 2010; Cândido *et al*., 2009; Monyeki *et al*., 2008; Chiolero *et al*., 2007a; Chiolero *et al*., 2007b; McNiece *et al*., 2007; Harrabi *et al*., 2006; Jago *et al*., 2006; Urrutia-Rojas *et al*., 2006; Sorof *et al*., 2004; Sorof *et al*., 2002; Ghannem *et al*., 2001; Ghannem *et al*., 2000; Balogun *et al*., 1990a). The blood pressure measurement device used was not stated in two reports (da Silva *et al*., 2007; Norero *et al*., 1981).

The use of different Korotkoff sound phases to determine diastolic blood pressure was observed across the studies where a sphygmomanometer was used. Most of the more recent studies (in the last two decades) employed the fifth Korotkoff sound phase (K5: disappearance of sound) to determine diastolic blood pressure. Other studies used the fourth Korotkoff sound phase (K4: muffling of sound).

In the second report from the National Heart, Lung, and Blood Institute (1987), the fourth Korotkoff sound (K4: muffling of sound) was used to define diastolic BP in the normative tables for children aged 3 to 12 years, and K5 was used for adolescents aged 13 to 18 years. Since the third report from NHBPEP Working Group on Children and Adolescents (1996), the fifth Korotkoff sound (K5: disappearance of sound) has been recommended as the definition of diastolic BP for all children and adolescents.

The choice of the sound phases to determine diastolic blood pressure, K4 or K5, has important implications in determining the prevalence diastolic hypertension, as the use of K4 may overestimate blood pressure readings (Biro *et al*., 1996), and make comparison of past and more recent studies difficult.

There were also differences in the number of BP measurement visits and the number of readings to confirm the presence of hypertension in the studies (Table 4). Most studies employed BP readings (with 1 to 3 sets of readings) obtained at a single visit. Other studies estimated high blood pressure from BP readings obtained from 2 visits (with 2 to 5 sets of readings taken 1 to 6 weeks apart) (Sharma *et al*., 2010; Bayat *et al*., 2009; Nur *et al*., 2008; Irgil *et al*., 1998; Sinaiko *et al*., 1989; M'buyamba-Kabangu *et al*., 1986; Epstein *et al*., 1981; Abdurrahman and Ochoga, 1977; Akinkugbe, 1969), and BP readings obtained from 3 visits (with 1 to 4 sets of readings taken 1 to 4 weeks apart) (Taksande *et al*., 2008; Chiolero *et al*., 2007a; McNiece *et al*., 2007; Mohan *et al*., 2004; Sorof *et al*., 2002; Anand and Tandon, 1996).

According to Wingfield *et al* (2002), multiple blood pressure readings have better predictive power than a single reading. For the majority of the studies, the estimates of hypertension or high blood pressure were based on 1 to 3 blood pressure measurements at a single visit. However, the NHBPEP Working Group on Children and Adolescents (2004) has suggested that accurate estimate of high blood pressure should be obtained through multiple blood pressure measurements obtained at 3 or more visits. Chiolero *et al* (2007c) highlighted that blood pressure obtained at 1 visit may overestimate usual blood pressure, because of possible regression toward the mean on successive blood pressure measurements (Sinaiko *et al*., 1989; Gardner and Heady, 1973).

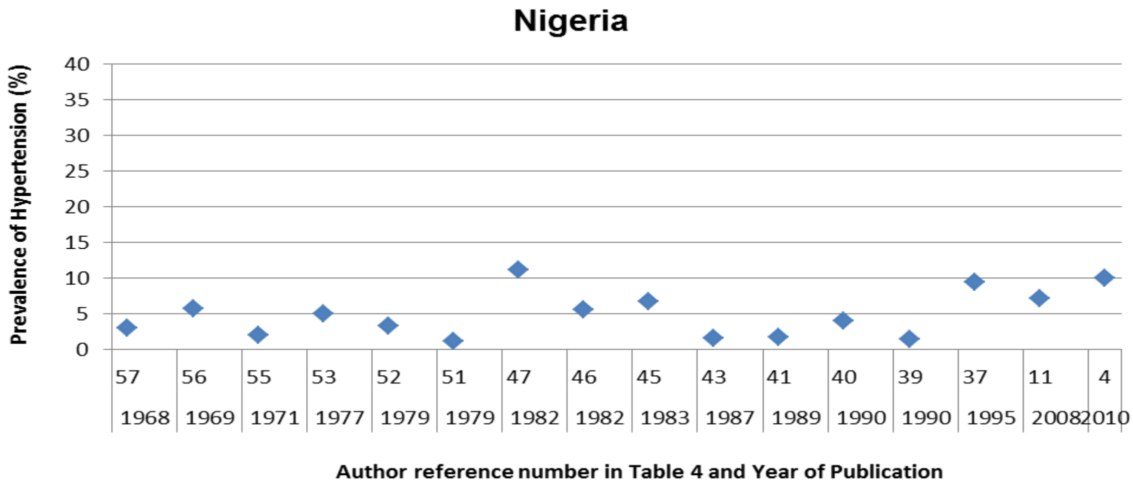
The reported prevalence of hypertension in the studies included in this review range from 0.46% reported in India by Anand and Tandon (1996) to 38.0% reported in Italy by Fuiano *et al* (2006) (Table 4). There was no specific pattern of increase or decrease in the prevalence of hypertension overtime in the studies, worldwide (Figure 11). Europe, USA and Middle East had somewhat higher levels of hypertension prevalence than other parts of the world (Figure 11). However, this should be interpreted with caution as I included a relatively lower number of studies from these regions as compared to my study setting – Nigeria in this review. The prevalence of hypertension in children and adolescents in Nigeria was reported to range from 1.2% (Alakija, 1979) to 11.2% (Einsterz *et al*., 1982). In other African countries, the prevalence of hypertension in children and adolescents was between 0.8% reported in Zaire (M'buyamba-Kabangu *et al*., 1986) and 11.2% in Tunisia (Ghannem *et al*., 2001). The European region had a range of hypertension prevalence of 2.2% in Switzerland (Chiolero *et al*., 2007a) to 38.0% in Italy (Fuiano *et al*., 2006) (Figure 11).

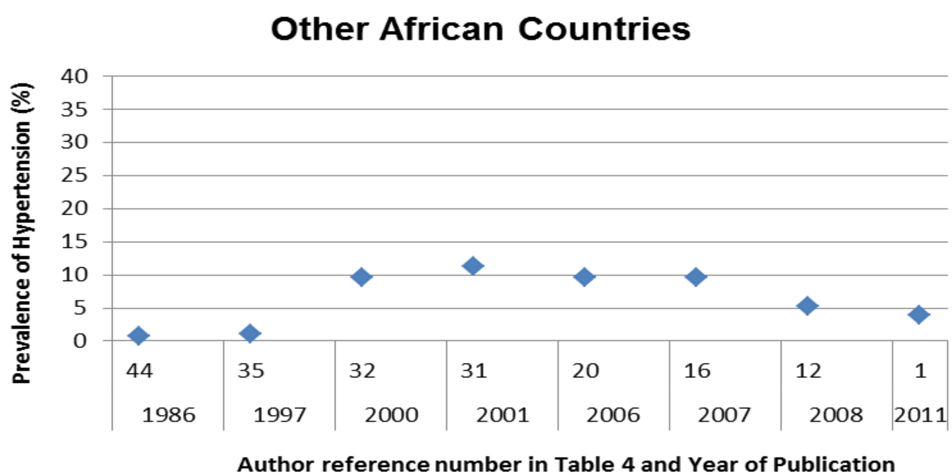
In the Middle East, hypertension prevalence in children and adolescents was between 7.7% in Iran (Kelishadi *et al*., 2006) and 16.3% in Israel (Epstein *et al*., 1981). Brazil was the only South American country in this review; the prevalence of hypertension ranged between 1.4% (Cândido *et al*., 2009) and 17.6% in Brazil (Moura *et al*., 2004). In the United States, prevalence of hypertension was between 1.0% (Sinaiko *et al*., 1989) and 21.6% (Urrutia-Rojas *et al*., 2006). Other North American studies reported hypertension prevalence of 6.5% in Mexico (Flores-Huerta *et al*., 2009) and 9.1% in Canada (Silverberg *et al*., 1975). India was the only Asian country in this review. It had hypertension prevalence rate between 0.46% (Anand and Tandon, 1996) and 9.4% (Durrani and Fatima, 2011) (Figure 11).

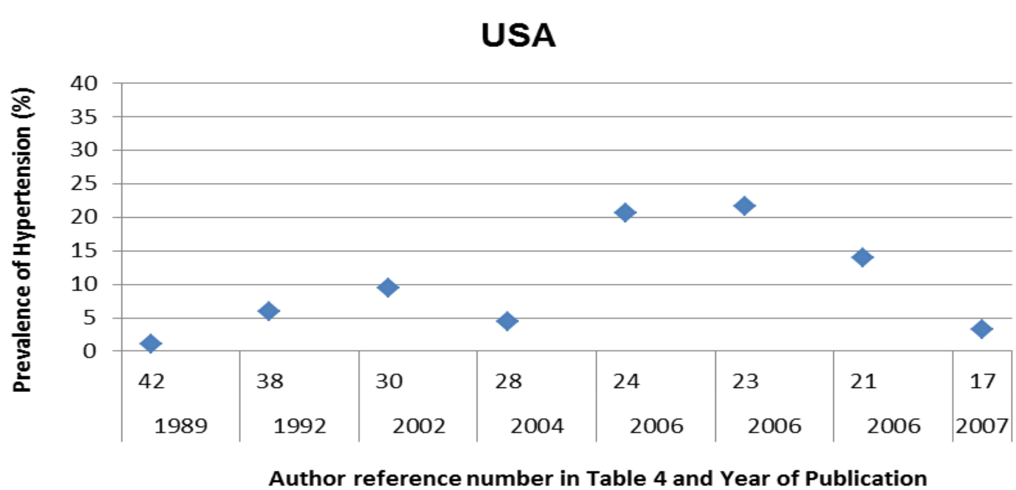
It is worth noting that one study by Akinkugbe *et al* (1990) in Nigeria reported a 0% hypertension prevalence rate; this was found in its sub-group population (Group 2 – middle income group). It was the only study which noted no participant with hypertension within its study sub-population.

In studies where rural and urban populations were specified, mostly consisting of studies from Nigeria, India and Tunisia, there were no discernible differences in the prevalence of hypertension between the urban and rural populations (Table 4). Most of the Nigerian studies included urban populations; only two studies (Einsterz *et al*., 1982; Akinkugbe and Ojo, 1968) involved rural populations. The study from rural Benue in Nigeria by Einsterz *et al* (1982) stands out from other Nigerian studies. Einsterz *et al* (1982) reported hypertension prevalence within the range of that reported by other Nigerian authors; however, they reported hypertension prevalence of 25% for their male population, which was more than twice the prevalence of hypertension noted in other Nigerian studies.

There was no specific pattern of increase or decrease in the prevalence of hypertension in studies from Nigeria spanning about 40 years (Figure 11). Most of the Nigerian papers were quite old. Only three papers (Ejike *et al*., 2010; Mijinyawa *et al*., 2008; Obika *et al*., 1995) have reported hypertension prevalence since 1990. In addition, the prevalence of hypertension in children and adolescents has been reported in only two studies from Lagos (my study setting) (Ekunwe and Odujinrin, 1989; Johnson, 1971), and these studies were carried out 20 to 30 years ago. These may be due to the fact that hypertension in children was thought to be a rare clinical problem at this time. It may also be due to the competing research interest with communicable and poverty-related diseases. It would be important to know how the current on-going epidemiological transition is impacting on the child and adolescent blood pressure in Nigeria (in particular, my study setting – Lagos).







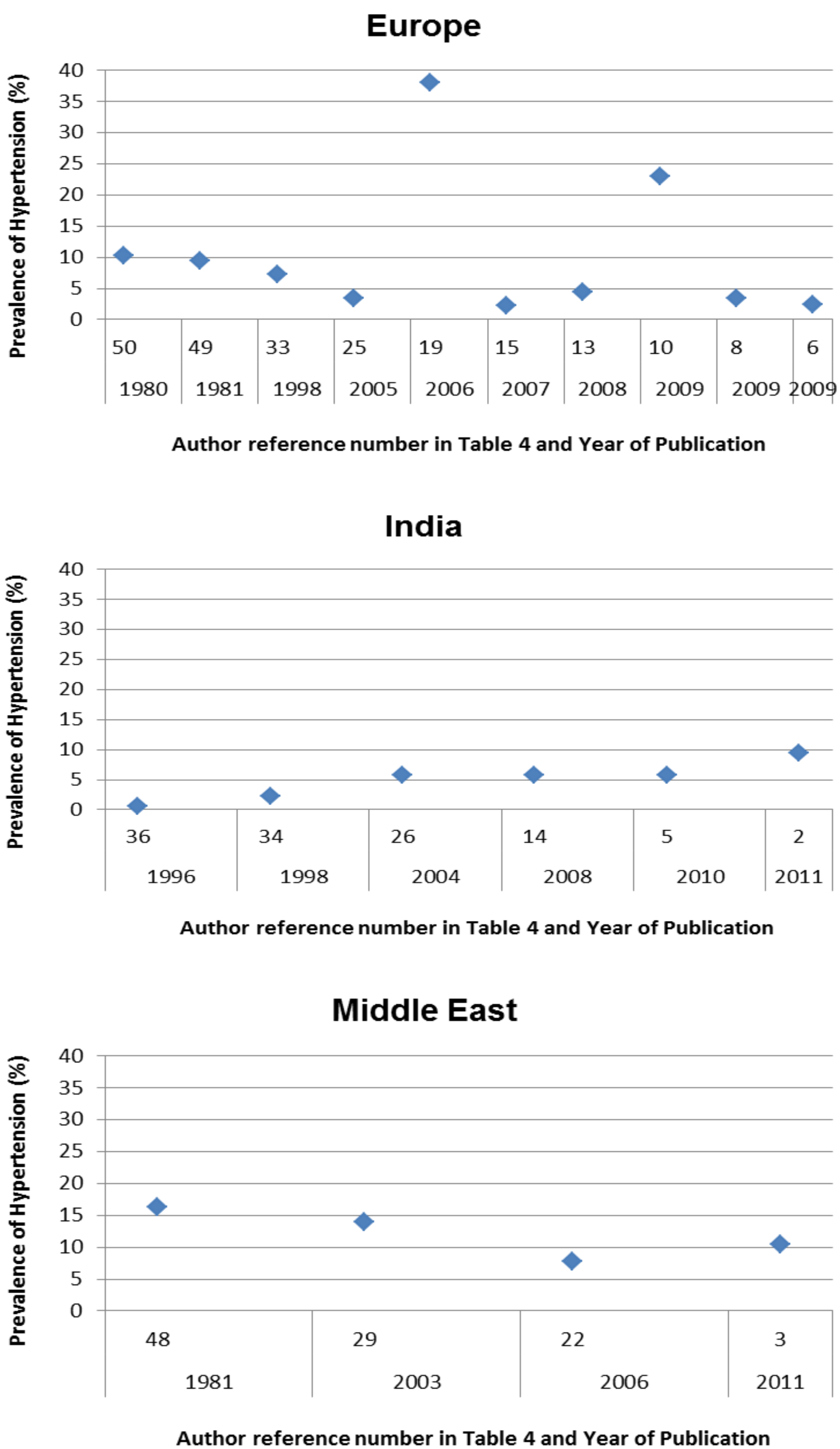


Figure 11: Prevalence of hypertension in children and adolescents in Nigeria, Other African countries, USA, Europe, India, and Middle East

SUMMARY

In this section, I presented a literature review of the prevalence of hypertension in children and adolescents in Nigeria and other parts of the world.

The studies included in this review reveal the presence of hypertension in children and adolescents. In particular, the reports have shown that hypertension in childhood and adolescence is not rare. The exact prevalence of child and adolescent hypertension for countries worldwide is not known. There are notable differences in hypertension prevalence rates in children and adolescents within and between countries and regions. Several factors may be important in the variation of the patterns and trends in childhood and adolescence hypertension across studies and countries, including: (a). the use of varying criteria for defining childhood and adolescence hypertension among different countries and researchers; (b). the different sample sizes, method of participant selection, and response rate; and (c). the differences in blood pressure measurement methods (including number of visits and blood pressure reading).

Although most studies from different countries have adopted the National High Blood Pressure Education Program (NHBPEP) Working Group recommended standardised blood pressure cut-off values; there might be significant differences between the USA child and adolescent population included in the development of the NHBPEP Working Group standard reference values and the population from countries using the cut-off values. Thus, country-specific blood pressure reference standards maybe needed to arrive at more accurate hypertension prevalence figures.

With regard to the Nigerian studies, there was no definite pattern of increase or decrease in the prevalence of hypertension in the last four decades. However most of the studies were old (mostly published two decades ago), thus, more recent studies are needed to support the evidence on the prevalence of hypertension in children and adolescents in Nigeria. In addition, given the current epidemiological transition occurring in developing countries (including Nigeria) in the 21st century, more recent studies are needed to assess its influence on child and adolescent blood pressure.

Furthermore, it has been highlighted that childhood and adolescence blood pressure predicts blood pressure in adulthood (Chen and Wang, 2008). Robust evidence from high quality studies assessing the prevalence of child and adolescent hypertension is needed so as to curb the significant hypertension-related morbidity and mortality observed in adulthood. These studies will provide a good understanding of the global situation (including Nigeria) of hypertension in children and adolescents, and assist the planning and developing of public health prevention programmes.

In the next section, I will present a literature review on the relationship between measures of socio-economic characteristics and blood pressure in children and adolescents.

Table 4: The prevalence of hypertension in children and adolescents in selected population studies in Nigeria and other parts of the world.

Author (year)	**Place of study**	**Number of participants, age (years)**	**BP Measurement Method**	**Definition of Hypertension**	**Number of visits**	**Mean SBP (SD) (mmHg) Both (B), Male (M), Female (F)**	**Mean DBP (SD) (mmHg) Both (B), Male (M), Female (F)**	**Prevalence of Hypertension (%) Both (B), Male (M), Female (F)**
Abolfotouh *et al* (2011) (1)	Urban, Egypt	1500, 11-19	Standard mercury sphygmomanometer. K1 and K5 were used. Two readings were taken, 1 minute apart, after an initial 5 minutes of rest. Mean of the 2 readings was used for SBP and DBP.	Systolic and/or diastolic BP ≥95th percentile, according to the 4th Task Force report on BP control in children (NHBPEP, 2004)	1 visit	-	-	B: 4.0, M: 4.5, F:3.6
Durrani and Fatima (2011) (2)	India	701 (363 males and 338 females), 12-16	Standard mercury sphygmomanometer. K1 and K5 were used. Three readings were taken 5 minutes apart.	Systolic and/or diastolic BP ≥95th percentile, according to the 4th Task Force report on BP control in children (NHBPEP, 2004)	1 visit	B: 114.48 (7.9)	B: 76.3 (5.13)	B: 9.4, M:9.36, F: 9.4
Merhi *et al* (2011) (3)	Lebanon	5710 (2918 males and 2792 females), 5-15	Standard mercury sphygmomanometer. K1 and K4 (5-9years) K5 (10-15 years) were used. Three readings were taken 5-10 minutes apart. Mean of the 3 readings was used for SBP and DBP.	Systolic and/or diastolic BP ≥95th percentile according to the 2nd Task Force report on BP control in children (NHBPEP, 1987)	1 visit	M: 103.05 (10.20) F: 110.84 (10.54)	M: 59.21 (6.87) F: 58.41 (6.96)	B: 10.5, M: 10.5, F:10.5

Ejike *et al* (2010) (4)	Semi-urban and urban, Kogi, Nigeria	843, 13-18	An automated digital BP monitor (Omron HEM-741 CINT). Three readings were taken 2 minutes apart, after an initial 10 minutes of rest. Mean of the last two readings used for SBP and DBP.	Systolic and/or diastolic BP ≥ 95th percentile according to the 4th Task Force report on BP control in children (NHBPEP, 2004)	1 visit	-	-	B: 10.1
	Semi-urban, Kogi, Nigeria					-	-	B: 4.4, M: 4.8, F: 4.1
	Urban, Kogi, Nigeria					-	-	B: 17.5, M: 16.9, F: 18.0
Sharma *et al* (2010) (5)	Rural and urban, India	1085 (570 males and 515 females), 11-17	Standard mercury sphygmomanometer. K1 and K5 were used. Three readings were taken 30 seconds apart, after an initial 30 seconds of rest. Mean of the last two readings was used for SBP and DBP.	Systolic and/or diastolic BP ≥ 95th percentile	2 visits	-	-	B: 5.7, M: 4.7, F: 6.8
	Urban, India	567 (311 males and 256 females), 11-17				-	-	B: 7.1, M: 5.5, F: 9.0
	Rural, India	518 (259 males and 259 females), 11-17				-	-	B: 4.3, M: 3.9, F: 4.6
Bayat *et al* (2009) (6)	Low-income level, Turkey	610 (301 males and 309 females), 6-17	Standard mercury sphygmomanometer. One reading was taken after an initial 10 minutes of rest.	Systolic and/or diastolic BP ≥ 95th percentile according to the 4th Task Force report on BP control in children (NHBPEP, 2004)	2 visits	B: 104.06 (12.01)	B: 63.99 (8.24)	B: 2.44, M: 1.9, F: 2.9
Cândido *et al* (2009) (7)	Urban, Brazil	755 (359 males and 396	An automated digital BP monitor (Omron HEM-705 CP). Three	≥ 95th percentile	1 visit	-	-	B: 1.4

		females), 6-14	readings were taken 10 minutes apart. Mean of the three readings used for SBP and DBP. Measurements were repeated with standard mercury sphygmomanometer when mean blood pressure values of exceeded the 90th percentile for confirmation.					
Dinc *et al* (2009) (8)	Urban, Turkey	1346 (766 males and 580 females), 15-18	Standard mercury sphygmomanometer. K1 and K5 were used. One to three readings (based on the level of BP) were taken 15 minutes apart, after an initial 5 minutes of rest.	Systolic and/or diastolic BP ≥ 95th percentile according to the 4th Task Force report on BP control in children (NHBPEP, 2004)	1 visit	-	-	B: 3.5, M: 3.7, F: 3.3
Flores-Huerta *et al* (2009) (9)	Mexico	912 (420 males and 492 females), 13-17	Standard mercury sphygmomanometer. K1 and K4 or K5 were used. Four readings were taken 1 minute apart. Mean of the last three readings were used for SBP and DBP.	Systolic and/or diastolic BP ≥ 90th percentile according to the 4th Task Force report on BP control in children (NHBPEP, 2004)	1 visit	M: 104.9 (10.1) F: 99.8 (9.4)	M: 65.7 (7.7) F: 64.2 (7.4)	B: 6.5
Kollias *et al* (2009) (10)	Semi-rural, Greece	2004: 446, 12-17	An automated digital BP monitor (Welch	Systolic and/or diastolic BP ≥ 95th	1 visit	B: 114.7 (12)	B: 63.2 (7.5)	B: 16.1

		2007: 558, 12-17	Allyn Vital Sign Monitor device). Three readings were taken 3 minutes apart, after an initial 5 minutes of rest. Mean of the three readings was used for SBP and DBP.	percentile according to the 4th Task Force report on BP control in children (NHBPEP, 2004)		B: 120.7 (11.4)	B: 73.8 (7.2)	B: 22.9
Mijinyawa *et al* (2008) (11)	Kano, Nigeria	968 (476 males and 492 females), 13-18	Standard mercury sphygmomanometer. K1 and K5 were used. Three readings were taken 5 minutes apart, after an initial 5 minutes of rest. Mean of the three readings was used for SBP and DBP.	≥ 140/90mmHg	1 visit	B: 111 (12.4) M: 112 (13.2) F: 111 (11.7)	B: 73 (9.4) M: 72 (9.5) F: 74 (9.2)	B: 7.2
Monyeki *et al* (2008) (12)	South Africa	1817 (938 males and 879 females), 7-13	An automated digital BP monitor. Three readings were taken 5 minutes apart, after an initial 5 minutes of rest. Mean of the last two readings used for SBP and DBP.	Systolic and/or diastolic BP ≥ 95th percentile according to the 4th Task Force report on BP control in children (NHBPEP, 2004)	1 visit	M: 98.4 (11.1) F: 101.4 (11.2)	M: 65.8 (9.3) F: 66.9 (9.0)	B: 5.3 M: 1 – 5.8 F: 3.1 – 11.4
Nur *et al* (2008) (13)	Turkey	1020 (593males and 427 females), 14-18	Standard mercury sphygmomanometer. K1 and K5 were used. Three readings were taken 5 minutes apart, after an initial 5 minutes of rest. Mean of the last two readings was used	Systolic and/or diastolic BP ≥ 95th percentile	2 visits	M: 111.9 (10.7) F: 109.7 (9.0)	M: 72.1 (8.6) F: 70.7 (7.7)	B: 4.4, M: 5.4, F: 3.0

			for SBP and DBP.					
Taksande *et al* (2008) (14)	Rural. India	2643 (1227 males and 1416 females), 6-17	Standard mercury sphygmomanometer. K1 and K5 were used. One reading after 5 minutes of rest. If the SBP was higher than 120 mm Hg and the DBP higher than 80 mm Hg, two additional readings were obtained. The lowest of the three readings was used for SBP and DBP.	Systolic and/or diastolic BP ≥ 95th percentile	3 visits	M: 105.7 (10.2) F: 103.5 (9.0)	M: 70.2 (6.8) F: 68.7 (6.8)	B: 5.75
Chiolero *et al* (2007a) (15)	Switzerland	5207 (2621 males and 2586 females), 10-15	An automated digital BP monitor (Omron M6). Three readings were taken 1 minute apart, after an initial 3 minutes of rest. Mean of the last two readings was used for SBP and DBP.	Systolic and/or diastolic BP ≥ 95th percentile according to the 4th Task Force report on BP control in children (NHBPEP, 2004)	1st visit	B: 112.9 (9.9) M: 113.1 (10.0) F: 112.6 (9.8)	B: 65.8 (7.1) M: 65.2 (7.1) F: 66..4 (7.0)	B: 11.4, M: 10.5, F:12.4
		542 (249 males and 293 females)			2nd visit	B: 121.5 (9.3) M: 123.0 (9.5) F: 120.3 (9.0)	B: 69.3 (7.5) M: 68.7 (7.8) F: 69.9 (7.2)	B: 3.8, M: 4.0, F: 3.7
		191 (100 males and 91 females)			3rd visit	B: 126.5 (9.6) M: 127.5 (10.5) F: 125.4 (8.3)	B: 72.2 (7.9) M: 72.2 (8.8) F: 72.2 (7.0)	B: 2.2, M: 2.3, F: 2.0
Chiolero *et al*	Seychelles	15612 (7802	An automated digital	Systolic and/or	1 visit	M: 104.4	M: 64.3 (9.1)	B: 9.6, M: 9.1,

(2007b) (16)		males and 7810 females), 5-16	BP monitor (Omron M5). Two readings were taken 1 minute apart, after an initial 5 minutes of rest. Mean of the two readings was used for SBP and DBP.	diastolic BP ≥ 95th percentile according to the 4th Task Force report on BP control in children (NHBPEP, 2004)		(11.6) F: 103.0 (10.9)	F: 65.6 (8.9)	F: 10.1
da Silva *et al* (2007) (17)	Brazil	1215 (531 males and 684 females), 7-17		Systolic and/or diastolic BP ≥ 95th percentile	1 visit	-	-	B: 7.7
McNiece *et al* (2007) (18)	USA	6790 (3463 males and 3327 females), 11-17	An automated BP monitor (Richmond, Va or Dinamap). Four readings were taken 1 minute apart, after an initial 3 minutes of rest. Mean of the last three readings was used for SBP and DBP.	Systolic and/or diastolic BP ≥ 95th percentile according to the 3rd Task Force report on BP control in children (NHBPEP, 1996)	3 visits	-	-	B: 3.2
Fuiano *et al* (2006) (19)	Italy	1563 (817 males and 746 females), 3-16	Standard mercury sphygmomanometer. K1 and K5. Three readings were taken 5 minutes apart, after an initial 10 minutes of rest. Mean of the three readings was used for SBP and DBP.	Systolic and/or diastolic BP ≥ 95th percentile according to the 3rd Task Force report on BP control in children (NHBPEP, 1996)	1 visit	B: 100.6 (12.2)	B: 71.5 (10.4)	B: 38.0, M: 35.1, F: 41.0

Harrabi *et al* (2006) (20)	Urban, Tunisia	1569 (748 males and 821 females), 13-18	An automated digital BP monitor. Two readings were taken at least 10 minutes apart. Mean of the two readings was used for SBP and DBP.	Systolic and/or diastolic BP ≥ 95th percentile according to age	1 visit	B: 119.50 (11.36) M: 120.22 (10.75) F: 118.84 (11.36)	B: 70.87 (18.44) M: 69.36 (11.40) F: 72.23 (22.97)	B: 9.6, M: 9.2, F: 9.9
Jago *et al* (2006) (21)	USA	1717, 12-14	An automated digital BP monitor (Omron HEM-907). Three readings were taken at least 1 minute apart, after an initial 5 minutes of rest.	Systolic and/or diastolic BP ≥ 95th percentile	1 visit	B: 114.0 (10.4) M: 117.7 (10.6) F: 111.1 (9.3)	B: 65.5 (8.8) M: 64.7 (8.8) F: 66.1 (8.7)	B: 13.8, M: 18.0, F: 10.5
Kelishadi *et al* (2006) (22)	Urban and rural, Iran	21111 (10253 males and 10858 females), 6-18	Standard mercury sphygmomanometer. K1 and K5. Two readings, after an initial 5 minutes of rest. Mean of the two readings was used for SBP and DBP.	Systolic and/or diastolic BP ≥ 95th percentile according to the 3rd Task Force report on BP control in children (NHBPEP, 1996)	1 visit	M: 103.7 (11.6) F: 102.0 (11.5)	M: 65.8 (9.7) F: 64.9 (9.3)	B: 7.7
King *et al* (2006) (23)	USA	1121 (594 males and 527 females), 5-18	Standard mercury sphygmomanometer. K1 and K5 were used. Two readings were taken 2 minutes apart, after an initial 5 minutes of rest. Mean of the two readings was used for SBP and DBP.	Systolic and/or diastolic BP ≥ 95th percentile according to the 4th Task Force report on BP control in children (NHBPEP, 2004)	1 visit	B: 110.8 (17.2)	B: 68.5 (9.3)	B: 21.6, M: 21.6, F: 21.5
Urrutia-Rojas *et al* (2006) (24)	USA	1066, 10-12	An automated BP monitor (Dinamap). Three readings were	Systolic and/or diastolic BP ≥ 95th percentile	1 visit	-	-	B: 20.6, M: 18.9, F: 22.3

			Mean of the three readings was used for SBP and DBP.	according to the 3rd Task Force report on BP control in children (NHBPEP, 1996)				
Pileggi *et al* (2005) (25)	Italy	603, 6-18	Standard mercury sphygmomanometer. K1 and K5 were used. Three readings were taken 5mins apart. Mean of the three readings was used for SBP and DBP.	Systolic and/or diastolic BP ≥ 95th percentile for age, gender and height, according to the Italian standard percentiles of BP	1 visit	-	-	B: 3.5, M: 2.2, F: 4.9
Mohan *et al* (2004) (26)	India	3326 Urban and Rural, 11-17	Standard mercury sphygmomanometer. K1 and K5 were used. Two readings were taken, after an initial 10 minutes of rest. Mean of the two readings was used for SBP and DBP.	≥ 2 SDs above the mean	3 visits	-	-	B: 5.68
		2467 Urban, 11-17				-	-	B: 6.69, M: 7.6, F: 5.81
		859 Rural, 11-17				-	-	B: 2.56, M: 3.17, F: 1.95
Moura *et al* (2004) (27)	Brazil	1,253 (547 males and 706 females), 7-17	Standard mercury sphygmomanometer. K1 and K5 were used. Two readings were taken at 2 minutes interval. Mean of the two readings was used for SBP and DBP.	Systolic and/or diastolic BP ≥ 95th percentile according to the 3rd Task Force report on BP control in children (NHBPEP, 1996)	1 visit	-	-	B: 9.4, M: 9.5, F: 9.3
		355, 7-10				-	-	B: 6.5, M: 4.2, F: 8.4
		552, 11-14				-	-	B: 8.9, M: 7.9, F: 9.5
		346, 15-17				-	-	B: 13.3, M: 17.6, F: 9.9
Sorof *et al* (2004) (28)	USA	5102 (2500 males and	An automated digital BP monitor. Three	Systolic and/or diastolic BP ≥ 95th	1 visit	126 (11)	70 (9)	B: 4.5

		2602 females), 10-18	readings were taken 1 minute apart, after an initial 3 minutes of rest.	percentile according to the 3rd Task Force report on BP control in children (NHBPEP, 1996)				
Al-Sendi *et al* (2003) (29)	Bahrain	504 (249 males and 255 females), 12-17	Standard mercury sphygmomanometer. Two readings were taken 3 minutes apart, after an initial 5 minutes of rest. Mean of the two readings was used for SBP and DBP.	Systolic and/or diastolic BP ≥ 95th percentile according to the WHO Expert committee on Hypertension Control (WHO, 1994).	1 visit	M: 122.9 (16.5) F: 118.6 (14.1)	M: 72.1 (12.1) F: 70.1 (11.7)	B: 14.0
Sorof *et al* (2002) (30)	USA	2460 (1157 males and 1303 females), 12-16	An automated digital BP monitor. Three readings were taken 1 minute apart, after an initial 3 minutes of rest.	Systolic and/or diastolic BP ≥ 95th percentile according to the 3rd Task Force report on BP control in children (NHBPEP, 1996)	3 visits	-	-	B: 9.5
Ghannem *et al* (2001) (31)	Rural, Tunisia	793 (369 males and 424 females), 12-17	An automated digital BP monitor. Two readings were taken 10 minutes apart. Mean of two readings was used for SBP and DBP.	SBP and/or DBP > 95th percentile of according to age	1 visit	B: 116.78 (13.38) M: 116.28 (14.21) F:117.21 (12.62)	B: 66.19 (10.18) M: 65.16 (10.8) F: 67.09 (9.54)	B: 11.2, M: 11.7, F: 10.8
Ghannem *et al* (2000) (32)	Urban, Tunisia	1569 (748 males and 821 females), 13-18	An automated digital BP monitor. Two readings were taken 10 minutes apart. Mean of two	Systolic and/or diastolic BP ≥ 95th percentile according to age	1 visit	B: 119.50 (11.36) M: 120.22 (10.75)	B: 70.87 (18.44) M: 69.36 (11.40)	B: 9.6, M: 9.2, F: 9.9

			readings was used for SBP and DBP.			F: 118.84 (11.36)	F: 72.23 (22.97)	
Irgil *et al* (1998) (33)	Turkey	3641 (1574 males and 2067 females), 13-18	Standard mercury sphygmomanometer. K1 and K5 were used. 15 minutes of rest before initial reading.	Systolic and/or diastolic BP ≥ 95th percentile according to the 2nd Task Force report on BP control in children (NHBPEP, 1987)	2 visits	-	-	B: 7.2
Thakor *et al* (1998) (34)	Urban, India	2250 (1092 males and 1158 females), 10-16	Standard mercury sphygmomanometer. K1 and K5 were used. Two readings were taken 10 to 15 minutes apart, after an initial 10 to 15 minutes of rest. Mean of the two readings was used for SBP and DBP.	Systolic and/or diastolic BP ≥ 95th percentile according to the 2nd Task Force report on BP control in children (NHBPEP, 1987)	1 visit	-	-	B: 2.3, M: 0.9, F: 3.5
Muraguri *et al* (1997) (35)	Kenya	397 (201 males and 196 females), 13-18	Standard mercury sphygmomanometer. K1 and K5 were used. Three readings were taken. Mean of the three readings was used for SBP and DBP.	Systolic and/or diastolic BP ≥ 95th percentile according to age and gender	1 visit	M: 111 (9.6) F: 108 (9.9)	M: 67 (7.85) F: 66 (6.54)	B: 1.0, M: 0.99, F: 1.2
Anand and Tandon (1996) (36)	Urban, India	5000 (2957 males and 2043 females), 5-17	Standard mercury sphygmomanometer. K1 and K5 were used. Three readings were taken 5 minutes apart, after an initial	≥ 2 SDs above the mean for age and gender	3 visits	M: 107.2 (4.1) F: 106.5 (3.4)	M: 71.6 (3.0) F: 71.1 (3.0)	B: 0.46

			5 minutes of rest. Mean of the three readings was used for SBP and DBP.					
Obika *et al* (1995) (37)	Urban, Kwara, Nigeria	2526 (1354 males and 1172 females), 1-14	Standard mercury sphygmomanometer. K1 and K4 and K5 were used. One reading was taken.	≥ 130/80mmHg	1 visit	-	-	B: 9.5
	Urban, Kwara, Nigeria			≥ 2 SDs above the mean		-	-	B: 4.9
	Rural, Kwara, Nigeria			≥ 130/80mmHg		-	-	B: 6.3
	Rural, Kwara, Nigeria			≥ 2 SDs of the mean		-	-	B: 2.9
O'Quin *et al* (1992) (38)	USA	5537, 14-19	Standard mercury sphygmomanometer. K1 and K5 were used. One reading was taken.	Systolic and/or diastolic BP ≥ 95th percentile according to the 2nd Task Force report on BP control in children (NHBPEP, 1987)	1 visit	-	-	B: 6.0
Akinkugbe *et al* (1990) (39)	Ibadan, Nigeria	1,340 (679 males and 661 females), 6-12	Standard mercury sphygmomanometer. K1 and K5 were used. One reading was taken.	≥ 95th percentile	1 visit	M: 102.2 F: 105.3	M: 67.4 F: 68.5	B: 1.5, M: 1.3, F: 1.8
		Group 1 (high-income) - 444 (240 males and 204 females), 6-				M: 96.9 F: 101.2	M: 63.3 F: 65.5	B: 0.2, M: 0.4, F: 0.1

		12						
		Group 2 (middle-income) - 368 (167 males and 201 females), 6-12				M: 100.9 F: 102.8	M: 66.4 F: 66.6	B: 0.0, M: 0.0, F: 0.0
		Group 3 (low-income) - 528 (272 males and 256 females), 6-12				M: 107.6 F: 110.6	M: 71.5 F: 72.3	B: 4.2, M: 2.9, F: 5.5
Balogun *et al* (1990a) (40)	Urban, Osun, Nigeria	807 (430 males, 377 females), 8-18	An automated digital BP monitor. One reading was taken after an initial 20 minutes of rest.	≥ 95th percentile	1 visit	B: 104.3 (14.1)	B: 72.8 (9.6)	B: 4.0
Ekunwe and Odujinrin (1989) (41)	Urban, Lagos, Nigeria	541 (309 males and 232 females), 11-17	Standard mercury sphygmomanometer.	Diastolic BP ≥ 97th percentile for age and gender	1 visit	M: 102.2 (8.6) F: 107.7 (9.9)	M: 64.4 (7.7) F: 67.5 (7.9)	B: 1.7, M: 1.9, F: 1.3
Sinaiko *et al* (1989) (42)	USA	14686 (7578 males and 7108 females), 10-15	Standard mercury sphygmomanometer. K1 and K4 (10-12 years) and K5 was used (13-15 years). Two readings were taken 1 minute apart, after an initial 5 minutes of rest. Mean of the two	Systolic and/or diastolic BP ≥ 95th percentile according to the 2nd Task Force report on BP control in children (NHBPEP, 1987)	1 visit	M: 107.4 (0.1) F: 106.5 (0.1)	M: 62.2 (0.2) F: 65.7 (0.1)	B: 4.2

			readings was used for SBP and DBP.					
Adams-Campbell *et al* (1987) (43)	Urban, Edo, Nigeria	254 (153 males, 101 females), 6-17	Standard mercury sphygmomanometer, K1 and K5 was used. Three readings were taken. Mean of the last two readings was used for SBP and DBP.	≥ 140/90mmHg	1 visit			B: 1.6, M: 1.3, F: 2.0
		6-11				M: 95.7 (10.7) F: 96.6 (12.7)	M: 61.9 (10.8) F: 59.5 (8.9)	B: 0.7
		12-17				M: 108.5 (12.0) F: 111.2 (10.4)	M: 69.0 (9.6) F: 68.7 (9.7)	B: 2.3
M'Buyamba-Kabangu *et al* (1986) (44)	Urban, Zaire	251(110 males and 141 females), 10-18	Aneroid sphygmomanometer. K1 and K5 were used. Five readings were taken 5 minutes apart. Mean of the ten readings was used for SBP and DBP.	≥ 160/95mmHg	2 visits	M: 110 (1.0) F: 109 (1.0)	M: 60 (1.0) F: 60 (1.0)	B: 0.8, M: 0.9, F: 0.7
Abu-Bakare and Oyaide (1983) (45)	Urban, Edo, Nigeria	684 females, 11-18	Standard mercury sphygmomanometer. K1 and K4 were used. Two readings were taken 5 minutes apart, after an initial 5 minutes of rest. Mean of the two readings was used for SBP and DBP.	≥ 2 SDs above the mean	1 visit	B: 110.60 (11.11)	B: 69.46 (10.47)	B: 6.8
Eferakeya and Ekeocha (1982) (46)	Edo, Nigeria	1137 (592 males and 545	Standard mercury sphygmomanometer. K1 and K4 were	≥ 2 SDs above the mean for age	1 visit	B: 101.2 (9) M: 100.1 (9)	B: 59.7 (5) M: 59.4 (5)	B: 5.6, M: 6.3, F: 5.1

		females), 6-15	used. Two readings were taken 5 minutes apart, after an initial 5 minutes of rest. Mean of the two readings was used for SBP and DBP.			F: 100.1 (9)	F: 58.5 (5)	
Einsterz *et al* (1982) (47)	Rural, Benue, Nigeria	133 (60 males and 73 females), 11-15	Standard mercury sphygmomanometer. K1 and K4 and K5 were used. Two readings were taken 2 minutes apart. Mean of the two readings was used for SBP and DBP.	≥ 140/90mmHg	1 visit	M: 112.9 F: 115.2	M: 66.5 F: 66.4	B: 9.95, M: 16.1, F: 3.8
		160 (56 males and 104 females), 16-20				M: 129.1 F: 119.7	M: 77.1 F: 71.4	B: 12.5, M: 20.0, F: 5.8
Epstein *et al* (1981) (48)	Israel	804 (434 males and 370 females), 16-18	Standard mercury sphygmomanometer. K1 and K5 were used. An initial 10 minutes of rest.	≥ 130/90mm Hg	2 visits	M: 119.3 (13.9) F:113.7 (13.3)	M: 72.5 (10.8) F: 70.8 (10.1)	B: 16.3, M: 20.3, F: 11.6
Norero *et al* (1981) (49)	Urban, Chile	2976 (1325 males and 1651 females), 11-18	One reading was taken.	≥ 95th percentile	1 visit	-	-	B: 9.5, M: 10.2, F: 8.9
		1224 (622 males and 602 females), 11-14						B: 11.3, M: 11.3, F: 11.3
		1752 (703 males and 1049 females), 15-18						B: 8.2, M: 9.2, F: 7.5

Muñoz *et al* (1980) (50)	Venezuela	2,809 (1392 males and 1417 females), 6-15	Standard mercury sphygmomanometer. K1, K4 and K5 were used. One reading was taken in general. Two more readings were taken if the SBP was ≥130mmHg and DBP was ≥80mmHg. Lowest of the three readings was used for SBP and DBP.	SBP ≥ 130mmHg (6-10 years), SBP ≥ 140mmHg (11-15 years), DBP ≥ 84mmHg (6-10 years), DBP ≥ 90mmHg (11-15 years)	1 visit	M: 107.30 (15.24) F: 110.56 (16.25)	M: 66.70 (9.68) F: 68.89 (10.36)	B: 10.2, M: 7.0, F: 13.3
Alakija (1979) (51)	Edo, Nigeria	318, 10-18	Standard mercury sphygmomanometer. K1 and K4 and K5 were used. Three readings were taken. Mean of the three readings was used for SBP and DBP.	≥ 160/90mmHg	1 visit	M: 105.0 F: 110.0	M: 64.0 F: 65.0	B: 1.2, M: 1.6, F: 0.7
Ayoola (1979) (52)	Semi-urban, Oyo, Nigeria	487 (294 males and 193 females), 11-18	Standard mercury sphygmomanometer. K1 and K5 were used. Three readings were taken, after an initial 30 minutes of rest.	≥ 150/90mmHg	1 visit	B: 106.5 (11.8) M: 106.2 (12) F: 106.9 (11)	B: 61.0 (9) M: 59.9 (8.8) F: 62.7 (9.5)	B: 1.0
				≥ 2 SDs above the mean				B: 3.3
Abdurrahman and Ochoga (1977) (53)	Kaduna, Nigeria	592, 6-15	Standard mercury sphygmomanometer. K1 and K4 were used. Two readings were taken.	≥ 2 SDs above the mean	2 visits	M: 103.6 (9) F: 103.7 (10)	M: 64.3 (9) F: 63.6 (10)	B: 3.5
				≥ 120/80mmHg: children ≤ 10 years and ≥ 140/90mmHg: children ≥ 11 years				B: 5.0

Silverberg *et al* (1975) (54)	Canada	15594 (7782 males and 7812 females), 15-18	Standard mercury sphygmomanometer. K1 and K5 were used. One to three readings (based on the level of BP) were taken 5 minutes apart, after an initial 5 minutes of rest.	≥ 150/95mmHg	1 visit	M: 125.0 (12.1) F: 119.8 (10.2)	M: 71.8 (10.9) F: 72.3 (9.2)	B: 2.2, M: 3.1, F: 1.3
				≥ 140/90mmHg				B: 9.1, M: 12.4, F: 5.9
Johnson (1971) (55)	Urban Lagos, Nigeria	370 (150 males and 220 females), 10-18	Standard mercury sphygmomanometer. K1 and K4 were used. One reading was taken, after 5 minutes of rest.	≥ 160/95mmHg	1 visit			B: 2.0, M: 2.4, F: 1.7
		199 (73 males and 126 females), 10-14				M: 109.2 (12) F: 113.4 (12.2)	M: 69.7 (10.2) F: 71.7 (16.6)	
		171 (77 males and 94 females), 15-18				M: 124.3 (17) F: 125.4 (13.6)	M: 78.8 (11.8) F: 78.8 (10.0)	
Akinkugbe (1969) (56)	Oyo, Nigeria	1383 (863 males and 520 females), 12-18	Standard mercury sphygmomanometer, K1 and K4 were used. Two readings were taken.	Diastolic BP > 90mmHg	2 visits	-	-	B: 5.8
Akinkugbe and Ojo (1968) (57)	Rural, Oyo, Nigeria	620 (335 males and 285 females), 10-14	Standard mercury sphygmomanometer. K1 and K4 were used.	≥ 140/90mmHg	1 visit	M: 97 (15.6) F: 101.5 (16.2)	M: 59.6 (12.0) F: 61.7 (12.2)	B: 0.5, M: 0.3, F: 0.7
		499 (238 males and 261				M: 116.1 (19.4)	M: 71.4 (11.6)	B: 5.7, M: 7.6, F: 3.8

		females), 15-18				F: 115.0 (14.1)	F: 72.1 (9.2)	

3.2 SOCIO-ECONOMIC CHARACTERISTICS AND BLOOD PRESSURE IN CHILDREN AND ADOLESCENTS

INTRODUCTION

In this section, I will present a detailed review of published evidence that assesses the relationship between measures of socioeconomic characteristics and blood pressure in children and adolescents.

The term 'socio-economic characteristics' (SEC) refers to presumed homogeneous features (such as of needs, values, attitudes, diet, occupational aspirations and opportunities, education, habits, stress, effective income, material possession, physical environments, prestige and social participation) of people (individuals, families, households, or other aggregates) who occupy similar positions within a status stratification determined by the society (Oladipo and Adekunle, 2010; Bollen *et al*., 2001; Hunter *et al*., 1979). Socio-economic characteristics are most commonly associated contributors to the discrepancies in health (Dalglish, 2009; Shavers, 2007; Adler *et al*., 1994; Kaplan and Keil, 1993).

It has been theorised that as social-cultural transitions occur during the process of economic development, risk factors for cardiovascular disease (including high blood pressure) and certain lifestyles (such as sedentary activities, smoking, high energy and high fat diet) become more prevalent in those of higher socio-economic characteristics (SEC) (Suchday *et al*., 2008; Mendez *et al*., 2003; Colhoun *et al*., 1998). With more widespread westernisation and economic development, it is hypothesised that the direction of the gradient of the risk factor associations will alter, becoming more prevalent in those of lower socio-economic characteristics (Suchday *et al*., 2008;

Mendez *et al*., 2003; Colhoun *et al*., 1998). Given this theory, a relatively consistent negative gradient is observed in developed countries (Colhoun *et al*., 1998; Kaplan and Keil, 1993), and in contrast, a positive but a more heterogeneous association occurs in developing countries (where various countries are at different stages of the socio-cultural, and epidemiological transitions) (Mendez *et al*., 2003; Colhoun *et al*., 1998; Gilberts *et al*., 1994; Bunker *et al*., 1992; Ogunlesi *et al*., 1991).

Several authors have suggested that socio-economic circumstances in utero – "the Barker hypothesis" – and in childhood have an influence on cardiovascular risk, including blood pressure in adulthood (Galobardes *et al*., 2006; Kivimaki *et al*., 2006; Hardy *et al*., 2003; Poulton *et al*., 2002; Zhao *et al*., 2002; Blane *et al*., 1996; Curhan *et al*., 1996a; Curhan *et al*., 1996b; Wannamethee *et al*., 1996). Given the relative consistency in the socio-economic gradient in blood pressure in adults in developed and developing countries, and the importance of the impact of socio-economic characteristics early in life on blood pressure in adulthood, it is uncertain at what stage in a person's lifetime these socio-economic differences are established and have their health effect. If a socio-economic gradient in blood pressure does exist in early life, the direction of this gradient is unknown and may not be the same in all countries.

I undertook a narrative review of the association between socio-economic characteristics and blood pressure in children and adolescents. The studies included were identified through various search methods. A comprehensive literature search was undertaken using MEDLINE (OVID) database (from 1946 to June Week 2, 2012) (search terms used were children, adolescents, childhood, adolescence, paediatrics, blood pressure, systolic, diastolic, hypertension, cardiovascular disease, socio-economic, socioeconomic, socioeconomic position, socioeconomic factors, socio-economic status, socio-economic class, social class, social group, occupation, education, income, wealth, deprived, privileged, disadvantaged, gradient, race, ethnicity, urban, rural, rich, poor, developed, developing, risk factors, determinant, school). Searches were carried out between January 2010 and June 2012. Papers obtained from Google Scholar, hand searches, scanning of reference list of publications and recommended papers from colleagues were also included.

Publications selected for further assessment fulfilled the following inclusion criteria: 1). studies characterised by cross-sectional study design; 2). studies published in English language; 3). studies that included male or female children and adolescents, 18 years or below; 4). studies that included participants with no identifiable, known pathology (e.g., infection, neoplasm, fractures); 5). studies that presented data on the association between any measure of socio-economic characteristics and blood pressure; 6). studies that used blood pressure as a continuous variable; and 7). studies that analysed the association between measures of socio-economic characteristics and blood pressure using multiple linear regression statistics or Pearson correlation or Analysis of variance (ANOVA) or t-test.

Studies of socio-economic characteristics differences in blood pressure among children and adolescents in Nigeria are limited. The first study that investigated the relationship between socio-economic characteristics and blood pressure in Nigerian children and adolescents was published three decades ago by Eferakeya and Ekeocha (1982), and since then only a few studies have been carried out on the Nigerian child and adolescent population (Akor *et al*., 2010; Akinkugbe *et al*., 1999; Akinkugbe *et al*., 1990; Balogun *et al*., 1990a; Adams-Campbell *et al*., 1987). In this review, I included studies from both developed countries (including United Kingdom, United Sates of America

(USA), Poland, Turkey, Finland, Australia, and Israel) and developing countries (including Nigeria, India, Congo, Indonesia, Iran and Ghana) that assessed the relationship between socio-economic characteristics and blood pressure (Table 5).

The studies had sample sizes ranging from approximately 250 (Adams-Campbell *et al*., 1987) to 21,000 (Kelishadi *et al*., 2006) participants. Only one study indicated any sample size calculation (Kozinetz, 1991). Most of the studies used schools as their sample source to recruit participants, except for three studies where participants were recruited from electronic medical record (EMR) data from primary care practices (Falkner *et al*., 2006) and national register (Leino *et al*., 1996; and Macintyre *et al*., 1991). Half of the studies selected participants using random sampling. However, in a number of studies, samples were not randomly selected but represented volunteers (Rao and Apte, 2009; Akinkugbe *et al*., 1999; Balogun *et al*., 1990a; Liebman *et al*., 1986; Dwyer *et al*., 1980). Others studies did not describe the method of participant selection (Falkner *et al*., 2006; Soylu *et al*., 2000; Epstein *et al*., 1981; Kotchen *et al*., 1974).

Participant response rate was reported in some studies (Rao and Apte, 2009; Harding *et al*., 2008; Julia *et al*., 2006; Van Lenthe *et al*., 2001; Leino *et al*., 1996; Rona *et al*., 1996; Kozinetz, 1991; Macintyre *et al*., 1991; Gliksman *et al*., 1990; Walter and Hofman, 1987; Gillum *et al*., 1985; Khoury *et al*., 1981; Miller and Shekelle, 1976; Kotchen *et al*., 1974). The highest participant response rate was 99% (Kotchen *et al*., 1974) and the lowest response rate was 39% (Kozinetz, 1991). Many of the studies had a high participant response rate; only a few of the studies reported a participant response rate of less than 70% (Leino *et al*., 1996; Kozinetz, 1991; Gillum *et al*., 1985; Miller and Shekelle, 1976).

A small number of studies reported both a random sampling selection of participants and a participant response rate (Harding *et al*., 2008; Julia *et al*., 2006, Van Lenthe *et al*., 2001; Leino *et al*., 1996; Rona *et al*., 1996; Kozinetz, 1991; Macintyre *et al*., 1991; Gliksman *et al*., 1990; Walter and Hofman, 1987; Gillum *et al*., 1985; Khoury *et al*., 1981; Miller and Shekelle, 1976; Kotchen *et al*., 1974). None of these studies were from Nigeria or even from the African continent. A selective non-participation (selection) bias may have occurred in the studies using non-representative samples of children, which may influence the findings from these studies. An indication of the study participation rate is important, as a low participation rate may lead both to selection bias where the appropriate population has not been included in the studies, and also to a smaller reduced sample size which may reduce the statistical power of the study.

Measuring socio-economic characteristics (SEC) in both adults and children has been highlighted to be problematic, complex and multifactorial (Sheppard *et al*., 2009; Braveman *et al*., 2005) (see Methodological Issues Chapter (Chapter 4)). The measures of socio-economic characteristics varied across studies. Most of the studies have used a single variable to measure socio-economic characteristics, while a few studies have used multiple variables to measure socio-economic characteristics (Kulaga *et al*., 2010; Kelishadi *et al*., 2006; Macintyre *et al*., 1991; Balogun *et al*., 1990a; Liebman *et al*., 1986; Gillum *et al*., 1985; Epstein *et al*., 1981; Khoury *et al*., 1981; Blankson *et al*., 1977). In addition, most studies used socio-economic characteristics variables without noting the rationale for why a given measure was selected over others. Only Macintyre *et al* (1991) and Balogun *et al* (1990a) mentioned the rationale for their choice of socio-economic characteristics measurement method. According to Braveman *et al* (2005), a measure of socio-economic characteristics may have varied meanings in different societies. The accuracy of socio-economic characteristics measures for given populations is important for valid results to be obtained from studies.

Numerous measures of socio-economic characteristics were used in the studies; these include: family income, family type (nuclear or single-parent), place of residence (privileged or deprived, and child's postcode of residence), parental education level, parental occupation, living environment, housing tenure, crowding index, wealth (poor urban or non-poor urban), insurance type, school type (private or public schools), location of schools, and school tuition fee level (Table 5). There is no notable difference in the measures of socio-economic characteristics reported between studies from developed and developing countries. The most commonly used measures of socio-economic characteristics were school tuition fee level, parent education level and parent occupation.

Blood pressure was also measured with a variety of methods and measuring instruments across studies (Table 5). The most commonly used BP measuring instruments was the standard mercury sphygmomanometer, used in about 60% of the studies. Approximately 23% and 13% of studies used an automated blood pressure monitor and random-zero sphygmomanometer for BP measurement, respectively. Other studies used an aneroid sphygmomanometer or an automated sphygmomanometer. Falkner *et al* (2006) is the only study which used both an aneroid sphygmomanometer and an automated monitoring device. The number of BP measurements undertaken per visit varied between the studies. Some used a single BP measurement, while others used two to five measurements of BP. Multiple BP readings reduce within-individual variability in BP measurements (Gillman and Cook, 1995), thus producing more precise measurement values.

The majority of the papers reviewed here had the relationship between measures of socio-economic characteristics and blood pressure as one of the main areas of focus. Others treated socio-economic characteristics as potential confounders of relationships between other variables and blood pressure (Harding *et al*., 2008; Falkner *et al*., 2006; Kelishadi *et al*., 2006; Kozinetz, 1991; Liebman *et al*., 1986). Comparing findings of different studies is difficult and complex because of the heterogeneity of samples (such as ethnicity and stage of economic development), methodological differences (such as sample size and participant selection methods, inconsistency in blood pressure measurement procedures, blood pressure instrument), differences in measure of socio-economic characteristics and statistical analysis.

In adult populations, somewhat consistent evidence on the pattern in socio-economic characteristics and blood pressure association is observed, with a difference in socio-economic characteristics and blood pressure association between developed and developing countries in the adult population. A negative/inverse association is reported in developed countries in the adult population, while a positive association is reported in developing countries (Mendez *et al*., 2003; Colhoun *et al*., 1998; Gilberts *et al*., 1994; Kaplan and Keil, 1993; Bunker *et al*., 1992; Ogunlesi *et al*., 1991). Studies in this present literature review have shown inconsistent results for the relationship between socio-economic characteristics and blood pressure in children and adolescents, irrespective of the stage of socio-economic development of the countries (that is, developing or developed countries).

Some studies have indicated an inverse relationship between the measure of socio-economic characteristics used and blood pressure (systolic and diastolic blood pressure) in children and adolescents. These include studies from developed countries (Kulaga *et al*., 2010; Leino *et al*., 1996; Macintyre *et al*., 1991; Gillum *et al*., 1985; Miller and Shekelle, 1976; Kotchen *et al*., 1974), and from a developing country (Congo) (Longo-Mbenza *et al*., 2007). A negative or inverse relationship between only diastolic blood pressure (DBP) and the measure of socio-economic characteristics was reported in other studies from developed countries (Rona *et al*., 1996; Walter and Hofman, 1987), and developing countries (Kelishadi *et al*., 2006; Blankson *et al*., 1977). One study (Liebman *et al*., 1986) from the USA reported a negative or inverse relationship between only systolic blood pressure (SBP) and socio-economic characteristics (family type).

A racial or gender difference in the findings was reported by some of these studies mentioned above. Miller and Shekelle (1976) reported an inverse association between blood pressure and their measure of socio-economic characteristics in white but not in black children; while Kotchen *et al* (1974) reported an inverse relationship between their measure of socio-economic characteristics and blood pressure in black but not white children. Leino *et al* (1996) found that only blood pressure in males was inversely related to their socio-economic characteristics. Macintyre *et al* (1991) reported that only blood pressure in females was inversely associated with only one of the socio-economic characteristics measures (housing tenure).

On the other hand, a higher socio-economic characteristics with higher blood pressure (a positive relationship) in childhood and adolescence was reported in some studies, both from developed countries (Falkner *et al*., 2006; Soylu *et al*., 2000), and developing countries (Akor *et al*., 2010; Rao and Apte, 2009; Akinkugbe *et al*., 1990). One study reported a gender difference in their findings. Akinkugbe and colleagues (1990) reported that both SBP and DBP were higher in males from the highest socio-economic group; however, only DBP was higher in females from the highest socio-economic group.

Some authors reported mixed findings within their study on direction of gradient on the relationship between socio-economic characteristics and blood pressure in children and adolescents. Kelishadi *et al* (2006) reported that school type measure of socio-economic characteristics was positively related to blood pressure (SBP and DBP); while a negative relationship with DBP was reported for mother's education level. Akinkugbe *et al* (1999) found that SBP was negatively related to father's education level in only the older female children; while DBP was positively related to father's education level in only the older female children.

Other studies found no significant relationship between socio-economic characteristics and blood pressures in children and adolescents (Harding *et al*., 2008; Julia *et al*., 2006; Van Lenthe *et al*., 2001; Kozinetz, 1991; Balogun *et al*., 1990a; Gliksman *et al*., 1990; Adams-Campbell *et al*., 1987; Eferakeya and Ekeocha, 1982; Epstein *et al*., 1981; Khoury *et al*., 1981; Dwyer *et al*., 1980).

SUMMARY

In this section, I have carried out a review of literature on the association between measures of socio-economic characteristics and blood pressure in children and adolescents.

Socio-economic development associated with the epidemiological transition in developing countries (including Nigeria) is theorised to influence the pattern at which higher blood pressure emerges in a society. This review provides mixed findings from the studies on the association between blood pressure and socio-economic characteristics in children and adolescents worldwide, as there were no discernible differences in the pattern of association between socio-economic characteristics and blood pressure in developed and developing countries. The pattern of socio-economic characteristics-BP association in children and adolescents is still being debated. It is unclear whether the pattern of socio-economic characteristics-BP association in children and adolescents mimics that reported in adults.

In Nigeria, studies on the socio-economic characteristic differences in blood pressure among children and adolescents are scarce and quit old. It would be important to know how the current on-going socio-economic development that influences the epidemiological transition in developing countries (including Nigeria) is impacting on child and adolescent blood pressure. Additional work on the socio-economic characteristics-BP relationship for children and adolescents is needed from Nigeria and the rest of the world. Studies with sound methodological rigour and justification which avoid the potential limitations highlighted from previous studies (such as method of participant selection, reporting of participant response rates, the lack of standardised methods used for blood pressure measurement, and rationale for the use measures of assessing socio-economic characteristics) are needed. These studies will provide a strong evidence-base for understanding the association between socio-economic characteristics and blood pressure, and enable appropriate preventive programmes in children and adolescents.

In the next section, I will present a literature review on the association between adiposity and blood pressure in children and adolescents.

Table 5: Association between measures of socio-economic characteristics and blood pressure in children and adolescents

Author (year)	**Country (country type)**	**Number of participants (Both, Male, Female), age (years)**	**Instrument, BP measurements**	**Socio-economic characteristic measure**	**Statistics/ variables adjusted for**	**Outcome**	
						SBP Both, Male (M), Female (F)	**DBP Both, Male (M), Female (F)**
Akor *et al* (2010)	Nigeria (developing country)	650 (310 males and 340 females), 5-12 years	Standard mercury sphygmomanometer. K1 and K5. Two readings were taken. Mean of the two readings was used for SBP and DBP.	School type. Private and public schools.	t-test/None	Higher in private school compared with public school (p<0.05)	Higher in private school compared with public school (p<0.05)
Kulaga *et al* (2010)	Poland (developed country)	16976 (8133 males and 8843 females),7-18 years	An automated digital BP monitor (Datascope Accutor). Three readings were taken 5 minutes apart, after an initial 5 minutes of rest. Mean of the last two readings used for SBP and DBP.	Mother's education (academic to basic)	ANOVA/BMI and weight	Mean z-score: -0.23 (p<0.0001)	Mean z-score: -0.15 (p<0.0001)
				Father's education (academic to basic)		Mean z-score: -0.29 (p<0.0001)	Mean z-score: -0.20 (p<0.0001)
				Income per capita (highest to lowest)		Mean z-score: -0.23 (p<0.0001)	Mean z-score: -0.21 (p<0.0001)
Rao and Apte (2009)	India (developing country)	2078 males, 9-16 years	Standard mercury sphygmomanometer. K1 and K5. One reading was taken, after an initial 10 minutes of rest.	School tuition fee level. High socio-economic (HSE) class school and lower socioeconomic (LSE) class school.	t-test/None	Higher for HSE boys (p<0.01)	Higher for LSE boys (p>0.01)
Harding *et al* (2008)	United Kingdom (developed country)	6407, 11-13 years	An automated digital BP monitor (Omron M5 -1). Three readings were taken 1 minute apart, after an initial 5 minutes of	Standard of living circumstances.	Multiple Regression/Age, temperature, overweight status, height, pubertal stage, ethnicity	M: Constant: SES 1 (least disadvantage) SES 2: Beta = 0.39 (95% CI, -	M: Constant: SES 1 (least disadvantage) SES 2: Beta = -0.01 (95% CI, -

			rest. Mean of the last two readings used for SBP and DBP.			0.75 – 1.54) (p>0.05) SES 3: Beta = 0.66 (95% CI, -0.34 – 1.66) (p>0.05) SES 4: Beta = 0.50 (95% CI, -0.57 – 1.57) (p>0.05) F: Constant: SES 1 (least disadvantage) SES 2: Beta = 0.35 (95% CI, -0.92 – 1.63) (p>0.05) SES 3: Beta = 0.55 (95% CI, -0.54 – 1.65) (p>0.05) SES 4: Beta = 0.72 (95% CI, -0.41 – 1.85) (p>0.05)	0.87 – 0.84) (p>0.05) SES 3: Beta = 0.29 (95% CI, -0.46 – 1.05) (p>0.05) SES 4: Beta = 0.19 (95% CI, -0.62 – 0.99) (p>0.05) F: Constant: SES 1 (least disadvantage) SES 2: Beta = 0.88 (95% CI, -0.12 – 1.88) (p>0.05) SES 3: Beta = 0.65 (95% CI, -0.21 – 1.51) (p>0.05) SES 4: Beta = 0.98 (95% CI, 0.09 – 1.87) (p<0.05)
Longo-Mbenza *et al* (2007)	Congo (developing country)	1535; 1049 (569males and 480 females), aged 5-11 years; and 486 (362	An automated digital BP monitor (Omron HEM-705). Five readings were taken, after an initial 20 minutes of rest.	Living environment. The lowest socio-economic status (underdeveloped environment) and highest socio-	t-test/None	p<0.05	p<0.01

		males and 124 females), aged ≥ 12 years	Mean of the last two readings used for SBP and DBP.	economic status (affluent environment).			
Falkner *et al* (2006)	USA (developed country)	18618 (9897 males and 8721 females), 2-18 years	Aneroid sphygmomanometer. K1 and K5. An automated BP monitor (Dinamap) was used at only one site.	Insurance type. commercial/private or government/public.	Multiple Regression/Age, height, gender and BMI	Beta = 0.112 (p=0.000)	Beta = 0.026 (p=0.000)
Julia *et al* (2006)	Indonesia (developing country)	1753, 6-9 years	Standard mercury sphygmomanometer. K1 and K5 was used. Three measurements at 5 minutes interval. Average of the last two measurements was used.	Poor urban and non-poor urban.	Multiple regression/age, gender, stature and BMI	Beta = -0.34 (-1.37 – 0.70) (p>0.05)	Beta = -0.77 (-1.89 – 0.35) (p>0.05)
Kelishadi *et al* (2006)	Iran (developing country)	21111 (10253 males and 10858 females), 6-18 years	Standard mercury sphygmomanometer. K1 and K5. Two readings, after an initial 5 minutes of rest. Mean of the two readings was used for SBP and DBP.	School type. Public and private school.	SBP: Multiple Regression/BMI, height, WC, physical activity and current dietary habit DBP: Multiple Regression/ gender, weight , WC, mother's education level, low birth weight, a positive family history of hypertension, current dietary	Beta = 0.24 (p=0.000)	Beta = 0.26 (p=0.000)

					habit, history of breast feeding during infancy, the consumption of whole grain bread, and the frequency of vegetable		
				Mother's education level	SBP: Multiple Regression/BMI, height, school type, waist circumference, physical activity and current dietary habit DBP: Multiple Regression/ Gender, weight, waist circumference, school type, low birth weight, a positive family history of hypertension, current dietary habit, history of breast feeding during infancy, the consumption of whole grain bread, and the frequency of vegetable	- (p>0.05)	Beta = - 0.24 (p=0.002)
Van Lenthe *et al* (2001)	United Kingdom (developed	509 (251 males and 258 females), 12	Random zero sphygmomanometer. K1 and K4.	Occupation of the main breadwinner in the family (non-	t-test/None	M: p= 0.74 (p>0.01)	M: p= 0.67 (p>0.01)

	country)	years		manual and manual).		F: p= 0.61 (p>0.01)	F: p= 0.58 (p>0.01)
Soylu *et al* (2000)	Turkey (developed country)	1024 (513 males and 511 females), 9-11 years	Standard mercury sphygmomanometer. K1 and K4. Three readings were taken. Mean of the three readings was used for SBP and DBP.	Locations of schools. Well-developed (WD), moderately developed (MD) and underdeveloped areas.	Kruskhall-Wallis one- way variance analysis/ anthropometric structure	WD vs. MD (p>0.05) WD vs UD (p<0.05) MD vs UD (p<0.05)	WD vs MD (p<0.05) WD vs UD (p<0.05) MD vs UD (p>0.05)
Akinkugbe *et al* (1999)	Nigeria (developing country)	1669 (824 males and 845 females), 11-18 years	Standard mercury sphygmomanometer. K1 and K4. Two readings were taken. Mean of the two readings was used for SBP and DBP.	Father's education. Group1: parents with very high literacy level and Group 2: parents with high literacy level.	Pearson/None	Group 1 (M): r= 0.001 to – 0.009 (p>0.05) Group 1 (F): r= - 0.520 (p>0.05) to – 0.135 (p<0.05) Group 2 (M): r= 0.030 to – 0.063 (p>0.05) Group 2 (F): r= - 0.018 to – 0.018 (p>0.05)	Group 1 (M): r= 0.101 to – 0.059 (p>0.05) Group 1 (F): r= 0.102 (p>0.05) to – 0.147 (p<0.05) Group 2 (M): r= - 0.129 to – 0.129 (p>0.05) Group 2 (F): r= - 0.127 to – 0.127 (p>0.05)
Leino *et al* (1996)	Finland (developed country)	1211 (593 males and 618 females), 9, 12 and 15 years	Random zero sphygmomanometer. K1 and K5.	Occupation of the parents. I: upper non-manual, II: lower non-manual, III: upper manual, IV: lower manual and F: farmers	ANOVA/None	M: p= 0.02 F: p= 0.59	M: p= 0.09 F: p= 0.78

Rona *et al* (1996)	United Kingdom (developed country)	1310 (664 males and 646 females), 8-9 years	Automated sphygmomanometer (Dinamap 1846). Three readings were taken 1 minute apart, after an initial 5 minutes of rest. Mean of the three readings was used for SBP and DBP.	Father's occupation	Multiple Regression/ Gender, ethnic origin and English or Scottish sample, mother's education level, number of children, child's length of pregnancy and birth weight, total parental smoking at home, whether mother smoked in pregnancy, maternal and paternal, BMI, mother's age at the child's birth, child's height, weight for height, sum of skinfolds, skinfold distribution	p>0.05	Constant: Not known occupation Non-manual: Beta = -0.0066 (p=0.003) Manual: Beta = - 0.0121 (p=0.003) Not applicable: Beta = - 0.0165 (p=0.003)

				Mother's education level.	Multiple Regression/ Gender, ethnic origin and English or Scottish sample, father's social class based on occupation, number of children, child's length of pregnancy and birth weight, total parental smoking at home, whether mother smoked in pregnancy, maternal and paternal, BMI, mother's age at the child's birth, child's height, weight for height, sum of skinfolds, skinfold distribution	p>0.05	p>0.05
Kozinetz (1991)	USA (developed country)	503, 7-18 years	Standard mercury sphygmomanometer. K1, K4 and K5. Three readings were taken. Mean of the last two readings was used for SBP and DBP.	Schools categorised into four income level groups from low to high.	Univariate regression analysis/None	p>0.05	p>0.05

Macintyre *et al* (1991)	United Kingdom (developed country)	838 (413 males and 425 females), 15 years	Random zero sphygmomanometer. K1 and K5. Two readings were taken, after an initial 5 minutes of rest. Mean of the two readings was used for SBP and DBP.	Father's current or last occupation, or, if there was no father or if he had no occupation, the mother's current or last occupation.	Multiple regression analysis/Weight, height, pulse rate, mother's height, birth weight, social class, housing tenure, summer, winter, room temperature, smoking, drinking, exercise	Non-manual class =0, manual = 1 M: - 1.24 (p>0.05) F: - 0.22 (p>0.05)	Non-manual class =0, manual = 1 M: - 0.73 (p>0.05) F: - 1.68 (p>0.05)
				Housing tenure.	Multiple regression analysis/Weight, height, pulse rate, mother's height, birth weight, social class, Father's current or last occupation, summer, winter, room temperature, smoking, drinking, exercise	Owner occupier = 0, other = 1 M: 0.64 (p>0.05) F: 3.22 (p<0.01)	Owner occupier = 0, other = 1 M: 1.11 (p>0.05) F: 3.15 (p<0.01)

Akinkugbe *et al* (1990)	Nigeria (developing country)	1,340 (679 males and 661 females), 6-12 years	Standard mercury sphygmomanometer. K1 and K4. Two readings were taken. Mean of the two was used for SBP and DBP.	Children from three different socio-economic backgrounds. Group1: Children from low-income area with high level of illiteracy. Group 2: Children from middle-income area. Group 3: Children attending private-fee primary schools in a low density suburban area of the city and children attending the Infant Welfare clinic of the Institute of Child Health (children in this group are of similar background).	ANOVA	M: $p<0.05$ F: $p>0.05$	M: $p<0.05$ F: $p<0.05$
Balogun *et al* (1990a)	Nigeria (developing country)	807 (430 males and 377 females), 8-18 years	An automated digital BP monitor. Reading was taken after an initial 20minutes of rest.	An aggregation of parental socio-economic characteristics (highest educational attainment of the parents, land and properties, the type of housing estate,	Pearson/None ANCOVA/age, weight and height.	-0.09 ($p<0.05$) $p>0.05$	-0.07 ($p>0.05$)

				the number of rooms and persons in the household and household utensils and appliance).			
Gliksman *et al* (1990)	Australia (developed country)	2400, 9, 12 and 15 years	Standard mercury sphygmomanometer. K1 and K4. Two readings were taken 5 minutes apart, after an initial 5 minutes of rest. Mean of the two readings was used for SBP and DBP.	Child's postcode of residence.	Multiple Regression/Age, gender, ethnicity.	SES 1 (highest): constant SES 2: Mean = 104.5mmHg (p>0.05) SES 3: Mean = 105.2mmHg (p>0.05) SES 4: Mean = 101.7mmHg (p>0.05)	SES 1 (highest): constant SES 2: Mean = 74.3mmHg (p>0.05) SES 3: Mean = 75.1mmHg (p>0.05) SES 4: Mean = 72.1mmHg (p>0.05)
Adams-Campbell *et al* (1987)	Nigeria (developing country)	254 (153 males, 101 females), 6-17 years	Standard mercury sphygmomanometer. K1 and K5. Three readings were taken. Mean of the last two readings was used for SBP and DBP.	Parental education (non-college educated and college educated).	Multiple Regression/Age, body mass index, heart rate.	p>0.05	p>0.05
Walter and Hofman (1987)	USA (developed country)	2591, mean age 9 years	Standard mercury sphygmomanometer. K1 and K4. Three readings were taken. Mean of the last two readings was used for SBP and DBP.	Area of residence. Bronx (lower socio-economic status area) and Westchester County (higher socio-economic status area).	Multiple Regression/ethnic origin, age, gender, height, triceps skinfold thickness, ponderosity index, recovery index, resting pulse rate.	Bronx minus Westchester Beta = -0.5 (p>0.05)	Bronx minus Westchester Beta = 2.0 (p<0.001)
Liebman *et*	USA	532 females,	Standard mercury	Family per capita	ANOVA/ Age,	p >0.05	p >0.05

al (1986)	(developed country)	12-14 years	sphygmomanometer. K1 and K4 or K5 were used. One to two readings (based on the level of first BP reading) were taken 15 minutes apart, after an initial 5-10 minutes of rest.	income.	ethnicity, family type, place of residence, and parental education level.		
				Family type (nuclear vs single-parent).		p <0.05	p >0.05
				Parental education levels (high, moderate, or low).		p >0.05	p >0.05
Gillum *et al* (1985)	USA (developed country)	1505, 7-10 years	Random zero sphygmomanometer. K1, K4 and K5. Two readings were taken. Mean of the two readings was used for SBP and DBP.	Hollingshead's two-factor index of social position based on Parents' occupation and education.	Pearson/None	r = 0.02 (p>0.05)	D4: r = 0.01 (p>0.05) D5: r = 0.01 (p>0.05)
Eferakeya and Ekeocha (1982)	Nigeria (developing country)	1124, 6-13 years	Standard mercury sphygmomanometer. K1 and K4 were used. Two readings were taken 5 minutes apart, after an initial 5 minutes of rest. Mean of the two readings was used for SBP and DBP.	School tuition fee. Fee-paying schools (high socio-economic class) and non-fee-paying schools (low socio-economic class).	t-test/None	p>0.1	p>0.1
Epstein *et al* (1981)	Israel (developed country)	804 (434 males and 370 females), 16-18 years	Standard mercury sphygmomanometer. K1 and K5 were used. An initial 10 minutes of rest.	An aggregation of socio-economic characteristics. Father's occupation and crowding index.	ANOVA/None	p>0.05	p>0.05
Khoury *et al* (1981)	USA (developed country)	893 (459 males and 434 females), 6-18 years	Standard mercury sphygmomanometer. One reading was taken.	Education and occupation of the head of the household (EDHD	Pearson/None	M: EDHD – r = -0.057 (p>0.05) OCCHD – r = -	M: EDHD – r = -0.060 (p>0.05) OCCHD – r = -

				and OCCHD).		0.083 (p>0.05) F: EDHD – r = -0.078 (p>0.05) OCCHD – r = -0.044 (p>0.05)	0.067 (p>0.05) F: EDHD – r = 0.034 (p>0.05) OCCHD – r = 0.086 (p>0.05)
Dwyer *et al* (1980)	Australia (developed country)	539 (287 males and 252 females),10 years	Standard mercury sphygmomanometer. K1 and K5 used. One reading was taken after an initial 5 minutes of rest.	Occupation of the head of household.	ANOVA/None	p>0.05	p>0.05
Blankson *et al* (1977)	Ghana (developing country)	4646, 5-12 years	Standard mercury sphygmomanometer. K1 and K4. One reading was taken after an initial 5 minutes of rest.	An aggregation of socio-economic characteristics. Material possessions and parental education.	Pearson/None	M: r = -0.05 -0.14 (p>0.05) F: r = 0.03 – 0.20 (p>0.05)	M: r = -0.14 – 0.07 (p<0.05) F: r = -0.19 – 0.04 (p<0.05)
Miller and Shekelle (1976)	USA (developed country)	13231 (6880 males and 6351 females), 15-16 years	Standard mercury sphygmomanometer. K1 and K5. One reading was taken, after an initial 5-10 minutes of rest.	Father's education	Multiple Regression/body mass index and pulse rate	Black (M): Beta = -0.09 (p>0.05) Black (F): Beta = 0.07 (p>0.05) White (M): Beta = -0.03 (p<0.05) White (F): Beta = -0.10 (p<0.001)	Black (M): Beta = 0.04 (p>0.05) Black (F): Beta = 0.01 (p>0.05) White (M): Beta = -0.08 (p<0.001) White (F): Beta = -0.08 (p<0.001)
Kotchen *et al* (1974)	USA (developed country)	797, mean age 18 years	Standard mercury sphygmomanometer. Readings were taken after an initial 5 minutes of rest. Consecutive	Parental occupation. Hollingshead's occupational scale.	ANOVA/None	Overall among Blacks (p>0.05) Hollingshead's classes 1 and 2 (high occupational	–

			readings were obtained until systolic BP was reproduced within 2 mmHg.			levels) vs Hollingshead's classes 6 and 7 (low occupational levels) ($p<0.01$). Overall among whites ($p>0.05$)	

3.3 ADIPOSITY AND BLOOD PRESSURE IN CHILDREN AND ADOLESCENTS

INTRODUCTION

In this section, I will present a review of the relationship between anthropometric measures of adiposity or fatness and blood pressure in children and adolescents.

Obesity (high adiposity or fatness) has been highlighted as a major public health problem in developed countries over the last 30 years and is an emerging worldwide epidemic (Renzaho, 2004), contributing to 2.7 million deaths worldwide each year and an estimated 35.8 million (2.3%) of global disability adjusted life years (DALYs) (World Health Organisation, 2011a). Obesity is noticeably on the rise in developing countries (predominantly in urban populations) undergoing rapid socio-economic and nutrition transitions, creating an obesogenic (obesity promoting) environment with high fat, energy rich, low micronutrient diet, and reduced physical activity (Lobstein *et al*., 2004). Subsequently, these developing countries are experiencing a coexistence of under nutrition and over nutrition (termed a double burden of malnutrition), in places where under nutrition was formerly the only cause of concern (Subramanian *et al*., 2007; Wang and Lobstein, 2006; World Health Organisation, 2006; Lobstein *et al*., 2004), and obesity was once generally considered to be a sign of affluence, good health and contentment (Renzaho, 2004).

Children and adolescents are becoming a major part of this worldwide epidemic of obesity (Gelbrich *et al*., 2008; Sorof and Daniels, 2002). Obesity in childhood and adolescence has increased dramatically in the last 20 years (Flores-Huerta *et al*., 2009). It has become one of the most common nutritional conditions in young people globally (Flores-Huerta *et al*., 2009). Globally, 10% (155 million) of children and adolescents are already affected (Gelbrich *et al*., 2008; Lobstein *et al*., 2004). Over 20% of children and adolescents in North America, South America and Europe are obese (Lobstein *et al*., 2004). In sub-Saharan Africa about 2% of children and adolescents are obese (Lobstein *et al*., 2004). The prevalence of obesity in children and adolescents ranges from 2.3% to 17.2% in Nigeria (Ejike *et al*., 2010; Goon *et al*., 2010; Opara *et al*., 2010; Senbanjo *et al*., 2009; Akinpelu *et al*., 2008).

According to Lobstein *et al* (2004), children and adolescents from lower socio-economic segments of the population in developed countries are mostly affected by obesity because of poor diet and inadequate physical activity. In developing countries, obesity is most common in children and adolescents from wealthier families. However, among the urban poor in the developing countries, childhood obesity is also on the increase, which may be due to their exposure simultaneously to the nutrition transition and to urbanisation (Lobstein *et al*., 2004).

The noticeable rise in the prevalence of obesity in childhood and adolescence is a major cause of concern in particular due to the association of obesity with several morbidities (such as impaired glucose tolerance, type 2 diabetes, arterial hypertension, and lipid abnormalities) (Gelbrich *et al*., 2008; Ippisch and Daniels, 2008), and also the fact that obesity in childhood has been suggested as a major predictor of adult obesity (Thompson *et al*., 2007; Whitaker *et al*., 1997; Must *et al*., 1992).

The association between adiposity and blood pressure in children and adolescents has been widely reported; however, the exact mechanism for this association remains unclear (Ejike and Ugwu, 2010; Chu *et al*., 2001). The association has been highlighted as important for understanding, assessing and preventing the public health and medical impact of the anticipated worldwide obesity epidemic which may have an impact on blood pressure in childhood and adolescence (Agyemang *et al*., 2009; Munter *et al*., 2004), and in determining future high blood pressure in adulthood (Sinaiko *et al*., 1999).

I undertook a narrative review of the association between adiposity and blood pressure in children and adolescents. The studies included were identified through various search methods. A comprehensive literature search was undertaken using MEDLINE (OVID) database (from 1946 to June Week 2, 2012) (search terms used were cross-sectional, children, adolescents, paediatrics, blood pressure, systolic, diastolic, hypertension, cardiovascular disease, anthropometric parameters, obesity, overweight, body mass index, waist circumference, waist girth, growth, abdominal adiposity, body fat, fat distribution, weight, height, risk factors, determinant, school). Searches were carried out between January 2010 and June 2012. Papers obtained from Google Scholar, hand searches, scanning of reference list of publications and recommended papers from colleagues were also included.

Publications selected for further assessment fulfilled the following inclusion criteria: 1). studies characterised by cross-sectional study design; 2). studies published in English language; 3). studies that included male or female children and adolescents, 18 years or below; 4). studies that included participants with no identifiable, known pathology (e.g., infection, neoplasm, fractures); 5). studies that measured adiposity using anthropometric measures of BMI and waist circumference; 6). studies that used anthropometric measures of adiposity and blood pressure as continuous variables; and 7). studies that analysed the association between anthropometric measures of adiposity and blood pressure using Pearson correlation or multiple linear regression statistics.

The studies identified in this review span over 30 years. The studies included were carried out in Africa (Nigeria, Ghana, South Africa, Kenya and Zambia), Asia (India), Europe (United Kingdom, Turkey, Italy and Greece), North America (United States of America (USA) and Canada), the Middle East (Bahrain, Iran and Lebanon), South America (Tobago and Suriname), and Australia (Table 6). Almost all studies were school based, except a public screening hospital based study by Gundogdu (2008), and a study based on data collected from the electronic medical record (EMR) data from primary care practice (Falkner *et al*., 2006).

The studies had sample sizes ranging from 400 (Muraguri *et al*., 1997) to 19,000 (Falkner *et al*., 2006) participants. Studies differed in the method of selection of population groups: some studies selected participants using random selection method (Durrani and Fatima, 2011; Gopinath *et al*., 2011; Mazicioglu *et al*., 2010; Agyemang *et al*., 2009; Oyewole and Oritogun, 2009; Monyeki *et al*., 2008; Nur *et al*., 2008; Kelishadi *et al*., 2006; Monyeki *et al*., 2006; Janssen *et al*., 2005; Paradis *et al*., 2004; Al-Sendi *et al*., 2003; Maffeis *et al*., 2001; Hamidu *et al*., 2000; Muraguri *et al*., 1997; Akinkugbe *et al*., 1990; Miller and Shekelle, 1976), while others recruited participants using voluntary participation selection methods, thus, leaving room for likely volunteer bias in the selection of subjects for these studies, as the participants may not represent the general population. The method of participant selection was not specified in some studies (Taksande *et al*., 2008; Savva *et al*., 2000; Clarke *et al*., 1986; Andy *et al*., 1985).

A number of studies reported participant response rates (Durrani and Fatima, 2011; Gopinath *et al*., 2011; Merhi *et al*., 2011; Nur *et al*., 2008; Barba *et al*., 2006; Nichols and Cadogan, 2006; Janssen *et al*., 2005; Paradis *et al*., 2004; Muraguri *et al*., 1997;

Ng'amdu, 1992; Balogun *et al*., 1990b; Miller and Shekelle, 1976). The highest participant response rate was 100% (Balogun *et al*., 1990b) and the lowest response rate was 50% (Miller and Shekelle, 1976). The participant response rates were generally high. Only one study (Miller and Shekelle, 1976) reported a response rate of less than 70%. An indication of a study participation rate is important, as a low participation rate may bring about a selection bias which may reduce the generalisability and statistical power of the findings.

Only few studies reported both a random sampling selection of participants and a participant response rate (Durrani and Fatima, 2011; Gopinath *et al*., 2011; Janssen *et al*., 2005; Paradis *et al*., 2004; Muraguri *et al*., 1997). For the African studies, only one study from Kenya (Muraguri *et al*., 1997) reported both participant selection using random sampling method and a participant response rate (96%).

In Table 6, body mass index (BMI) and waist circumference (WC) were used as anthropometric measures of adiposity, worldwide. However, BMI was the most widely used anthropometric measure of adiposity.

Methodological differences in blood pressure measurement devices were found between studies (Table 6). Just over half of studies used the standard mercury sphygmomanometer for measuring BP. Approximately 11% of studies used the aneroid sphygmomanometer for BP measurement. Automated blood pressure monitoring devices were used in the other studies. Falkner *et al* (2006) is the only study that utilised both the aneroid sphygmomanometer and the automated monitoring device. Disparities in the number of BP measurements were also observed between the studies such as the use of 1 BP measurement or a multiple number (two to four) of BP measurements. Twenty four percent of the studies recorded 1 BP measurement per visit, about 35 percent recorded 2 or 3 BP measurements, and 6 percent recorded 4 BP measurements (Table 6). The majority of the studies used only one participant visit for blood pressure measurement. Only two studies had multiple visits (Karatzi *et al*., 2009; Fuiano *et al*., 2006).

Results on the association between anthropometric measures of adiposity and BP were obtained from Pearson coefficients correlation and multiple regression analysis (Table 6). The results obtained from multiple regression analysis were presented as either unstandardised Beta coefficients or percentage variation of BP explained by the measure of adiposity. In spite of the differences in the anthropometric measures of adiposity, blood pressure measurement methods, the statistical analysis method and presentation of findings between studies, anthropometric measures of adiposity (BMI and waist circumference) were found to be strongly positively associated with blood pressure (systolic and diastolic BP) in the majority of the studies.

On the other hand, some studies found no significant association between BMI and blood pressure (systolic blood pressure (SBP) and diastolic blood pressure (DBP)) (Hamidu *et al*., 2000; Akinkugbe *et al*., 1999; Akinkugbe *et al*., 1990; Ekpo *et al*., 1990; Andy *et al*., 1985). Gopinath *et al* (2011) found no significant association between waist circumference and blood pressure (systolic and diastolic BP) for their female population. Other studies found no association between BMI and diastolic blood pressure (Paradis *et al*., 2004; Balogun *et al*., 1990b).

SUMMARY

In this section, I have carried out a review of literature on the association between anthropometric measures of adiposity (body mass index and waist circumference) and blood pressure in children and adolescents.

The association between anthropometric measures of adiposity (body mass index and waist circumference) and blood pressure in children and adolescents has been reported in numerous studies internationally as well as in Nigeria, with broadly consistent findings, irrespective of the difference in the age range of participants, BP measurement methods, the statistical analysis method and presentation of findings. Noteworthy in the literature review is the relatively limited number of studies estimating the relationship between waist circumference and blood pressure, as compared to BMI. Given the fact that obesity is increasing in children and adolescents in the centre of the nutritional transition occurring worldwide (including African countries such as Nigeria), and the importance of childhood obesity in determining cardiovascular disease risk in adulthood, it is important to examine how adiposity or fatness is affecting blood pressure levels in children and adolescents.

With regards to the method of participant selection, reporting of participant response rates and standardised methods used for blood pressure measurement, a number of the studies in the literature review lacked methodological rigour (particularly the African studies). Good quality primary epidemiological studies assessing the association between adiposity and blood pressure in children and adolescents from Africa as well as other countries worldwide are needed, in order to add more insight to the adiposity-BP relationship.

In the next section, I will present a literature review on the association between pubertal maturation and blood pressure.

Table 6: Association between anthropometric measures of adiposity (BMI and waist circumference (WC)) and blood pressure in children and adolescents

Author (year)	**Country**	**Number of participants (Both, Male, Female), age (years)**	**Instrument, BP Measurements**	**Adiposity Measure**	**Statistics/ variables adjusted for**	**Outcome**	
						SBP Both, Male (M), Female (F)	**DBP Both, Male (M), Female (F)**
Durrani and Fatima (2011)	India	701 (363 males and 338 females), 12-16 years	Standard mercury sphygmomanometer. K1 and K5 were used. Three measurements were taken 5 minutes apart and the average value was used for SBP and DBP.	BMI	Pearson/None	r = 0.35 (p<0.01)	r = 0.23 (p<0.01)
Gopinath *et al* (2011)	Australia	1190, 3-6 years	An automated digital BP monitor (Omron HEM -907). Two readings were taken. Mean of the two readings used for SBP and DBP.	BMI	Multiple Regression/ Height, ethnicity, parental employment status	Both: Beta = 0.57 (p=0.01) M: Beta = 0.64 (p=0.05) F: Beta = 0.46 (p=0.001)	Both: Beta = 0.56(p=0.001) M: Beta = 0.56 (p=0.03) F: Beta = 0.53 (p=0.01)
				WC		Both: Beta = 0.14 (p=0.04) M: Beta = 0.20 (p=0.03) F: Beta = 0.03 (p=0.74)	Both: Beta = 0.23 (p=0.0004) M: Beta = 0.23 (p=0.001) F: Beta = 0.11 (p=0.21)
Merhi *et al* (2011)	Lebanon	5710 (2918 males and 2792 females), 5-15 years	Standard mercury sphygmomanometer. K1 and K4 (5-9years) K5 (10-15 years) were used. Three measurements were	BMI	Pearson/None	M: r =0.475 (p<0.0001) F: r = 0.441 (p<0.0001)	M: r = 0.471 (p<0.0001) F: r = 0.422 (p<0.0001)

			taken 5-10 minutes apart and the average value was used for SBP and DBP.				
Ejike and Ugwu (2010)	Nigeria	483, 13-18 years	An automated digital BP monitor (Omron HEM -741). Three readings were taken 2 minutes apart, after an initial 10 minutes of rest. Mean of the last two readings used for SBP and DBP.	BMI	Pearson/None	p<0.05	p<0.05
Mazicioglu *et al* (2010)	Turkey	2860 (1475 males and 1385 females), 11-17 years	Aneroid sphygmomanometer. K1 and K5. Two readings were taken 5-10 minutes apart. Mean of the two readings was used for SBP and DBP.	BMI	Multiple Regression/BMI, WC, WC/height, arm-fat area, fat percentage	M: Beta = 0.88 (p<0.001) F; Beta = 0.75 (p<0.001)	M: Beta = 0.55 (p<0.001) F: Beta = 0.49 (p<0.001)
				WC		M: Beta = 0.33 (p<0.001) F: Beta = 0.33 (p<0.001)	M: Beta = 0.22 (p<0.001) F: Beta = 0.25 (p<0.001)
Agyemang *et al* (2009)	Suriname	855, 12-17 years	An automated digital BP monitor (Omron M-5). Three readings were taken 1 minutes apart, after an initial 5 minutes of rest. Mean of the last two readings used for SBP and DBP. 2 visits.	BMI	Multiple Regression/Gender, Age, Heart rate, Exercise ≥ 5-7 days/week	Beta = 0.92 – 1.27 (p<0.000)	Beta = 0.44-1.14 (p<0.000 - p<0.004)
Bayat *et al* (2009)	Turkey	610 (301 males and 309 females), 6-17 years	Standard mercury sphygmomanometer. One reading was	BMI	Pearson/None	M: r = 0.362 (p=0.000)	M: r = 0.368 (p=0.000)

			taken, after an initial 10 minutes of rest.			F: r = 0.316 (p=0.000)	F: r = 0.298 (p=0.000)
Karatzi *et al* (2009)	India	754 (338 males and 416 females), 6-18 years	An automated digital BP monitor (Omron 705). Three readings were taken 1 minute apart, after an initial 5 minutes of rest. Mean of the last two readings used for SBP and DBP. 2 visits.	BMI (in z-score for height)	Multiple Regression/Height, age, gender, family history of hypertension	Beta = 0.305 (p<0.001)	Beta = 0.264 (p<0.001)
Oyewole and Oritogun (2009)	Nigeria	1638 (790 males and 848 females), 12-18 years	Aneroid sphygmomanometer. One reading was taken, after an initial 5 minutes of rest.	BMI	Multiple Regression/Age, gender, sum of skin fold	R^2 = 0.1269	R^2 = 0.093
Ejike *et al* (2008)	Nigeria	1088 (615 males and 473 females), 10-18 years	An automated digital BP monitor (Omron HEM -741). Three readings were taken 2 minutes apart, after an initial 10 minutes of rest. Mean of the last two readings used for SBP and DBP.	BMI	Pearson/None	r = 0.265 (p<0.001)	r = 0.230 (p<0.001)
Gundogdu (2008)	Turkey	1899, 6-14 years	Aneroid sphygmomanometer. K1 and K5. Three readings were taken 3 minutes apart. Mean of the three readings was used for SBP and DBP.	BMI	Multiple Regression/Age	M: Beta = 0.183 (p<0.001) F: Beta = 0.161 (p<0.001)	M: Beta = 0.190 (p<0.001) F: Beta = 0.163 (p<0.001)
Monyeki *et al* (2008)	South Africa	1617 (938 males and 879 females), 7-13 years	An automated digital BP monitor. Three readings were taken 5	BMI	Multiple Regression/Age, gender, stature	Beta = 1.344 (95% CI 1.009, 1.679) (p=0.000)	Beta = 0.554 (95% CI 0.273, 0.834) (p=0.000)

			minutes apart, after an initial 5 minutes of rest. Mean of the last two readings used for SBP and DBP.	WC		Beta = 0.517 (95% CI, 0.361 - 0.673) (p=0.000)	Beta = 0.204 (95% CI, 0.074 - 0.334) (p=0.002)
Nur *et al* (2008)	Turkey	1020 (593 males and 427 females) 14-18 years	Standard mercury sphygmomanometer. K1 and K5 was used. Three readings were taken 5 minutes apart, after an initial 5 minutes of rest. Mean of the last two readings used for SBP and DBP.	BMI	Pearson/None	r = 0.26 (p=0.00)	r = 0.23 (p=0.00)
Taksande *et al* (2008)	India	2643 (1227 males and 1416 females) 6-17 years	Standard mercury sphygmomanometer. K1 and K5 were used. One reading after 5 minutes of rest.	BMI	Pearson/None	r = 0.16 (p=0.01)	r = 0.14 (p=0.01)
Barba *et al* (2006)	Italy	3923 (1986 males and 1937 females), 6-11 years	Standard mercury sphygmomanometer. K1 and K5. Two readings were taken 2 minutes apart, after an initial 10 minutes of rest. Mean of the two readings was used for SBP and DBP.	BMI	Multiple Regression/ Gender, age, birth weight, physical activity, parental education level, parental history of overweight/ Obesity	Beta = 0.288 (p=0.0001)	Beta = 0.227 (p=0.0001)
				WC		Beta = 0.343 (p=0.0001)	Beta = 0.249 (p=0.0001)
Falkner *et al* (2006)	USA	Electronic medical record (EMR) data from primary care practices 18618 (9897 males	Aneroid sphygmomanometer. K1 and K5. An automated BP monitor (Dinamap)	BMI	Multiple Regression/Age, height, gender, and insurance status (as a measure of	Beta = 0.183 (p=0.000)	Beta = 0.153 (p=0.000)

		and 8721 females), 2-18 years	was used at only one site.		SES)		
Fuiano *et al* (2006)	Italy	1563 (817 males and 746 females), 3-16 years	Standard mercury sphygmomanometer. K1 and K5. Three readings were taken 5 minutes apart, after an initial 10 minutes of rest. Mean of the three readings was used for SBP and DBP. 3 visits	BMI	Simple linear regression/None	M: Coefficient r= 0.80 (p=0.03) F: Coefficient r= 0.85 (p=0.03)	M: Coefficient r= 0.69 (p=0.03) F: Coefficient r= 0.78 (p=0.03)
Kelishadi *et al* (2006)	Iran	21111 (10253 males and 10858 females), 6-18 years	Standard mercury sphygmomanometer. K1 and K5. Two readings, after an initial 5 minutes of rest. Mean of the two readings was used for SBP and DBP.	BMI	**SBP**: Multiple Regression/BMI, height, school type, waist circumference, physical activity and current dietary habit **DBP**: Multiple Regression/ Gender, weight, waist circumference, school type, low	Beta = 0.53 (p=0.009)	No association with BMI

				WC	birth weight, a positive family history of hypertension, current dietary habit, history of breast feeding during infancy, the consumption of whole grain bread, and the frequency of vegetable consumption, hip circumference and the mother's education level	Beta = 0.61 (p=0.000)	Beta = 0.44 (p=0.000)
Monyeki *et al* (2006)	South Africa	1884 (967 males and 917 females), 7-13 years	An automated digital BP monitor. Three readings were taken 5 minutes apart, after an initial 5 minutes of rest. Mean of the last two readings used for SBP and DBP.	BMI	Multiple Regression/Age, gender	Beta = 0.03 (p=0.000)	Beta = 0.0002 (p=0.57)
Nichols and Cadogan (2006)	Tobago	3749 (1610 males and 1239 females), 12-16 years	Standard mercury sphygmomanometer. K1 and K5. Two readings were taken 3 minutes apart, after an initial 5-10 minutes of rest. Mean of the two readings was used for SBP and DBP.	BMI	Multiple Regression/Age, height, gender, weight, % body fat, positive family history of hypertension	M: Age and BMI explained 26.7% of the variance F: Age and BMI explained 14.6% of the variance	M: Age and BMI explained 13.2% of the Variance F: Age and BMI explained 8.0% of the variance

Janssen *et al* (2005)	USA	2597 (1252 males and 1345 females), 5-18 years	Standard mercury sphygmomanometer. K1 and K5. Six readings, after an initial 5 minutes of rest. Mean of the six readings was used for SBP and DBP.	BMI	Multiple Regression/ Gender, ethnicity, age	R^2 = 0.073	R^2 = 0.048
				WC		R^2 = 0.077	R^2 = 0.052
Paradis *et al* (2004)	Canada	3589, Age 9: 1243 (615 males and 628 females), Age 13: 1171 (587 males and 584 females), and Age: 1156 (553 males and 603 females)	An automated BP monitor (Dinamap). Three readings were taken 1 minute apart, after an initial 5 minutes of rest. Mean of the last two readings was used for SBP and DBP.	BMI	Multiple Regression/ Fasting insulin, resting HR, and parental history of hypertension	Beta = 0.9 – 1.1 ($p<0.001$).	Beta = 0.2 – 0.3 (p = 0.003 – 0.06).
Al-Sendi *et al* (2003)	Bahrain	504 (249 males and 255 females), 12-17 years	Standard mercury sphygmomanometer. Two readings were taken 3 minutes apart, after an initial 5 minutes of rest. Mean of the two readings was used for SBP and DBP.	BMI	Age adjusted Pearson correlation	M: r = 0.358 ($p<0.001$) F: r = 0.504 ($p<0.001$)	M: r = 0.210 ($p<0.001$) F: r = 0.376 ($p<0.001$)
				WC		M: r = 0.379 ($p<0.001$) F: r = 0.513 ($p<0.001$)	M: r = 0.266 ($p<0.001$) F: r = 0.374 ($p<0.001$)
Maffeis *et al* (2001)	Italy	818 (443 males and 375 females), 3-11 years	Standard mercury sphygmomanometer. K1 and K5. Three readings were taken. Mean of the three readings was used for SBP and DBP.	WC	Pearson/None	r = 0.37 ($p<0.001$)	r = 0.37 ($p<0.001$)

Hamidu *et al* (2000)	Nigeria	273 (139 males and 134) females, 11-12 years	Standard mercury sphygmomanometer. K1 and K5. Four readings were taken, after an initial 5 minutes of rest. Mean of the last two readings at least 4 weeks apart was used for SBP and DBP.	BMI	Pearson/None	M: r = 0.37 (p>0.05) F: r = 0.40 (p>0.05)	M : r = 0.19 (p>0.05) F: r = 0.26 (p>0.05)
		348 (175 males and 173 females), 13-14 years				M: r = 0.16 (p>0.05) F: r = 0.38 (p>0.05)	M : r = 0.05 (p>0.05) F: r = 0.41 (p>0.05)
		240 (133 males and 107 females), 15-16 years				M : r = 0.02 (p>0.05) F: r = 0.21 (p>0.05)	M : r = 0.06 (p>0.05) F: r = 0.19 (p>0.05)
Savva *et al* (2000)	Greece	1987 (1037 males and 950 females), 10-14 years	Standard mercury sphygmomanometer. K1 and K5. Three readings were taken. Mean of the three readings was used for SBP and DBP.	BMI	Multiple Regression/ Waist circumference, waist-to-height ratio (WHtR), age, gender and pubertal stage	Beta = 1.09 (p<0.001)	Beta = 0.50 (p<0.001)
				WC	Multiple Regression/BMI, waist-to-height ratio (WHtR), age, gender and pubertal stage	Beta = 0.69 (p<0.001)	Beta = 0.40 (p<0.001)
Akinkugbe *et al* (1999)	Nigeria 2 Groups according to	1669 (824 males and 845 females), 11-18 years	Standard mercury sphygmomanometer. K1 and K4 was used.	BMI	Pearson/None		

	SEC (Group1: parents with very high literacy level and Group 2: parents with high literacy level).	1077 from Group 1 and 592 from Group 2	The average of the two readings was used.				
	Group 1	806 (447 males and 359 females), 11-15 years				M: r = 0.112 (p<0.05) -	M: r =0.005 (p>0.05) F: r = 0.125 (p>0.05)
	Group 1	271 (98 males and 173 females), 16-18 years				M: r =0.365 (p<0.05) F: r = 0.133 (p<0.05)	M:r = 0.300 (p<0.05) F: r = 0.189 (p<0.05)
	Group 2	270 (106 males and 164 females), 11-15 years				M: r = 0.485 (p>0.05) F: r =-0.013 (p>0.05)	M: r = 0.176 (p<0.05) F: r = 0.020 (p>0.05)
	Group 2	322 (173 males and 149 females), 16-18 years				M: r = 0.208 (p>0.05) F: r = 0.243 (p<0.05)	M: r = 0.176 (p<0.05) F: r = 0.323 (p<0.05)
Muraguri *et al* (1997)	Kenya	397 (201 males and 196 females), 13-18 years	Standard mercury sphygmomanometer. K1 and K5 were used. The average of the three readings was used.	BMI	Pearson/None	Both: r = 0.202 (p=0.002) M: r = 0.262 (p=0.0001) F: r = 0.350 (p=0.002)	Both: r = 0.187 (p=0.002) M: r = 0.222 (p=0.001) F: r = 0.288 (p=0.001)

Ng'amdu (1992)	Zambia	372 (160 males and 212 females), 7-16 years	Standard mercury sphygmomanometer. K1 and K5. One reading was taken after an initial 5 minutes of rest.	BMI	Multiple Regression/ Height	Beta = 0.029; R^2= 0.155; p=0.602	Beta = 0.066; R^2= 0.059; p=0.254
Akinkugbe *et al* (1990)	Nigeria	1,340 (679 males and 661 females), 6-12 years	Standard mercury sphygmomanometer. K1 and K4. Two readings were taken. Mean of the two was used for SBP and DBP.	BMI	Pearson/None		
		Group 1 (high-income) - 444 (240 males and 204 females), 6-12 years				r = 0.206 (p<0.05)	r = 0.240 (p<0.05)
		Group 2 (middle-income) - 368 (167 males and 201 females), 6-12 years				r = 0.079 (p>0.05)	r = 0.025 (p>0.05)
		Group 3 (low-income) - 528 (272 males and 256 females), 6-12 years				r = 0.039 (p>0.05)	r = 0.001 (p>0.05)
Balogun *et al* (1990b)	Nigeria	807 (430 males and 377 females), 8-18 years	An automated BP monitor. One reading was taken, after an initial 20 minutes of rest.	BMI	Multiple Regression/Age, weight, height, ponderosity index, left arm circumference, triceps skin fold	R^2 = 0.13 variation in SBP	R^2 almost negligible
Ekpo *et al* (1990)	Nigeria	874 urban and 674 rural children, 5-16 years	Standard mercury sphygmomanometer. K1 and K5. One reading was taken after an initial 5 minutes of rest.	BMI	Multiple Regression/Age, gender, height, weight, 24-hr urine sodium, 24-hr urine potassium, sodium/p	Beta = 0.222 (p>0.05)	Beta = -0.021 (p>0.05)

					otassium ration, locality		
Clarke *et al* (1986)	USA	2925 (1395 males and 1530 females) 15-18 years	Standard mercury sphygmomanometer. K1 and K4. One reading was taken.	BMI	Pearson/None	r = 0.29	r = 0.14
Liebman *et al* (1986)	USA	532 girls, 12-14 years	Standard mercury sphygmomanometer. K1 and K4 or K5 were used. One to two readings (based on the level of BP) were taken 15 minutes apart, after an initial 5-10 minutes of rest.	BMI	Pearson/None	r = 0.37	r = 0.25
		14-16 years				r = 0.33	r = 0.25
Andy *et al* (1985)	Nigeria	4318 (2301 males and 2017 females), 1-18 years	Standard mercury sphygmomanometer. K1 and K5. Two reading were taken. Mean of the two readings was used for SBP and DBP.	BMI	Multiple Regression/Age, height and weight	M: R = 0.003 (p>0.05) F: R = 0.04 (p<0.05)	M: R= 0.04 (p<0.05) F: R = 0.009 (p>0.05)
Blankson *et al* (1977)	Ghana	4646, 5-12 years	Standard mercury sphygmomanometer. K1 and K4. One reading was taken after an initial 5 minutes of rest.	BMI	Pearson/None	M: r = 0.19 (p<0.05) F: r = 0.21 (p<0.05)	M: r = 0.22 (p<0.05) F: r = 0.29 (p<0.05)
Miller and Shekelle (1976)	USA	13231 (6880 males and 6351 females), black and white, 15-16 years	Standard mercury sphygmomanometer. K1 and K5. One reading was taken after an initial 5-10 minutes of rest. .	BMI	Multiple Regression/ Father's educational attainment	Black (M): Beta = 0.34 (p<0.001) Black (F): Beta = 0.29 (p<0.001) White (M): Beta = 0.29 (p<0.001)	Black (M): Beta = 0.19 (p<0.001) Black (F): Beta = 0.25 (p<0.001) White (M): Beta = 0.10 (p<0.001)

						White (F): Beta = 0.20 (p<0.001)	White (F): Beta = 0.08 (p<0.001)

3.4 PUBERTAL MATURATION AND BLOOD PRESSURE

INTRODUCTION

In this section, I will present a detailed review of published evidence assessing the relationship between pubertal or sexual maturation and blood pressure.

Puberty represents a period of marked physical growth and development from childhood to adulthood (Chan *et al*., 2008). There are inter-individual variations in the patterns of pubertal or sexual maturation. There is notable difference in the chronologic timing of the onset, progression and end of pubertal or sexual maturation (Greil and Kahl, 2005). Chronological age has been suggested to be separate from pubertal maturation age, and may be an insufficient indicator of physical growth and development (Greil and Kahl, 2005). Pubertal maturation is accompanied by a complex set of physical, physiological and reproductive endocrine and hormonal changes (Meininger *et al*., 2004).

The physical (somatic) changes comprise of changes in body size and physique as well as the development of secondary sexual characteristics (sexual maturation) (Meininger *et al*., 2004); the physiological changes include changes in haematocrit, serum urate levels, serum alkaline phosphatase levels (Wu *et al*., 2001; Wacharasindhu *et al*., 2002); and reproductive endocrine changes comprise increased hormones (gonadal or sex hormones), including follicle-stimulating hormone (FSH) and luteinizing hormone (LH) which produce sex steroids such as testosterone, oestrogens, androgens and progesterone (Chan *et al*., 2008). The endocrine hormonal changes bring about the somatic changes (Wacharasindhu *et al*., 2002). Researchers on growth and development have recommended several measures to assess pubertal maturation in children and adolescents. I have presented information on these measures in the Methodological Issues Chapter (Chapter 4).

Pubertal maturation may be one of the various developmental markers related to blood pressure (Kozinetz, 1991). According to Kozinetz (1988), the relationship between pubertal maturation and blood pressure has important clinical and public health implications. Wang (2004) highlighted that there is a trend towards early pubertal maturation worldwide. The independent role of pubertal maturation in determining blood pressure values is still under debate. The mechanism of the relationship between pubertal maturation and blood pressure is not fully understood (Kozinetz, 1991). Maffeis *et al* (2003) noted that the rise in blood pressure during pubertal growth may be related to certain hormonal and physiological changes that take place during this period. Pubertal maturation has been suggested to be a normal physiological process that may influence blood pressure levels in later life (Shankar *et al*., 2005). Hulanicka *et al* (2007) highlighted that earlier pubertal maturation is an independent factor that influences the development of hypertension in adulthood. In addition, Liang and Mi (2011) noted that children and adolescents with hypertension during pubertal maturation are at a higher risk of developing hypertension in adulthood.

I undertook a narrative review of the association between pubertal maturation and blood pressure in children and adolescents. The studies included were identified through various search methods. A comprehensive literature search was undertaken using MEDLINE (OVID) database (from 1946 to June Week 2, 2012) (search terms used were cross-sectional, cohort, longitudinal, children, adolescents, paediatrics, blood pressure, systolic, diastolic, hypertension, cardiovascular disease, puberty maturation, sexual maturation, growth, menarche, sexual maturity rating, Tanner stages, secondary sex characteristics, development, risk factors, determinant, school). Searches were carried out between January 2010 and June 2012. Papers obtained from Google Scholar, hand searches, scanning of reference list of publications and recommended papers from colleagues were also included.

Publications selected for further assessment fulfilled the following inclusion criteria: 1). studies characterised by cross-sectional or longitudinal study design; 2). studies published in English language; 3). studies that included male or female children and adolescents, 18 years or below (at baseline for longitudinal studies); 4). studies that included participants with no identifiable, known pathology (e.g., infection, neoplasm, fractures); 5). studies that presented data on the association between any measure of pubertal maturation and blood pressure; and 6). studies that used blood pressure as a continuous variable.

Several longitudinal and cross-sectional studies have been carried out on the relationship between pubertal maturation and blood pressure. A lot of the longitudinal studies and cross-sectional studies have been based on USA and European samples (Table 7).

Overall the studies included in this review had sample sizes ranging from approximately 140 to 6650 participants. A few of the cross-sectional and longitudinal studies gave details of their sample size calculation (Daniels *et al*., 1998; Daniels *et al*., 1996; Kozinetz, 1991; Kozinetz, 1988). Only four studies (Chen and Wang, 2009; Kozinetz, 1991; Kozinetz, 1988; Lauer *et al*., 1984) randomly recruited participants; others did not report any method of randomisation, leaving room for likely bias in the selection of participants, with the likelihood of participants not representing the general population.

A small number of the cross-sectional studies reported a participant response rate (Harding *et al*., 2008; Meininger *et al*., 2004; Armstrong *et al*., 1992; Hansen *et al*., 1990; Kozinetz, 1988; Orchard *et al*., 1980). Harding *et al* (2008), Meininger *et al* (2004) and Hansen *et al* (1990) reported high participant response rates of approximately 81%, 91% and 81%, respectively. Armstrong *et al* (1992) noted a low participant response rate of 42%. Kozinetz (1988) also had a low participant response rate (37%) and the sample used was substantially less than the sample size calculated. Orchard *et al* (1980) had a fairly good participation rate of about 64%.

The longitudinal studies had varying length of follow-up ranging from 1 year to 20 years. Frontini *et al* (2003) in the USA had the longest length of follow-up of 20 years. Only four of the longitudinal studies (Harding *et al*., 2010; Frontini *et al*., 2003; Tell, 1985; Voors *et al*., 1979) reported participant response rates at baseline, and they had high participant response rates of 88%, 80%, 82% and 92%, respectively. A number of studies reported their follow-up rate (Harding *et al*., 2010; Chen and Wang, 2009; Reinehr and Toschke, 2009; Frontini *et al*., 2003; Kotchen *et al*., 1989; Lattuada *et al*., 1986; Vartiainen *et al*., 1986; Tell, 1985). Harding *et al* (2010) reported a 3-year follow-up rate of 72%. Chen and Wang (2009) had a 1.5-year follow-up rate of of 68.9%. Reinehr and Toschke (2009) reported a 1-year follow-up rate of 81%. Frontini *et al* (2003) noted a follow-up rate of 60%. Kotchen *et al* (1989) had a 5-year follow-up rate of 94.4%. Lattuada *et al* (1986) reported a 4-year follow-up rate of 64%. Vartiainen *et al* (1986) and Tell (1985) observed a 2-year follow-up rate of 82% and 54%, respectively. Voors *et al* (1979) noted a 1-year follow-up rate of 28%.

A low participation rate or high number of drop outs may reduce sample size and incur selection bias (where there is a possibility of dissimilarity between non-respondents and respondents) such that the participants are not representative of the population, and these factors may reduce the generalisability and statistical power of the findings. Some cross-sectional and longitudinal studies highlighted that there were no important differences observed between non-respondents and respondents or those lost to follow-up and those who completed the study (Chen and Wang, 2009; Reinehr and Toschke, 2009; Koziel *et al*., 2001; Kozinetz, 1991; Kotchen *et al*., 1989; Kozinetz, 1988).

Studies have used varied methods for assessing pubertal maturation (Table 7). Many of the studies have assessed sexual maturation by a health professional undertaking physical examination using the Tanner reference stages of sexual maturation rating. The sexual maturation stage rating was developed by Tanner (1962); it classifies and standardises secondary sex characteristics into five distinct stages, based on pubic hair development in both males and females, breast development in females and genital development in males, ranging from immature to fully mature (Facchini *et al*., 2008). Others have assessed sexual maturation using self-assessed Tanner stages of sexual maturation rating, self-reported age at menarche, serial height measurements, and sex hormone levels. Some studies used the Tanner stages of sexual maturation rating but did not indicate whether it was by health professional physical assessment or self-assessment. None of the studies mentioned the rationale for their choice of pubertal maturation assessment method.

Many of the studies which used Tanner stages of sexual maturation, modified the five Tanner stages by categorising the stages into two or three categories (Harding *et al*., 2010; Reinehr and Toschke, 2009; Harding *et al*., 2008; Hoffman *et al*., 2005; Meininger *et al*., 2004; He *et al*., 2002; Cho *et al*., 2001; Leccia *et al*., 1999; Daniels *et al*., 1998; Daniels *et al*., 1996). In addition, a few studies used varied indicators of the Tanner stages of sexual maturation. Some studies used all indicators (including, pubic hair, and breast or genital development), while others used one or two indicators.

There were differences in blood pressure measurement devices between studies (Table 7). Most of the studies used a standard mercury sphygmomanometer. Others used random-zero sphygmomanometer (Shankar *et al*., 2005; Armstrong *et al*., 1992; Hansen *et al*., 1990; Vartiainen *et al*., 1986; Orchard *et al*., 1980), an automated blood pressure monitoring device (Harding *et al*., 2010; Chen and Wang, 2009; Harding *et al*., 2008; Hoffman *et al*., 2005; Koziel *et al*., 2001), an aneroid sphygmomanometer (Weir *et al*., 1988) or an ambulatory blood pressure equipment (Meininger *et al*., 2004). The blood pressure measuring device used in one study was not reported (Tell, 1985).

The studies on pubertal maturation and blood pressure have produced conflicting results (Table 7). Comparing findings of these studies is difficult and complex because of the heterogeneity of study samples, methodological differences (such as sample size and participant selection methods, inconsistency in blood pressure measurement assessment methods), differences in measure of pubertal maturation and statistical analysis. A number of studies reported that pubertal maturation is statistically significantly independently associated with blood pressure (Chen and Wang, 2009; Reinehr and Toschke, 2009; Remsberg *et al*., 2005; Shankar *et al*., 2005; Meininger *et al*., 2004; Cho *et al*., 2001; Koziel *et al*., 2001; Armstrong *et al*., 1992; Kozinetz, 1991; Kotchen *et al*., 1989; Kozinetz, 1988; Tell, 1985; Lauer *et al*., 1984; Orchard *et al*., 1980; Voors *et al*., 1979).

Chen and Wang (2009) found a significant association between blood pressure at 1.5 years follow-up and baseline sexual maturation in girls. Early maturing girls had significantly higher 1.5 years follow-up blood pressure than late maturers. Reinehr and Toschke (2009) observed that change of pubertal status was significantly associated with changes in blood pressure. Blood pressure increased significantly among children and adolescents at the onset of puberty, but decreased significantly among children at late puberty, and was maintained among children and adolescents whose pubertal maturation stage remained unchanged between baseline and follow-up period. Remsberg *et al* (2005) reported that after adjusting for chronological age, age at menarche was significantly associated with changes in blood pressure. Girls with early menarche had higher blood pressure compared with later maturers.

Shankar *et al* (2005) noted that puberty growth period is strongly associated with significant increase in blood pressure. Shankar and colleagues found greater increase in systolic and diastolic blood pressure during pubertal growth period than before or after puberty. In addition, there was also noticeably greater increase in systolic BP during pubertal growth period in boys compared to girls and diastolic BP pubertal growth period in girls compared to boys. Meininger *et al* (2004) observed a significant association between sexual maturation and blood pressure: the more sexually mature individuals (Tanner stages 4 and 5) had higher blood pressure than less sexually mature individuals (Tanner stages 1 to 3). Cho *et al* (2001) reported that sexual maturation is significantly related with systolic blood pressure in both boys and girls. Koziel *et al* (2001) found that diastolic blood pressure was significantly associated with age at menarche: earlier maturers had higher diastolic blood pressure.

Armstrong *et al* (1992) reported that more mature children had higher systolic and diastolic blood pressures than less mature children, but after controlling for school year group the relationship for diastolic blood pressure in boys was no longer significant. Kozinetz (1991) also reported that sexual maturation accounted for the significant ethnic differences in blood pressure. Controlling for sexual maturation produced similar results to those after controlling for body size (height or weight). According to Kozinetz (1991), the effect of the stage of maturation on blood pressure measurement may be as important as height and weight. Kotchen *et al* (1989) observed that systolic blood pressure was inversely related to menarcheal age: that is, early maturers had higher systolic blood pressure while, in boys, systolic blood pressure subsequently increased at a more rapid rate in those males who matured at a later age as determined by change in height.

Kozinetz (1988) noted that sexual maturation had a positive and significant association with blood pressure; and sexual maturation contributed as much as body mass index to the variations in blood pressure. Tell (1985) reported a significant association between blood pressure and indices of sexual maturation in their two surveys conducted 2 years apart. Lauer *et al* (1984) noted that children who have the earliest sexual maturation have a higher blood pressure than those of the same age with less sexual maturation. Orchard *et al* (1980) observed a significant relationship between systolic blood pressure and sexual maturation. Voors *et al* (1979) reported sexual maturation correlates with blood pressure for the older children (aged 12 years), after a 1 year follow-up period.

Other studies have suggested that the association observed between different indices of pubertal maturation and blood pressure is as a result of the influence of body weight or height or body mass index or lean body mass on pubertal maturation (Leccia *et al*., 1999; Daniels *et al*., 1998; Daniels *et al*., 1996; Hansen *et al*., 1990; Weir *et al*., 1988; Halfon *et al*., 1987).

Leccia and colleagues (1999) observed that pubertal maturation was statistically significantly and independently associated with blood pressure in girls. However, this independent association with blood pressure was observed only when BMI or percent body fat was controlled for, while it ceased to exist when body weight, height and lean body mass were controlled for in the regression analysis. For boys, pubertal maturation was associated with systolic blood pressure only when percent body fat was included in the analysis, while it disappeared when BMI, body weight, height and lean body mass were included. Leccia *et al* (1999) suggested the effect of pubertal maturation on blood pressure may be mediated through body size, while percent body fat does not appear to have a very strong effect on blood pressure values. Daniels *et al* (1998) reported that blood pressure was related to stage of pubertal maturation after controlling for age, ethnicity and height, however after further adjustments with body mass index (BMI), pubertal maturation stage ceased to be a significant predictor of blood pressure, although trends remained for higher blood pressures with increasing sexual maturation.

Daniels *et al* (1996) observed that sexual maturation accounted for the significant ethnic differences in blood pressure. However, after controlling for height (for diastolic blood pressure) and for both height and sum of skinfolds (for systolic blood pressure) the effect of stage of maturation on blood pressure was eliminated, thus indicating that pubertal maturation exerts its effect on blood pressure mainly through height and body fatness. Hansen *et al* (1990) detected a positive and significant association between sexual maturation and diastolic blood pressure; however this significant association seemed to depend on body weight. Weir and colleagues (1988) reported an association between blood pressure and sexual maturation. However, they suggested that the sexual maturation effect on blood pressure is a body weight effect; since when body weight was used as an independent variable there continued to be an effect for sexual maturation. Halfon *et al* (1987) reported that the systolic blood pressure was significantly higher in girls that have experienced menarche than those who have not; however after controlling for weight and height this significance was lost. Halfon *et al* (1987) noted that the variation in blood pressure may be due to the influences of weight and height.

Conversely, some studies found no association between pubertal maturation and blood pressure (Harding *et al*., 2010; Harding *et al*., 2008; Hoffman *et al*., 2005; Frontini *et al*., 2003; He *et al*., 2002; Savva *et al*., 2000; Lattuada *et al*., 1986; Vartiainen *et al*., 1986; Londe *et al*., 1975).

Harding *et al* (2010) reported no significant association between blood pressure at 3 years follow-up and baseline sexual maturation. Harding *et al* (2008) and Hoffman *et al* (2005) noted that pubertal maturation was not a significant correlate of blood pressure. Frontini *et al* (2003) found no association between age at menarche and blood pressure from childhood to adulthood. He *et al* (2002) and Savva *et al* (2000) observed that pubertal maturation did not prove to be a significant predictor of blood pressure. Lattuada *et al* (1986) reported that pubertal maturation had no determinant influence on blood pressure over time. Blood pressure differences between more and less mature individuals were small over the 4-year period of the study. Vartiainen *et al* (1986) found that in the 2-year follow-up, change in sexual maturation values were not significantly associated with changes in blood pressure. Londe *et al* (1975) observed no association between blood pressure and sexual maturation, illustrated by sex hormones (luteinizing and follicle-stimulating hormone), Tanner breast and pubic hair stages, and age at menarche.

SUMMARY

In this section, I have carried out a review of literature on the association between pubertal or sexual maturation and blood pressure.

All the study samples in this literature review were from the USA and Europe. There appears to be no evidence from the African continent relating variability in blood pressure to pubertal maturation. There were methodological differences between studies in terms of sample size and participant selection methods, blood pressure measurement and pubertal maturation assessment methods, and statistical analysis. Some studies reported no randomised method of participant selection, sample size calculation, participant response rate (for the cross-sectional studies), and baseline participant response rate and/or follow-up rate (for the longitudinal studies). These may likely reduce the integrity of the studies and minimise the generalisability and statistical power of the findings.

The independent role of pubertal maturation in determining blood pressure values is still controversial. Some studies indicate an independent statistically significant association between different indices of pubertal maturation and blood pressure. While other investigators have suggested that pubertal maturation exerts its effect on blood pressure mainly through body size. Some authors have emphasised that early pubertal maturation may be positively associated with obesity, particularly in females; while either early or delayed pubertal maturation may be associated with obesity in males (Ramzan *et al*., 2008; Wang, 2004).

Puberty may be an important factor when discussing blood pressure. Further epidemiological studies with sound methodological rigour which address the potential limitations highlighted from previous studies (such as method of participant selection, reporting of participant response rates, the lack of standardised methods used for blood pressure measurement, and rationale for measures of assessing pubertal maturation) are needed to assess the independent role of pubertal maturation on variations in blood pressure; particularly in African populations where there seems to be no evidence. This may provide new empirical data for determining normal blood pressure standards for children and adolescents, identifying risk factors linked with the natural history of hypertension, and guiding preventive interventions for hypertension in future life.

In the next section, I will present the justification of this study, and state my research questions, aims and objectives and the null hypothesis of the study.

Table 7: Association between pubertal maturation and blood pressure

Author (year)	**Study design/ Country**	**Number (Both, Male, Female), baseline age (years)**	**Number (Both, Male, Female), follow-up length (years)**	**Instrument, BP Measurements**	**Pubertal Maturation Measure**	**Statistics/ variables adjusted for**	**Outcome**		
								SBP Both, Male (M), Female (F)	**DBP Both, Male (M), Female (F)**
Harding *et al* (2010)	Longitudinal/ United Kingdom	6643, 11-13 years	4779, 3 years	An automated digital BP monitor (Omron M-5). Three readings were taken 1 minute apart, after an initial 5 minutes of rest. Mean of the last two readings used for SBP and DBP.	Self-assessment of Tanner (breast for girls and genital for boys) stages categorised into 2 groups: early/middle puberty (stages 1, 2 and 3); and late puberty (stages 4 and 5).	Multiple Regression/Age, ethnicity, *z* scores of height, weight, leg length, the changes in *z* scores for these variables between the baseline survey (11 to 13 years) and the follow-up survey (14 to 16 years), SEC, parental employment, smoking status, BMI score, born abroad		M: Beta = 0.5 (95% CI, -0.4 -1.3) (p>0.05) F: Beta = -0.2 (95% CI, -1.0 -0.6) (p>0.05)	M: Beta = -0.3 (95% CI, -1.0 -0.3) (p>0.05) F: Beta = 0.2 (95% CI, -0.5-0.8) (p>0.05)
Chen and Wang (2009)	Longitudinal/ USA	411 (177 males and 234 females), 9-15 years	283 (120 males and 163 females), 1.5 years.	An automated digital BP monitor (Omron HEM -907). Two readings were taken 2-5 minutes apart. Mean of the two readings was used	Self-assessment of Tanner stages: breast (stage 1–5 stages) for girls, and genitalia (stage 1–5 stages) for boys.	Multiple Regression/ Baseline height and 1.5-year height and BMI change		M: Beta = -1.2 (p>0.05) F: Beta = 1.75 (p<0.05)	M: Beta = -1.17 (p>0.05) F: Beta = 2.18 (p<0.05)

				for SBP and DBP.	Timing of maturation (early vs. non-early maturers). Based on timing of arriving at a specific Tanner sexual maturation stage in relation to the median chronologic age for that stage in the USA national data for African American children and adolescents.			M: Beta = -1.38 (p>0.05) F: Beta = 4.30 (p<0.05)	M: Beta = 0.31 (p>0.05) F: Beta = 3.28 (p<0.05)
Reinehr and Toschke (2009)	Longitudinal/ Germany	384, 4-16 years	287 (134 males and 153 females), 1 year	Standard mercury sphygmomanometer. Two readings were taken, after an initial 10 minutes of rest. Mean of the two readings was used for SBP and DBP.	Physical examination using Tanner (breast for girls and genital for boys) stages categorised into 3 groups: pre-pubertal (stage 1); pubertal (stages 2 and 3); and late pubertal (≥ stage 3)	Generalised linear models/Gender, age, change in standard deviation score-BMI, change in Height		Change Between Baseline and 1-y Follow-up, Mean (SD) SBP and DBP	
							Pre-pubertal during entire study period	1.98 (17.06) p>0.05	3.63 (13.25) p<0.05
							Entering puberty during study period	6.69 (16.69) p<0.05	5.77 (15.83) p<0.05
							Pubertal during entire study period	3.64 (16.50) p>0.05	2.78 (15.72) p>0.05
							Entering late puberty during study period	-5.31 (17.96) p<0.05	-5.79 (18.60) p<0.05
							Late pubertal during entire study period	-0.54 (20.05) p>0.05	2.07 (15.75) p>0.05

Harding *et al* (2008)	Cross-sectional/ United Kingdom	6407, 11-13 years		An automated digital BP monitor (Omron M5 -1). Three readings were taken 1 minute apart, after an initial 5 minutes of rest. Mean of the last two readings used for SBP and DBP.	Self-assessment of Tanner breast, genitalia and pubic hair stages categorised into 3 groups: pre-puberty (stage 1 for breasts or genitalia and pubic hair), early puberty (stages 2 and 3 for breasts or genitalia), and late puberty (stages 4 and 5 for breasts or genitalia).	Multiple Regression/Age, temperature, overweight status, height, standard of living circumstances, ethnicity		Beta = 0.19 (95% CI, -0.55 – 0.93) (p>0.05)	Beta = 0.18 (95% CI, -0.40 – 0.76) (p>0.05)
Hoffman *et al* (2005)	Cross-sectional/ USA	138 females, 8-12 years		An automated digital BP monitor (Dinamap). Five readings were taken 1 minute apart, after an initial 10 minutes of rest. Mean of the last three readings was used for SBP and DBP.	Physical examination using: 1). Tanner breast development (stages 1-5) 2). Tanner pubic hair development (stages 1-5) 3). Sexual maturation rating (a three-category composite index created by collapsing breast development,	ANCOVA/Age, glucose, and insulin adding fat mass (FM), free fat soft tissue (FFST)		p>0.05	p>0.05

					pubic hair development, and menarche (pre-pubertal, pubertal but pre-menarcheal, and pubertal and menarcheal)); and 4). A two-category indicator of menarche (pre- and post-menarcheal).				
Remsberg *et al* (2005)	Longitudinal/ USA		391 females, 8-21 years of age	Standard mercury sphygmomanometer.	Menarcheal age. Early menarche, average menarche and late menarche were classified according to published national estimates of the timing of menarche for non-Hispanic white U.S. girls derived from the National Health and Nutrition Examination Survey III	Mixed effects Regression/ Chronological age		Beta = -1.24 (p<0.0001)	Beta = -0.86 (p<0.01)
Shankar *et al* (2005)	Longitudinal/ USA	715, 6-9 years	151 (86 males and 65 females),	Random zero sphygmomanometer. K1 and K5 were used. Three readings	Pubertal growth (PG) - serial measurements of height.	ANOVA/BMI percentile, height	3 years before onset of PG (rate of increase in	p=0.029	p>0.05

			10 years	were taken. Mean of the last two readings was used for SBP and DBP.	Onset of pubertal growth = the age 2 years before the age at maximum height velocity End of puberty (age where near final adult height is reached) = the age after the onset of the pubertal growth spurt when height velocity first declined to ≤2 cm/year.		BP)		
							Between the onset of PG and the end of PG (rate of increase in BP)	p<0.001	p<0.001
							3 years after end of PG (rate of increase in BP)	p<0.05	p>0.05
Meininger *et al* (2004)	Cross-sectional/ USA	371 (173 males and 198 females), 11-16 years		Ambulatory blood pressure equipment. 24-hour ambulatory blood pressure was used.	Physical examination using Tanner (breast for girls and genital for boys) stages categorised into 2 groups: less mature (stages 1, 2, and 3); and more mature (stages 4 and 5).	Mixed effects Regression/ Height, socioeconomic status, ethnicity, gender, 12 moods, activity, position and location		Parameter estimate = -1.58 (p<0.05)	Parameter estimate = -1.82 (p>0.05)
Frontini *et al* (2003)	Longitudinal/ USA	5-17 years	1479 females, 14-20 years	Standard mercury sphygmomanometer. Six readings were taken for SBP and DBP. K1 and K4 was used for children. K1	Menarcheal age. Grouped into two categories according their age of menarche:	ANOVA Difference in mean BP between early menarche and	In childhood (5-11 years)	p>0.05	p>0.05
							In adolescence (12-18 years)	p>0.05	p>0.05

				and K5 was used for adults.	early menarche (<12 years) and (late menarche ≥12 years).	late menarche	In young adulthood (19-37 years)	p>0.05	p>0.05
He *et al* (2002)	Cross-sectional/ USA	920 (478 males and 442 females), 5-18 years		Standard mercury sphygmomanometer. Six readings were taken for SBP and DBP. K1 and K4 was used for 5-12 year olds. K1 and K5 was used for 13-18 year olds.	Tanner breast, genitalia and pubic hair stages categorised into 3 groups: pre-puberty (stage 1 for breasts or genitalia and pubic hair), early puberty (stages 2 and 3 for breasts or genitalia), and late puberty (stages 4 and 5 for breasts or genitalia). Physical examination using Tanner stages for individuals <11 years old and self-assessed Tanner stages for individuals ≥11 years old.	Multiple Regression/ Gender, ethnicity, pubertal group, height, trunk fat		p>0.05	p>0.05
Cho *et al* (2001)	Cross-sectional/ USA	179 males and 204 females, 11-16 years		Standard mercury sphygmomanometer. K1 and K5. Two readings were taken after an initial 5 minutes of rest. Mean of the two	Physical examination using Tanner breast stages 1-5 for girls and genital stages 1-5 for boys.	Multiple Regression/ Ethnicity, height, age, BMI		M: Beta = 2.83 (p<0.05) F: Beta = 3.27 (p<0.05)	M: Beta = -2.28 (p>0.05) F: Beta = 0.92 (p>0.05)

				readings was used for SBP and DBP.	Pubertal maturity stage was expressed in relation to the median maturity stage for the age group to which the child belonged. Pubertal maturation was categorised into 2 groups: above the median and those equal to or below median.				
Koziel *et al* (2001)	Cross-sectional/ Poland	1149 females, 14 years		An automated digital BP monitor (Omron HEM -704). One reading was taken after an initial 15 minutes of rest. Mean of the last two readings used for SBP and DBP.	Menarcheal age	Multiple Regression/ Height, BMI, waist hip ratio (WHR)		Beta = -0.01 (p>0.05)	Beta = - 0.11 (p<0.05)
Savva *et al* (2000)	Cross-sectional/ Greece	1987 (1037 males and 950 females), 10-14 years		Standard mercury sphygmomanometer. K1 and K5. Three readings were taken. Mean of the three readings was used for SBP and DBP.	Tanner breast stages 1–5 for girls, genitalia stages 1–5 for boys and pubic hair stages 1–5 for both boys and girls.	Multiple Regression/ Waist circumference, waist-to height ratio (WHtR), BMI, age, gender		p>0.05	p>0.05
Leccia *et al* (1999)	Cross-sectional	185 (98 males		Standard mercury sphygmomanometer.	Tanner pubic hair stages	Multiple Regression/		M: r^2= 0.041 (p<0.05)	M: p>0.05

	study/Italy	and 87 females), 10-14 years		Two readings were taken 3 minutes apart, after an initial 5 minutes of rest. Mean of the two readings was used for SBP and DBP.	categorised into 2 groups: prepubertal (stages 1–2) and pubertal (stages 3–5).	Percentage body fat		F: r^2= 0.104 (p<0.01)	F: r^2 = 0.061 (p<0.05)
Daniels *et al* (1998)	Longitudinal/ USA	2379 females, 9 or 10 years	4-5 years	Standard mercury sphygmomanometer. K1, K4 and K5. Three readings were taken 1 minute apart. Mean of the last two readings was used for SBP and DBP.	Tanner areolar and pubic hair stages, and menarche categorised into 3 groups: prepubertal (premenarcheal and stage 1 in areolar or pubic hair stages), pubertal (premenarcheal, but at stage ≥2 in either areolar or pubic hair stages), and postmenarcheal girls.	Multiple Regression/Age, ethnicity, height, BMI		p>0.05	p>0.05
Daniels *et al* (1996)	Cross-sectional/ USA	2379 females, 9 or 10 years .		Standard mercury sphygmomanometer. K1, K4 and K5. Three readings were taken 1 minute apart. Mean of the last two readings was used for SBP and DBP.	Physical examination using Tanner stages based on areolar and pubic hair stages categorised into 2 groups: pre-pubertal (stage 1 in areolar or pubic hair stages) and	Multiple Regression/Age, ethnicity, height, sum of skin folds		Beta = 0.33 (p>0.05)	K4: Beta = 0.21 (p>0.05) K5: Beta = 0.71 (p>0.05)

					pubertal (stage 2 in either areolar or pubic hair stages).				
Armstrong *et al* (1992)	Cross-sectional/ United Kingdom	679 (343 males and 336 females), 11-16 years		Random zero sphygmomanometer. K1, K4 and K5 were used. Three readings were taken after an initial 3 minutes of rest. Mean of the last two readings was used for SBP and DBP.	Tanner breast stages 1–5 for girls, genitalia stages 1–5 for boys and pubic hair stages 1–5 for both boys and girls.	ANCOVA/school year group		M: p<0.05 F: p<0.05	M: p>0.05 F: p<0.05
Kozinetz (1991)	Cross-sectional/ USA	503 females, 7-18 years		Standard mercury sphygmomanometer. K1 and K5. Three readings were taken. Mean of the last two readings was used for SBP and DBP.	Self-assessment of Tanner breast stages 1–5 and pubic hair stages 1–5.	ANCOVA/Height , weight, ethnicity		p<0.05	p<0.05
Hansen *et al* (1990)	Cross-sectional/ Denmark	1330 (676 males and 654 females), 8-10 years		Random zero sphygmomanometer. K1 and K4 were used. One readings was taken.	Tanner breast stages 1–5 for girls, genitalia stages 1–5 for boys and pubic hair stages 1–5 for boys and girls.	Multiple Regression/ Weight, height, age, triceps, skin fold thickness, gender, heart rate, body mass		p>0.05	p>0.05
Kotchen *et al* (1989)	Longitudinal/ USA	304, 14-15 years	287, 5 years	Standard mercury sphygmomanometer. K1 and K5. Readings were taken were obtained until systolic blood pressure was reproduced within	Menarcheal age for girls Change in height for boys.	Pearson/None		M: r = 0.24 (p<0.005) F: r = - 0.23 (p<0.005)	- -

				2mmHg, after an initial 5 minutes of rest.					
Kozinetz (1988)	Cross-sectional/ USA	361 females, 7-18 years		Standard mercury sphygmomanometer. K1, K4 and K5. Three readings were taken 30 seconds apart, after an initial 5 minutes of rest. Mean of the last two readings was used for SBP and DBP.	Self-assessment of Tanner breast stages 1–5 and pubic hair stages 1–5.	Univariate Regression/ None		Beta = 3.4 ($p<0.0001$)	K4: Beta = 2.2 ($p<0.0001$) K5: Beta = 2.3 ($p<0.0001$)
Weir *et al* (1988)	Cross-sectional /USA	746 (424 males and 322 females), 8-18 years		Aneroid sphygmomanometer. K1 and K5 were used. One reading was taken.	Physical examination using Tanner pubic hair stages 1–5.	Multiple Regression/ Weight, age		$p>0.05$	$p>0.05$
Halfon *et al* (1987)	Cross-sectional/ Jerusalem	1154 (556 males and 448 females), 12 years		Standard mercury sphygmomanometer. K1 and K5. Three readings were taken 1-2 minutes apart, after an initial 5 minutes of rest. Mean of the last two readings was used for SBP and DBP.	Menarche	ANCOVA/Height , weight		$p>0.05$	$p>0.05$
Lattuada *et al* (1986)	Longitudinal/ Italy	1905, mean age 14.5 years	1252, 4 years	Standard mercury sphygmomanometer. K1 and K5. Two readings were taken 1 minute apart, after an initial 10 minutes of rest. Mean of the	Pubic hair for boys and menses onset before or after the age of 12 for girls. These were catergorised into two groups:	Multiple Regression/BMI, height		$p>0.05$	$p>0.05$

				two readings was used for SBP and DBP.	pre and post				
Vartiainen *et al* (1986)	Longitudinal/ Finland	966 (503 males and 463 females), 13 years	851 (435 males and 416 females), 2 years	Random-zero sphygmomanometer. K1 and K5. Two readings were taken 30 seconds apart. Mean of the two readings was used for SBP and DBP.	Physical examination using Tanner breast stages 1–5 for girls, genitalia stages 1–5 for boys and pubic hair stages 1–5 for both boys and girls.	Pearson/None		M: r = 0.33 (p>0.05) F: 0.26 (p>0.05)	M: r = -0.09(p>0.05) F: 0.07 (p>0.05)
Tell (1985)	Longitudinal/ Norway	828, 10-15 years	550, 2 years		Physical examination using Tanner breast stages 1–5 for girls, genitalia stages 1–5 for boys and pubic hair stages 1–5 for both boys and girls.	Pearson/None		M: r= 0.39 - 0.47 (p<0.05) F: r= 0.16 - 0.32 (p<0.05)	M: r= 0.33 - 0.35 (p<0.05) F: r= 0.19 - 0.22 (p<0.05)
Lauer *et al* (1984)	Cross-sectional/ USA	2165 (1132 males and 1033 females), 12-15 years		Standard mercury sphygmomanometer. K1 and K5. Three readings were taken. Mean of the last two readings was used for SBP and DBP.	Physical examination using Tanner breast stages 1–5 for girls, and genitalia stages 1–5 for boys.	ANOVA		p<0.05	p<0.05
Orchard *et al* (1980)	Cross-sectional/ USA	625 (319 males and 306 females), 13-18 years		Random zero manometer. K1, K4 and K5. Two readings were taken 5 minutes apart, after an initial 30 seconds	Physical examination using Tanner breast stages 1–5 for girls, genitalia stages 1–5 for	Pearson/None		r = 0.14 (p<0.01)	p>0.01

				of rest. Mean of the two readings was used for SBP and DBP.	boys and pubic hair stages 1–5 for both boys and girls.				
Voors *et al* (1979)	Longitudinal/ USA	3524, 5-14 years	972, 1 year	Standard mercury sphygmomanometer. Six readings were taken. Mean of the readings was used for SBP and DBP. Physiometrics recorder. Three readings were taken. Mean of the three readings was used for SBP and DBP.	Tanner breast stages 1–5 for girls, genitalia stages 1–5 for boys and pubic hair stages 1–5 for both boys and girls.	Multiple Regression/Age, ethnicity, gender, height ponderosity index, upper-arm circumference, triceps skinfold thickness, serum total cholesterol, serum triglyceride, serum lipoprotein, blood haemoglobin	6 years	p>0.05	p>0.05
							9 years	p>0.05	p>0.05
							12 years	Beta = 0.48 (p<0.001)	Beta = 0.54 (p<0.0001)
							15 years	p>0.05	p>0.05
Londe *et al* (1975)	Cross-sectional/ USA	418 (229 males and 189 females), 10-14 years		Standard mercury sphygmomanometer.	Sex hormones (luteinizing and follicle-stimulating hormone); Tanner breast stages 1–5 and age at menarche for girls, and pubic hair stages 1–5 for boys	Pearson/None		p>0.05	p>0.05

INTRODUCTION

In this section, I will present the justification or rationale of this study, and indicate my research questions, aims and objectives and the null hypothesis of the study.

3.5 JUSTIFICATION OF THE STUDY

Rapid epidemiological transition is currently sweeping across Nigeria and many other developing countries alike. The epidemiological transition is taking place along with demographic and nutrition transitions (towards low mortality and birth rate, and longer life expectancy, and towards unhealthy diets and more sedentary lifestyles – a likely prerequisite for increased adiposity (obesity)). These transitions are the consequences of socio-economic development, socio-cultural transitions, rapid urbanisation, globalisation, and westernisation in the developing countries.

Cardiovascular disease (CVD) is a major chronic non-communicable disease at the centre of the epidemiological transition. Discrepancy in CVD outcomes persists in developing countries compared to the developed countries because of the inadequacies of the health system to deal with double burden of disease (that is, communicable and poverty-related diseases, and chronic non-communicable diseases) experienced in the developing world. An increase in hypertension elucidates an increase in CVD. It is well established within the literature that hypertension is a common health problem, worldwide. It is no longer believed to occur only in the adult population. An increasingly large number of epidemiological studies from different countries have clearly demonstrated the presence of hypertension in children and adolescents. However, the definite prevalence of child and adolescent hypertension is unknown.

Several longitudinal studies have highlighted that increased blood pressure levels during childhood and adolescence strongly predicts hypertension in adulthood. Given the poor outcomes of hypertensive related chronic non-communicable diseases (cardiovascular disease) in adulthood populations and the extra burden on the health system in developing countries in transition from communicable and poverty-related disease to chronic non-communicable diseases, it may be logical to begin the development and implementation of public health preventive interventions in childhood and adolescence in course of the epidemiological transition, so as to improve the health outcomes for future cohorts, as they grow up in a world influenced by its associated environmental and life style changes. However, this requires more evidence on the link between blood pressure and its associated factors in children and adolescents.

There is presently little or no information available on the distribution of blood pressure and the factors which determine its distribution in Nigeria. The review of the literature reveals there is inadequate and inconsistent evidence on the relationship between blood pressure and socio-economic characteristics in children and adolescents in Nigeria. The evidence on the relationship between anthropometric measures of adiposity and blood pressure is somewhat consistent in literature; however, more information on the association is required in developing countries, in the wake of the emerging worldwide obesity epidemic (owing to the nutrition transition), comprising Nigeria and other developing countries. In addition, there is presently no known evidence on the relationship between blood pressure and pubertal maturation status of children and adolescents in Nigeria, and the entire African populace; though it has been suggested that blood pressure distribution may vary with pubertal maturation status in the child and adolescent population.

3.6 RESEARCH QUESTIONS

1). Is the blood pressure of children and adolescents aged 11 to 18 years in Nigeria associated with socio-economic characteristics, pubertal maturation status and anthropometric measures of adiposity?

2). What is the prevalence of hypertension in the population of secondary school aged children and adolescents in Nigeria?

3.7 AIMS AND OBJECTIVES

The aims and objectives of this epidemiological population-based study are:

1). to determine the association between socio-economic characteristics (school fee level, parent education level, and household wealth index) and blood pressure (BP) in children and adolescents aged 11 to 18 years in Nigeria;

2). to evaluate the association between pubertal maturation status and blood pressure in children and adolescents aged 11 to 18 years in Nigeria;

3). to evaluate the association between anthropometric measures of adiposity (body mass index and waist circumference) and blood pressure in children and adolescents aged 11 to 18 years in Nigeria; and

4). to determine the overall prevalence of hypertension using internationally agreed guidelines, for the population of secondary school aged children and adolescents in Nigeria.

3.8 NULL HYPOTHESES

1). There is no association between socio-economic characteristics (such as school fee level, parent education level, and household wealth index) and blood pressure in children and adolescents aged 11 to 18 years in Nigeria.

2). There is no association between pubertal maturation status and blood pressure in children and adolescents aged 11 to 18 years in Nigeria.

3). There is no association between anthropometric measures of adiposity (body mass index and waist circumference) and blood pressure in children and adolescents aged 11 to 18 years in Nigeria.

4). There are no secondary school aged children and adolescents with hypertension in Nigeria.

SUMMARY

In this chapter, I have presented a literature review on my four research questions, including: the epidemiology of hypertension in children and adolescents; the association between blood pressure and adiposity; the association between blood pressure and socio-economic circumstances; and the association between blood pressure and pubertal maturation status. I have also presented the justification or rationale of this study, and stated my research questions, aims and objectives and the null hypotheses of the study.

In the next chapter, I will highlight the basis for choosing methodological approaches used in the study. I will provide the possible methodological approaches which could be adopted in the present study.

CHAPTER 4: METHODOLOGICAL ISSUES

4.0 METHODOLOGICAL ISSUES

INTRODUCTION

In this chapter, I will discuss the rationale for choosing methodological approaches used in the study.

I will provide possible methodological approaches which could be adopted in the present study (each with both strengths and limitations). The use of a particular methodological approach is mainly determined by the study aims and objectives, sample population, time allocated for completion of the research, and human and financial resources. Where there is a choice available I have explained the rationale behind the choice. This is important because the development and application of appropriate methodological approaches determines the quality of the data collected and quality of the findings from the research.

4.1 STUDY SETTING

As a resident of Lagos State, I selected Lagos State as my study area because I have local knowledge of its medical and educational facilities, and the health profile of the state is of particular interest to me. In addition, based on the background information on the important influence of urbanisation, socio-economic development and changing lifestyle in the epidemiological transition (Kadiri, 2005), I considered Lagos State an appropriate choice of study area because it is the most populous state in Nigeria and constitutes Nigeria's largest growing urban area (known as the Lagos Metropolis) (Lagos State Government, 2011). Lagos is suggested to be the most economically important state in Nigeria (Fadare and Oduwaye, 2009). The urban area of Lagos State constitutes almost the entire state's population (90%) (Lagos State Government, 2011) and it is the population in Nigeria which has the greatest exposure to socio-economic development and lifestyle changes (see Background Chapter (Chapter 2)) for more details on the study area).

4.2 STUDY DESIGN

Selection of an appropriate study design is very important in an attempt to answer a given research question. This study was carried out using a stratified random sample, school-based cross-sectional study design. A cross-sectional design study is an observational scientific technique used to demonstrate associations between disease conditions and exposure factors, as well as to determine the prevalence of a disease condition in a given population at a single point in time (Rothman *et al*., 2008). This design was chosen in order to examine the association between blood pressure and socio-economic characteristics, body mass index, waist circumference, and pubertal maturation status, as well as to determine the prevalence of hypertension in children and adolescents in Lagos State, Nigeria. A cross-sectional study design is appropriate as it is not costly, all data can be collected at the same time, and the study does not require a follow-up period. This design also allows the research to be carried within the restricted time-frame available to complete a PhD. Conversely, this study design has its disadvantage since it does not allow for identification of cause-and-effect relationships (Rothman *et al*., 2008).

An alternative is a longitudinal study design, which examines the association between disease conditions and risk factors, but demonstrates changes in these associations over time. This study design can examine the association between blood pressure and socio-economic characteristics, body mass index, waist circumference, and pubertal status over a long period of time, making it more likely to identify cause-and-effect relationships (for example whether changing BMI precedes change in blood pressure). A longitudinal study design can be prone to significant participant drop outs over time (Timmreck, 2002), and it was not feasible to adopt for this study as it would have been extremely expensive and would have required too long a follow-up period (Timmreck, 2002).

4.3 SAMPLE SELECTION

Sampling is designed to allow for valid inferences to be drawn about the entire population, since it is not possible to directly observe every single person in a whole population. The sample size calculation is described in the Methods Chapter (Chapter 6).

4.3.1 SCHOOL SELECTION

Secondary schools in Lagos State, Nigeria do not draw their students from the same socio-economic groups; in order to increase the representativeness of the sample from each socio-economic stratum and to make inferences to specific groups, secondary schools in Lagos State, Nigeria were stratified into three socio-economic groups (high-income, middle-income and low-income group), based on the level of school fee. Stratified sampling allows equal numbers of individuals from each stratum to be selected, where strata may typically vary extensively in size. In addition, stratified sampling has the power to maximise variation between groups and minimise variation within groups, thus leading to greater stability of statistical power of difference between groups (Frankel, 2010).

Following stratification of schools into three socio-economic groups, secondary schools were purposively selected within each stratum. Purposive sampling is a non-probability sampling technique (that is all schools in each stratum do not have equal chance of being selected), however, it aims to enrich data by intentionally selecting participants (that is secondary schools) because they have specific characteristics relating to the objective of the study (such as age range, socio-economic status and number of students) (Macnee and McCabe, 2008). The purposive sampling method was chosen to be appropriate for this study because it is a relatively easy, inexpensive and less time consuming technique (Macnee and McCabe, 2008), given the enormous and complex sampling frame and procedure that would be required if probability sampling were employed.

4.3.2 PUPIL SELECTION

Within each of the purposively selected secondary schools, children and adolescents aged 11 to 18 years were selected to participate in the study using random sampling. The age range has been established as a period where high blood pressure with no known cause usually starts to develop (that is not associated with a disease) (Gulati, 2006). This age range is also appropriate for determining maturation level, as it reflects for the majority of adolescents the period from before the development of secondary sexual characteristics to the attainment of full sexual maturation (Marshall and Tanner, 1970; Marshall and Tanner, 1969). A class was randomly selected in each year group and then students were selected from the class register, using random number computer generated method. This simple random sampling is a probability sampling technique that allows all children and adolescents in each school to have an equal chance of being selected (Frankel, 2010). This sampling method was used because the representativeness of the sample is essential to enable broader generalisation of the findings from the research (Frankel, 2010).

4.4 DATA COLLECTION

The use of suitable tools to collect data in a study is of utmost importance to achieve accurate findings. In the present study, data was collected by means of a questionnaire and measurement devices. The rationale for the choice of assessment methods and measurement tools used in the study is explained below.

4.4.1 BLOOD PRESSURE MEASUREMENT DEVICE

An automated digital blood pressure monitor was used to measure blood pressure (systolic and diastolic blood pressure) in this study. The automated digital blood pressure monitor (Omron HEM-907) has been validated by El Assaad *et al* (2002) and White and Anwar (2001). The conventionally used blood pressure measurement device is the standard mercury sphygmomanometer (which is considered the “gold standard” for blood pressure measurements) (Pickering *et al*., 2005; Gillman and Cook, 1995). However, the use of the standard mercury sphygmomanometer is decreasing in both the clinical and research settings due to concerns surrounding the toxicity of mercury for persons using mercury sphygmomanometers (O’Brien *et al*., 2003), and because of growing evidence that the device may wrongly classify many individuals as hypertensive (this is because accurate readings obtained from the device are difficult and prone to digit preference and observer bias) (Pickering *et al*., 2005; Gillman and Cook, 1995).

The standard mercury sphygmomanometer is increasingly being replaced by other devices that are designed for automated measurement. I considered an automated digital blood pressure monitor the most suitable blood pressure measurement device in my study because it has been suggested to be appropriate for epidemiological studies involving children and adolescents (Gillman and Cook, 1995). An automated digital blood pressure monitor improves inter-rater reliability and eliminates inter-rater variability, digit preference and errors of interpretation (O'Brien *et al*., 2003; Gillman and Cook, 1995). Given that the blood pressure readings are automated, no individual judgment is required for blood pressure readings and the device can be used outside the clinical setting without a clinician presence (Pickering *et al*., 2005).

An automated digital blood pressure monitor also produces sequential readings (such as three readings obtained in the present study). It has been suggested that multiple blood pressure readings have greater predictive power than one reading (Wingfield *et al*., 2002). Automated readings eliminate the need for repeated costly training of assessors in the use of the standard mercury sphygmomanometer, important to minimise observer bias (Pickering *et al*., 2005). The main limitation of using an automated digital blood pressure monitor is the problem of comparison with previous research since a significant number of previous epidemiological study data are based on measurements obtained from the standard mercury sphygmomanometer (Pickering *et al*., 2005).

The ambulatory blood pressure (ABP) monitor is an alternative automated digital blood pressure monitor. The ambulatory blood pressure monitor is typically used for diagnostic purposes outside the clinical setting to identify persons with white coat hypertension (Pickering *et al*., 2005). An ambulatory blood pressure monitor measures blood pressure over a long duration, usually 24 hours, thus producing more readings and identifying potential variability in blood pressure with time of day and activity (O'Brien *et al*., 2003). This monitor was not practical for use in this study as it could be uncomfortable for participants to carry around, expensive and time consuming (O'Brien *et al*., 2003).

4.4.2 MEASURES OF ADIPOSITY

Body fatness or adiposity is measured by a variety of methods. These include direct 'gold standard' measures, such as, underwater weighing, magnetic resonance imaging (MRI), total body water, total body electrical conductivity, total body potassium, computed tomography, densitometry and dual energy X-ray absorptiometry (DEXA) (Neovius *et al*., 2005; Lobstein *et al*., 2004; Mei *et al*., 2002; Dietz and Bellizzi, 1999), and indirect anthropometric measures of relative adiposity or fatness, such as waist circumference measurement, hip circumference measurement, skinfold thickness, body mass index (BMI) and the ponderal index (Senbanjo *et al*., 2009; Lobstein *et al*., 2004).

As direct measures are complex, costly, often time-consuming and the applicability is poorly suited for clinical and population-based screening and research (Must and Anderson, 2006), alternative indirect anthropometric measures, which are less accurate, less expensive, accessible, simple, easily administered (Neovius *et al*., 2005), are the most frequently used tools in clinical and population-based screening and research (Must and Anderson, 2006; Mei *et al*., 2002). According to Wang (2004), an ideal measure for adiposity that is accurate, precise, accessible, acceptable, predicts health risks, appropriate to develop some cut-offs to separate individuals into different groups regarding their adiposity, appropriate in clinical setting or population-based studies, cost effective, and easy to use in both sexes and across all ages and ethnic groups, remains to be determined.

In the present study, I measured adiposity using two anthropometric measures (BMI and waist circumference) to maximise the accuracy of assessment of adiposity. BMI and waist circumference have been suggested to be quick and easy to measure, reproducible, require simple measurement tools, and are considerably valid anthropometric measures of adiposity (Senbanjo *et al*., 2009; Must and Anderson, 2006; Neovius *et al*., 2005; Wang, 2004; Mei *et al*., 2002; Daniels *et al*., 2000; Dietz and Bellizzi, 1999).

Body mass index is the most extensively employed indirect measure of adiposity in population-based studies (Ribeiro *et al*., 2003). It has also been recommended and used to screen for underweight, overweight, and obesity among children and adolescents (Mei *et al*., 2002), and several BMI-for-age gender-specific reference charts have been produced. The three most widely recommended are the Center for Disease Control (CDC) reference data (Kuczmarski *et al*., 2002), International Obesity Task Force (IOTF) international growth reference (Cole *et al*., 2000), and the WHO reference data (de Onis *et al*., 2007). In the present study, I used the WHO (2007) growth reference data (see Appendix 3). One main problem of BMI is that it estimates body mass without separating fat mass from lean mass (Mazicioglu *et al*., 2010; Flores-Huerta *et al*., 2009; Must and Anderson, 2006).

Auxiliary measures (such as waist circumference) have been recommended to be used in conjunction with BMI in clinical and research practice (Neovius *et al*., 2005). According to Neovius *et al* (2005), the inclusion of circumferential measures may help to resolve the major limitation of BMI. Waist circumference estimates the exact fat content situated centrally in the body (Flores-Huerta *et al*., 2009). It has also been recommended as a measure to determine the criteria for adiposity (Senbanjo *et al*., 2009; Janssen *et al*., 2004). Unlike BMI, internationally recommended reference values for waist circumference are scarce (Neovius *et al*., 2005), and many countries have produced and rely on their own country-specific reference values (Senbanjo *et al*., 2009). In this study, I used an American waist circumference reference chart (Fernández *et al*., 2004) (see Appendix 4). To the best of my knowledge, there is no Nigerian specific waist circumference reference chart available.

4.4.3 SOCIO-DEMOGRAPHIC INFORMATION AND HEALTH HISTORY

Both the socio-demographic information and health history information (such as age, gender, religion, ethnicity, current medical conditions and regular medication) obtained from the questionnaire do not require an assessment tool. I obtained information on age, gender, religion and ethnicity in order to have a detailed knowledge of the socio-demographic characteristics for the study population, observe the distribution of these characteristics within the study population as well as determine the socio-demographic representativeness of the sample in order to make broader generalisation of the findings from the study. Information on current medical conditions and regular medication was also obtained for the study population so as to identify individuals who may have significant medical conditions and/or are taking medications that may affect their blood pressure level.

4.4.4 PHYSICAL ACTIVITY LEVEL

Physical activity level in children and adolescents is measured using a variety of procedures including doubly labeled water, direct observation, accelerometers, calorimetry and self-report questionnaires (Lachat *et al*., 2008; Eisenmann, 2004; Kohl *et al*., 2000). The laboratory-based calorimetry and doubly labeled water methods are the most valid, but are intrusive and substantially expensive to implement (Eisenmann, 2004). Compared to other methods, self-report questionnaire is considered to have a relatively low validity; and is prone to “recall bias” and understanding of questionnaire (Kohl *et al*., 2000). However, self-report questionnaire is the most frequently used assessment technique in population-based studies because it is relatively cost-effective, less onerous for participants and researchers, quick and easier to implement and allows for more physical activity information to be obtained at the same time (Janz *et al*., 2008; Lachat *et al*., 2008; Kohl *et al*., 2000).

A variety of self-reported questionnaires have been developed and validated to assess physical activity in children and adolescents. The adopted assessment tool must be reliable, valid, and appropriate for the age of the study population and for the types of standard activities carried out in the study population (Treuth *et al*., 2005). In this study, physical activity level was self-reported using the validated Fels Physical Activity Questionnaire (PAQ) for children and adolescents (Treuth *et al*., 2005). The Fels Physical Activity Questionnaire was originally used in rural Maryland, United States for children and adolescents aged 7 to 19 years. It is considered a reliable (r = 0.48 to

0.76) and valid (r = 0.11 to 0.34) assessment tool (Treuth *et al.*, 2005). The scores of the sport, leisure and work (household chores)) activities of the Fels Physical Activity Questionnaire are based on the values of intensity and frequency of the activities which are converted to Likert scales (where, 0 (no sports listed) = 1; 0.01-<4 = 2; 4-<8 = 3; 8-<12 = 4; and ≥12 = 5). The Likert scores are averaged to obtain sports index, leisure index and work (household chores) index. The total score for physical activity is a summation of the values of the sport, leisure and work (household chores) index (Treuth *et al.*, 2005). There is no unit for physical activity level derived from the Fels Physical Activity Questionnaire.

To the best of my knowledge, there is no specific standard questionnaire for measuring physical activity level in children and adolescents in Nigeria. I considered the Fels Physical Activity Questionnaire for children and adolescents suitable for all children and adolescents (irrespective of the socio-economic group) in Lagos, Nigeria, because it consists of items on sports activities, leisure activities and household chores, relevant to society in Lagos, Nigeria.

4.4.5 SALT INTAKE

The assessment of dietary salt intake in epidemiological studies is hampered by some methodological challenges. The “gold standard” method for assessing dietary salt intake is the objective laboratory measure of urinary sodium excretion from multiple 24-hour urine collections (Matsuzuki *et al.*, 2008; Charlton *et al.*, 2007; Bentley, 2006; He and MacGregor, 2006; Micheli and Rosa, 2003). However, this procedure is accompanied by practical problems which hinder its use in large epidemiological surveys, particularly in children and adolescents. It is expensive, time consuming, mostly uncomfortable and inconvenient for individuals to perform and adhere to. In addition, urine collection may be incomplete, timing for each collection may be inaccurate, and habitual salt intake may be altered during the process (Charlton *et al*., 2007; Bentley, 2006; Micheli and Rosa, 2003; Shepherd and Farleigh, 1987).

Other objective laboratory measures of urinary sodium excretion using repeated overnight urine and spot urine collections have been suggested to assess dietary salt intake (Hashimoto *et al*., 2008; Micheli and Rosa, 2003; Lee *et al*., 1983; Liu *et al*., 1979a; Liu *et al*., 1979b) in an attempt to reduce the practical difficulties observed in the 24-hour urine collection. In general, the objective laboratory measure of urinary sodium excretion is appropriate, if practicable, for comparing salt intakes in populations, but, limited in determining separate estimation of salt intake from different dietary sources (Charlton *et al*., 2007; Shepherd and Farleigh, 1987).

Many questionnaires (such as food diary and dietary recall questionnaire) have been developed to identify habitual individual dietary sources of salt and categorise individuals in relation to their use of salt (Charlton *et al*., 2007). The use of subjective questionnaires to assess dietary salt intake in epidemiological studies has been highlighted as relatively cost-effective, easy to administer, with low participant burden in terms of time and practicalities. Also questionnaires allow several sources of dietary salt information to be obtained at the same time (Charlton *et al*., 2007; Bentley, 2006; Caggiula *et al*., 1985; Shepherd *et al*., 1985; Pietinen *et al*., 1982). However, dietary salt intake questionnaires are limited as assessment tools for the evaluation of salt intake because of inaccuracy in dietary report resulting from participant error in recording food portions and salt composition of processed foods (because of variation by manufacturers), participant difficulty in remembering previously consumed foods (due to daily variation in food consumption) and varied degree of motivation to complete the record accurately (Bentley, 2006; Micheli and Rosa, 2003).

The distinctive dietary characteristics of each population have limited the applicability of salt intake questionnaires validated with other populations. The choice of questionnaire adopted in a study would depend on dietary features of the study population and the objective of the research (Bentley, 2006). To the best of my knowledge, there is no questionnaire developed specifically for the general Nigerian population in order to identify individual habitual dietary sources of salt and group individuals in relation to their use of salt.

I could not identify a validated questionnaire on dietary salt intake from the literature suitable for the Nigerian population for this study. Accurate estimates of salt intake from questionnaire are difficult due to the numerous sources of dietary salt that exist, (including natural salt content in food, salt content in drinking water, salt added during food manufacturing, preservation, cooking and at the table) (Charlton *et al*., 2007; Kim *et al*., 2007), and children and adolescents may not be aware of some of these sources. In the present study, I therefore considered a single source of dietary salt intake by self-reported habitual use of table salt the most appropriate method to assess salt intake in the study population and to attempt to classify individuals according to their use of salt.

The method of self-reported habitual use of table salt has been employed to assess salt intake in several populations (Tesfaye *et al*., 2009; Adamopoulos *et al*., 1987; Shepherd and Farleigh, 1987; Mittelmark and Sternberg, 1985; Phillips *et al*., 1985; Pietinen *et al*., 1982), including a study on an adult Nigerian population (Olubodun *et al*., 1997). It has been suggested that self-reported habitual use of table salt is strongly associated with actual use (Mittelmark and Sternberg, 1985); however, it is only valuable in indicating discretionary use of salt and not total dietary salt (Charlton *et al*., 2007).

4.4.6 SOCIO-ECONOMIC CHARACTERISTICS

Accurate measures for assessing socio-economic characteristics are important for epidemiological studies (Hargreaves *et al*., 2007). Socio-economic characteristics is a complex concept assessed by a wide range of measures (West *et al*., 2001; Winkleby *et al*., 1992). In the present study, I used multiple proxy measures to assess the socio-economic characteristics of the study participants – school fee level, household wealth index, and parent/carer education level. I considered this to increase the possibility of obtaining accurate assessment of socio-economic characteristics within the study. Multiple measures of socio-economic characteristics have been suggested to be important in order to gain a better knowledge of health outcomes among children and adolescents (Currie *et al*., 1997).

Prior to the selection into this study, I stratified secondary schools in Lagos State into three socio-economic groups (high-income, middle-income and low-income schools) based on the school fee level. However, in order to achieve an adequate representation of the low, middle and high income population within the Lagos society, I considered it necessary to assess socio-economic characteristics further by using other proxy measures (such as household wealth index and parent/carer education level). This is because level of school fee is a crude proxy measure of socio-economic characteristics, and schools in each socio-economic stratum could comprise not just one major dominant socio-economic group, but could also include other minority socio-economic groups (for example, there could be students from a poor home on scholarship attending a high fee paying school).

Established methods of assessing socio-economic characteristics include direct measures of socio-economic characteristics, such as income, expenditure and consumption, and proxy measures of socio-economic characteristics such as occupation, education and household wealth index developed from information on living circumstances (Balen *et al*., 2010; Filmer and Pritchett, 2001). According to Winkleby *et al* (1992), there can be no measure of socio-economic characteristics that is generally valid and appropriate for all populations. The choice of an appropriate measure of socio-economic characteristics of children and adolescents depends on the study practicalities, inclusiveness (that is, can be measured for all children and adolescents in the study), and stability of measure over time (that is, a measure that may not vary extensively in the short period) (Currie *et al*., 1997; Hauser, 1994).

Occupation is one of the most commonly used measures of socio-economic characteristic in epidemiological research, alongside income and education (Lien *et al*., 2001; Currie *et al*., 1997). Occupation is a significant socio-economic characteristic in the developed world (Kaplan and Keil, 1993). In developed countries, there are established standard classifications of individuals into various occupations as a proxy measure of socio-economic characteristics (for example, the General Register of Occupations in the United Kingdom) (Cortinovis *et al*., 1993; Zurayk *et al*., 1987). However, such classifications do not exist in developing countries (such as Nigeria), where organisational difficulties within the countries have hindered the attainment of such national registers (Cortinovis *et al*., 1993). The application of the occupational based socio-economic classification in developed countries to developing countries will be inappropriate based on the core differences in economy, characteristic social organisations and values between these societies (Cortinovis *et al*., 1993).

In a country like Nigeria, where the informal and service sector economy is widespread, as compared to developed countries (Zurayk *et al*., 1987), the adoption of occupational classification in developed countries is not practicable and realistic. Furthermore, occupational classifications generally often face some challenges such as continuous requirement of changes to the classifications as new occupations are created or rank of occupations change, and also problems in taking account of unemployed and retired persons, as well as housewives (Kaplan and Keil, 1993; Zurayk *et al*., 1987).

Money-metric information such as income and consumption expenditure are regarded as the most established, common, gold standard and direct measures of socio-economic characteristics (Hargreaves *et al*., 2007; Vyas and Kumaranayake, 2006; Sahn and Stifel, 2003; Filmer and Pritchett, 2001). However, these direct measures of socio-economic characteristics are arduous, time consuming and expensive to conduct (Balen *et al*., 2010; Onwujekwe *et al*., 2006; McKenzie, 2004; Houweling *et al*., 2003; Montgomery *et al*., 2000), and often require significantly advanced analytic skills which is often beyond the context of most epidemiological studies (Balen *et al*., 2010; Hargreaves *et al*., 2007; Kaplan and Keil, 1993). In addition, information on income or consumption expenditures is often not available in many national demographic surveys (McKenzie, 2004; Falkingham and Namazie, 2002; Ferguson *et al*., 2002; Filmer and Pritchett, 2001; Montgomery *et al*., 2000).

According to Kaplan and Keil (1993), income is a significant measure of socio-economic characteristics because it is a means of obtaining goods and services. However, the challenges encountered in obtaining complete and accurate income data are well recognised (Shavers, 2007; Falkingham and Namazie, 2002), particularly in developing countries (Moser and Felton, 2007). Income data are most often poor and under-reported in high-income households and where income is acquired from various sources, particularly those obtained from private and informal sectors (for instance, developing countries, such as Nigeria, where informal remuneration process is widespread) (Moser and Felton, 2007; Vyas and Kumaranayake, 2006; Falkingham and Namazie, 2002; Zurayk *et al*., 1987). These problems with data quality are mostly due to problems of recall, personal/cultural sensitivity and security reasons towards disclosing income information, and suspicion of consequential tax investigation (Balen *et al*., 2010; Moser and Felton 2007; Falkingham and Namazie, 2002; Akinkugbe *et al*., 1999; Adams *et al*., 1997; Balogun *et al*., 1990a).

Measurement of income can also be problematic for societies that engage in barter (mainly in developing countries) (Cortinovis *et al*., 1993), self-employed individuals, and individuals in agricultural or tourist industries due to seasonal fluctuations in earnings (Balen *et al*., 2010; Vyas and Kumaranayake, 2006; McKenzie 2004; Sahn and Stifel, 2003). Thus income at a single period in time may be inaccurate for these groups of people (Moser and Felton, 2007). The overall potential measurement error and recall bias in the assessment of income, limits it as a reliable measure of socio-economic characteristics, particularly in developing countries (Balen *et al*., 2010; Moser and Felton, 2007; Adams *et al*., 1997).

A cumulative of consumption expenditures is suggested to be an adequate direct measure of socio-economic characteristics in developing countries (Sahn and Stifel, 2003; Montgomery *et al*., 2000), particularly for short term measurement periods. Consumption expenditures are relatively easier to collect and more reliable than income information (Kolenikov and Angeles, 2008; Filmer and Pritchett, 2001; Montgomery *et al*., 2000). Individuals are more prepared to provide information on their consumption expenditure than income with less suspicion of the outcome of such disclosure and less personal/cultural sensitivity (Moser and Felton, 2007).

Unlike income data, consumption expenditure is not influenced by the presence of informal and private sectors, numerous and constantly changing sources of income, as well as issues of seasonality in earning because of consumption “smoothing” over time (for instance, although individuals may experience fluctuations in earnings, this is smothered in consumption expenditure as many individuals tend to save during peak times as a support for down times) (Moser and Felton, 2007; Sahn and Stifel, 2003; Filmer and Pritchett, 2001).

Although consumption expenditure data has its merits over income data, it has several notable limitations, some of which are similar to income. Consumption expenditure information is prone to recall bias, which varies with the length of the measurement periods (Scott and Amenuvegbe, 1990) and measurement error (as great parts of goods consumed from home produce, self-service and bartered good may not be captured) (Moser and Felton, 2007; Sahn and Stifel, 2003). In addition, complex technical difficulties (such as lack of accurate and reliable price indices of goods and services, and high variability in inflation rates) are experienced in the formation of consumption expenditure aggregates (Sahn and Stifel, 2003).

The overall potential measurement error and recall bias in the assessment of income and consumption expenditure information, limits them as reliable measures of socio-economic characteristics, particularly in developing countries (Balen *et al*., 2010; Moser and Felton, 2007; Sahn and Stifel, 2003; Adams *et al*., 1997). In addition, the majority of children and adolescents may not have adequate knowledge of the consumption expenditure and various sources of income of their parents/carers (Currie *et al*., 1997).

Based on the potential difficulties involved in obtaining and using occupation, income and consumption expenditure information as proxy and direct measures of socio-economic characteristics, respectively, particularly in developing countries, and also the suitability of a proxy measure of socio-economic characteristics for the age range of the study population, in the present study, I considered using household wealth index, first put forward by Rutstein in the 1990s (Rutstein and Johnson, 2004), as a proxy measure to further assess socio-economic characteristics. The household wealth index was developed from questions on living circumstances (including access to drinking water, sanitation and electricity, household assets, housing features, number of rooms used for sleeping, agricultural land and farm animal ownership) adapted from the Household Questionnaire of the Demographic and Health Survey (DHS) (2010).

I adapted the DHS Household Questionnaire, originally designed for interviewers, for self-report by the children and adolescents in the present study. I needed to adapt the DHS Household Questionnaire because to the best of my knowledge no standardised

Nigerian specific household questionnaire exists. The DHS Household Questionnaire is well acknowledged, validated and recommended for use in many countries, such as Nigeria, where no established measures of socio-economic characteristics exist (Demographic and Health Survey, 2010). The Household Questionnaire has been used in about two hundred DHS surveys carried out in about eighty sub-Saharan African countries over the last thirty years, each one typically covering between five thousand and thirty thousand representative households of a country's population) (Demographic and Health Survey, 2011). It therefore allows for cross country comparisons (Gwatkin *et al*., 2007; Vyas and Kumaranayake, 2006; Filmer and Pritchett, 2001).

Household wealth index derived from household surveys such as the Demographic and Health Survey has been used as a proxy of socio-economic characteristics in many studies in developing countries in order to determine wealth differences in various outcomes, such as enrolment and educational attainment (Filmer and Pritchett, 2001), school attendance (McKenzie, 2004), use of health services (Schellenberg *et al*., 2003), child under-nutrition, infant and child mortality, immunisation coverage (Houweling *et al*., 2003), fertility, smoking and alcohol use and contraceptive practices (Gwatkin *et al*., 2007). The household wealth index has been suggested to be reliable, and produce a considerable consistency with income and consumption expenditure (Balen *et al*., 2010; Lindelow, 2006; McKenzie, 2004; Houweling *et al*., 2003; Sahn and Stifel, 2003; Booysen, 2002; Filmer and Pritchett, 2001; Morris *et al*., 2000; Filmer and Pritchett, 1998). On the other hand, some authors are sceptical about the precision of the household wealth index (Montgomery *et al*., 2000), and the reliability of using the household wealth index has also been queried by other researchers (Onwujekwe *et al*., 2006).

The main advantage of using household wealth index over the direct methods based on income and consumption expenditure is that it circumvents most of the measurement challenges related to income and consumption expenditure, such as under-reporting, recall bias, seasonality and measurement errors (Balen *et al*., 2010; Kolenikov and Angeles, 2008; Moser and Felton, 2007; Vyas and Kumaranayake, 2006; McKenzie, 2004; Rutstein and Johnson, 2004; Filmer and Pritchett, 2001). It also requires fewer data components, indicators are easier to collect as questionnaires are readily available, it is less time consuming (as information can be obtained at a single time) and relatively inexpensive compared to income and consumption expenditure (Vyas and Kumaranayake, 2006; McKenzie, 2004). The household wealth index has also been suggested to be more indicative of long-term wealth than income and consumption expenditure (Ferguson *et al*., 2002; Filmer and Pritchett, 2001). In addition, the majority of children and adolescents are likely to have an adequate knowledge of their living environment (Balogun *et al*., 1990a).

The use of household wealth index has some criticisms. According to McKenzie (2004), the main difficulty of using household wealth index is the problem of ensuring an adequately wide range of living circumstances indicators are included to allow for clear distinction across households. There is no consensus on a single standard set of variables or questions used to develop a household wealth index and most studies often select variables on an ad-hoc basis (Houweling *et al*., 2003; Montgomery *et al*., 2000). Houweling *et al* (2003) noted that the choice of variables included may influence the stability of the households in their relative socio-economic positions. As with other proxy measures of socio-economic characteristics, the household wealth index is obtained at household level, although poor persons could reside in wealthy households and vice versa. Household wealth index is more representative of longer term wealth, not considering short term shocks in the household (Vyas and Kumaranayake, 2006). Thus, a household wealth index may not be appropriate where the outcome of concern is related to current resources of the household (Vyas and Kumaranayake, 2006).

Household wealth index may not be equally appropriate for both urban and rural populations (Balen *et al*., 2010; Lindelow, 2006). A case is drawn where ownership of farm animals and agricultural land may be more descriptive of wealth in rural than urban populations (Vyas and Kumaranayake, 2006; Falkingham and Namazie, 2002). The quality of the household features is typically not highlighted within the living circumstances information (Morris *et al*., 2000). The usual wall material of cement or brick within the urban population is part of the best quality wall materials, but their conditions are not highlighted as they are varied within the urban population. In addition, the urban dwellings may be of poorer conditions than rural populations living in more rudimentary dwellings made of stone with mud or plywood (Falkingham and Namazie, 2002).

The quantity and/or quality of durable household assets (such as television, car, mobile phone, laptop, satellite transmission and refrigerators etc.) are not captured within the living circumstances information (Falkingham and Namazie, 2002). Those more affluent may have superior quality or advanced model appliances than those less privileged. In addition, the working conditions of durable household assets are not highlighted (Falkingham and Namazie, 2002). Also, the consistency of delivery of services such as water and electricity is not captured. For example, households in many developing countries (including Nigeria) experience regular interruptions to electrical power supply (Falkingham and Namazie, 2002).

Lastly, the statistical analytic method employed to create the household wealth index from indicators of living circumstances has also been criticised. The aggregation of indicators of living circumstances can be carried out using several methods such as a simple tallying of all indicators, which considers all indicators as equal (Moser and Felton, 2007), weighting of indicators according to local knowledge (Balogun *et al*., 1990a), or through the application of statistical techniques such as factor analysis (Sahn and Stifel, 2003), multiple correspondence analysis (MCA) (Booysen *et al*., 2005; Cortinovis *et al*., 1993), principal axis factoring (Balen *et al*., 2010), and principal components analysis (PCA) (Filmer and Pritchett, 2001).

In the present study, I used the principal component analysis method to develop a household wealth index, as suggested for the Household Questionnaire of the DHS (Rutstein and Johnson, 2004) and recommended by Filmer and Pritchett (2001). The use the principal components analysis to create a household wealth index was first put forward by Rutstein in the 1990s (Rutstein and Johnson, 2004), with further support from many researchers (Balen *et al*., 2010; Gwatkin *et al*., 2007; Hargreaves *et al*., 2007; Vyas and Kumaranayake, 2006; McKenzie, 2004; Houweling *et al*., 2003; Schellenberg *et al*., 2003; Ferguson *et al*., 2002; Filmer and Pritchett, 2001; Durkin *et al*., 1994).

PCA is a data summary technique used for aggregating information spread in numerous numeric measures into one single dimension or index (Kolenikov and Angeles, 2008; Vyas and Kumaranayake, 2006; Filmer and Pritchett, 2001). The principal components analysis is relatively simple to perform and gives more precise weights than simple summation method and other statistical options (Moser and Felton, 2007; Vyas and Kumaranayake, 2006). Vyas and Kumaranayake (2006) highlighted that the main argument among critics about the use of principal components analysis is that it is considered to be arbitrary and has been suggested to lack theory in the process of selecting the number of components and the choice of variables included. Also, the technique is solely based on the predictive strength of the first principal component to assess socio-economic characteristics (Vyas and Kumaranayake, 2006) (see Methods Chapter (Chapter 6) for more details). Vyas and Kumaranayake (2006) further noted that various problems relating to the information on living circumstances will influence the outcome of the principal components analysis.

Parent/carer education level was also used a proxy measure of socio-economic characteristics in the present study. Shavers (2007) highlighted that education is considered the most basic constituent of socio-economic characteristics due to its impact on occupational and earning prospects. Education has been noted to be related to occupation and income; however, it is considered an independent dimension of socio-economic characteristics (Braveman *et al*., 2005; Lien *et al*., 2001; Currie *et al*., 1997). According to Zurayk *et al* (1987), in the absence of established socio-economic characteristics measures, for urban populations in transition in developing countries (where disparity in educational prospects for populations has occurred; ranging from uneducated to tertiary education level, creating considerable education groups), education measure of socio-economic characteristics may be a more suitable and practical measure compared to occupation or income.

I considered education as a suitable measure to represent social class standings within my study population as I am not aware of any standardised scales of socio-economic characteristics within the Nigerian society. Many authors have used parental education level information as a proxy measure of socio-economic characteristics of children and adolescents in Nigeria (Olatunde, 2010; Omigbodun *et al*., 2010; Opara *et al*., 2010; Senbanjo and Oshikoya, 2010; Ogunlesi *et al*., 2008; Akinkugbe *et al*., 1999; Akinkugbe *et al*., 1990; Adams-Campbell *et al*., 1987).

Parent education level information is often obtained from children and adolescents in school based studies for the basic reason that it is typically hard to include parents, as this often requires added time, effort, and cost (Looker, 1989). Proxy report of parental education level by children and adolescents has been reported to show good agreement with the direct report from parents (Pu *et al*., 2011; Pueyo *et al*., 2007; Lien *et al*., 2001; Tuinstra *et al*., 1998; Looker, 1989; Youngblood, 1977; Niemi, 1974; Cohen and Orum, 1972). However, some authors are wary about its use and provided cautious conclusions, mostly noting direct parental education information should be obtained to avoid likely uncertainties about proxy reports (Kayser and Summers, 1973; Kerckhoff *et al*., 1973; Borus and Nestel, 1973). One author has debated its use, highlighting it as inappropriate (St. John, 1970).

Proxy report on parental education level has been noted to be more accurate in older children (Pueyo *et al*., 2007; Looker, 1989; Youngblood, 1977; Kerckhoff *et al*., 1973; Cohen and Orum, 1972); however, this is not supported by some authors (Lien *et al*., 2001). In addition, residing with the parent has also been highlighted to increase the accuracy of proxy reports on parental education level (Looker, 1989). The accuracy of proxy reports on father's education level and mother's education level has been highlighted to be typically similar (Pu *et al*., 2011; Lien *et al*., 2001).

The main merit of employing a widely used proxy measure of socio-economic characteristics such as education is the fact that it allows for findings to be more easily comparable to past research (Miech and Hauser, 2000; Winkleby *et al*., 1992). Education is also suggested to be a stable aspect of socio-economic characteristics which is usually established by early adulthood and often remains constant through the life span (Shavers, 2007; Siri, 2005; Krieger *et al*., 1997; Winkleby *et al*., 1992; Zurayk *et al*., 1987), irrespective of changes in state of health (such as poor health in adulthood) compared with income and occupation (Shavers, 2007; Krieger *et al*., 1997; Kaplan and Keil, 1993). Education has also been highlighted to have practical advantages as the information obtained is easy, inexpensive and relatively less time consuming to collect and code and classify, which is most important for research with cost or time restraints (Shavers, 2007; Miech and Hauser, 2000; Krieger *et al*., 1997; Winkleby *et al*., 1992; Zurayk *et al*., 1987). Education information is usually inclusive of most populations (such as the retired, housewives and persons out of work, illiterates to persons with many years of education) (Shavers, 2007; Krieger *et al*., 1997; Looker, 1989).

Although education is a valuable proxy measure of socio-economic characteristics for all of the reasons mentioned above, it has some limitations. The problem of high levels of non-response by children and adolescents to questions on parental education level has been highlighted by several researchers (Pueyo *et al*., 2007; Wardle *et al*., 2002; Lien *et al*., 2001); however, this is generally not supported (Pu *et al*., 2011; Kerckhoff *et al*., 1973). The fixed nature of education has been noted to likely conceal significant changes in persons' economic circumstances (for example corporate downsizing) (Krieger *et al*., 1997; Winkleby *et al*., 1992). According to Kaplan and Keil (1993), the importance of level of education as a proxy measure of socio-economic characteristics may vary for different populations as education has different social values in different cultures. Zurayk *et al* (1987) highlighted that education may be relatively low in rural or deprived areas as compared with urban developed areas; therefore, education may not be a suitable measure of socio-economic characteristic for all populations. In addition, Balogun *et al* (1990a) noted that education may not an adequate measure of socioeconomic characteristics in certain populations where individuals with no formal education, mainly engaged in trading or farming, maybe financially buoyant.

There may also be large birth cohort differences in level of education between populations as the social importance of education may vary in different times (Shavers, 2007; Krieger *et al*., 1997; Kaplan and Keil, 1993; Winkleby *et al*., 1992). For instance, the proportion of the population obtaining more than secondary school education may have increased over time leading to differences in educational attainment between populations of various age groups. Socio-demographic (such as ethnicity or gender) differences in earning power may exist between persons with the same level of education and financial investments in education (Shavers, 2007; Krieger *et al*., 1997);

thus, leading to inaccurate categorisation of individuals into their social groups. Increasing similarity in education as the years of education increase has also been suggested to lead to greater difficulties in socio-economic differentiation between educational groups (Shavers, 2007).

4.4.7 PUBERTAL MATURATION STATUS

Many studies on growth and development have identified the pubertal maturation of children and adolescents from reproductive endocrine hormonal measures and somatic measures such as skeletal/bone age, age at attainment of adult height and also development of secondary sexual characteristics (Veldre and Jürimäe, 2004). Research on growth and development has been hindered due to the difficulties of assessing pubertal or sexual maturation in epidemiologic research. I also found it difficult to pick an appropriate measure for estimating pubertal maturation, while considering the acceptability of the measure to children and adolescents and to other relevant individuals involved with the assessment.

According to Norris and Richter (2008), the most direct measure of pubertal stage may be reproductive endocrine hormone levels using hormonal assays, however, the many hormones linked with puberty and the practical of challenges of collecting biological samples and the cost of laboratory tests are considerable interferences in using endocrine hormone measures in large community or school-based studies. Somatic measure of pubertal maturation status focuses on indicators such as body weight, height (commonly estimated using age at peak height velocity, that is, age of rapid height increase), skeletal or bone age (using radiographic images), dental development (using radiographic images) and the development of secondary sexual characteristics (sexual maturation including: the onset of menstruation (menarche), appearance and advancement of breast, pubic hair, and development of genitalia) (Veldre and Jürimäe, 2004). Skeletal or bone age using radiographic image of the wrist bone is suggested to be one of the most accurate estimate of stage of growth and development status during puberty but is impeded because of X-ray radiation exposure and the relative expense needed, and is thus, not commonly reported (Kozinetz, 1988).

Measures of assessing the development of secondary sexual characteristics (including: menarche, appearance and advancement of breast, pubic hair, and development of genitalia) are the most widely used in epidemiological studies. Though information on menarcheal age is easy to obtain, menarcheal age is prone to reporting bias as menarche could have occurred at the beginning of the age or end of the age, giving a variation in the reported time period between two people with the same age of menarche. It is also prone to recall bias as time may have elapsed between menarche and time of study, thus some individuals may not remember the precise month within the year or even the year (Koo and Rohan, 1997). The most acknowledged standard measure of pubertal development is the sexual maturation stage rating of secondary sexual characteristics (Norris and Richter, 2008). Facchini *et al* (2008) highlighted that the easiest, accurate, reliable, most common and relatively cost effective direct method of assessing pubertal maturation status is the sexual maturation stage rating. As described in the Literature Review Chapter (Chapter 3), the sexual maturation stage rating was developed by Tanner (1962); it classifies and standardises secondary sex characteristics into five distinct stages, based on pubic hair development in both males and females, breast development in females and genital development in males, ranging from immature to fully mature (Facchini *et al*., 2008).

The sexual maturation rating was designed for expert physical examination use of a trained assessor or health professional in order to determine pubertal development in children and adolescents (Peterson *et al*., 1988). Physical examination of pubertal maturation stages by a trained assessor or health professional is a widely used method (Reinehr and Toschke, 2009; Hoffman *et al*., 2005; Meininger *et al*., 2004; He *et al*., 2002; Cho *et al*., 2001; Hansen *et al*., 1990; Vartiainen *et al*., 1986; Tell, 1985; Orchard *et al*., 1980). However, it is considered to be an invasive method which can be uncomfortable for participants as it requires a considerable amount of physical exposure and it has been opposed by parents, school personnel, and also the children and adolescents in many countries (Wacharasindhu *et al*., 2002). It may limit the representativeness of a study sample, as some eligible individuals may refuse participation so as to avoid the procedure.

A self-assessment non-invasive conservative indirect method of sexual maturation stage rating has been suggested as an accurate and acceptable alternative method (Petersen *et al*., 1988). Although prone to recall bias, underestimation and overestimation of pubertal maturation stage, the self-assessment method has been reported to have considerable agreement with the health professional physical assessment (Chan *et al*., 2008; Leone and Comtois, 2007; Norris and Richter, 2005; Schmitz *et al*., 2004; Schall *et al*., 2002; Wacharasindhu *et al*., 2002; Taylor *et al*., 2001; Matsudo and Matsudo, 1994; Williams *et al*., 1988; Brooks-Gunn *et al*., 1987; Neinstein, 1982; Duke *et al*., 1980; Morris and Udry, 1980), while some researchers are sceptical about the validity (Azevedo *et al*., 2009; Desmangles *et al*., 2006; Wu *et al*., 2001; Hergenroeder *et al*., 1999; Schlossberger *et al*., 1992).

The self-assessment of pubertal maturation stages involves the child's or adolescent's identification of sexual maturation by Tanner stages rating or scale of maturation presented as photographs (Azevedo *et al*., 2009; Desmangles *et al*., 2006; Norris and Richter, 2005; Wacharasindhu *et al*., 2002; Wu *et al*., 2001; Matsudo and Matsudo, 1994; Schlossberger *et al*., 1992; Williams *et al*., 1988; Duke *et al*., 1980) or line drawings (Chan *et al*., 2008; Leone and Comtois, 2007; Norris and Richter, 2005; Schmitz *et al*., 2004; Schall *et al*., 2002; Taylor *et al*., 2001; Hergenroeder *et al*., 1999; Williams *et al*., 1988; Brooks-Gunn *et al*., 1987; Neinstein, 1982; Morris and Udry, 1980). In the present study, I considered the five pictorial Tanner stages of breast development and genital development (Tanner, 1962) the most appropriate method for the children and adolescents to assess their own stage of pubertal maturation.

4.5 PARTICIPANT CONSENT

Attaining an unbiased sample population, with high response rates is of utmost importance in health research (Junghans *et al*., 2005). Researchers use two types of approaches (referred to as opt-in and opt-out techniques) to gain consent to carry out a study (Hewison and Haines, 2006). In the opt-in method, individuals actively indicate willingness to participate, while in the opt-out method individuals are considered willing to participate unless they indicate otherwise (Junghans *et al*., 2005).

The opt-in approach is increasingly used in different types of research because it increases the likelihood that participants are fully aware of the ethics of a study, of their rights to participate, confidentiality and the purpose and procedures of the study. Opt-in also safeguards the researcher against any allegations arising from study participants (Wiles *et al*., 2005). On the other hand, the opt-in technique is relatively more prone to increased response bias and decreased response rate compared to the opt-out method (Courser *et al*., 2009; Hewison and Haines, 2006; Junghans *et al*., 2005). According to Hewison and Haines (2006), the potential adverse effects of the opt-in technique on the achievement of methodological rigorous research with generalisable research findings may be more significant than any noted benefits of the technique.

In the present study, I initially chose the use of an opt-out approach (where the parents are considered willing to have their child/ward participate unless they indicate otherwise) with the purpose of obtaining potentially high response rate; but I finally used the opt-in approach (where the parents actively indicate willingness for their child/ward to participate) as a condition of ethics approval from the Biomedical Research Ethics Committee of the University of Warwick and a requirement from the Ministry of Education in Lagos State. The opt-in approach was suggested to be ethically more justifiable by the Biomedical Research Ethics Committee of the University of Warwick and the Ministry of Education in Lagos State because the study population includes children, who are regarded as vulnerable individuals, thus, active indication for participation from parents/carers is deemed necessary before inclusion into the study.

To the benefit of the methodological rigour of the study, the study had a substantially high response rate; the insistence on opt-in approach by the Biomedical Research Ethics Committee of the University of Warwick and the Ministry of Education in Lagos State did not have any significant influence on the participant's response rate. Written informed consent was received at every level: school Principals, parents/carers and students.

4.6 PARTICIPANT INCENTIVE

In recognition of the time and effort that the students gave, and to show an appreciation of the survey organisation in the school as a whole, I provided incentives in the form of chocolates and sweets to students who completed the questionnaires and measurements, and a number of books were donated to the school libraries.

Morrow (2009) noted that that exclusion of incentives in research can be viewed as unethical. Grant and Sugarma (2004: 721) define an incentive as “an added element without which the desired action probably would not occur”. It is a benefit considered as a stimulus to action (Grant and Sugarma, 2004). Incentives in research could be provided in form of a monetary or non-monetary gift. Incentives are usually provided unconditionally prior to the survey taking place or conditional on response (Laurie and Lynn, 2009). According to Rice and Broome (2004), incentives should be equal to the amount of time, effort and involvement needed. Several factors affect the provision, the type and value of incentives for children (which are applicable to other populations). These include: the school authority’s policy about distribution of incentives, the age of the child (for example incentives for one age might not be suitable at another age), the type of research (clinical or non-clinical), the burden (length and level of commitment) of the study, and the socio-economic status of the child (Rice and Broome, 2004).

In many studies the use of incentives pose no ethical problems, provided the studies meets the standard ethical conditions; however, certain situations exist where incentives are associated with two major ethical issues of undue influence or a coercive offer (Grant and Sugarma, 2004). An incentive could be said to be coercive when it produces obvious threat of harm and prevents the freedom of choice, where participants have no choice but to comply (Iltis, 2009; Rice and Broome, 2004). The ethical concern of undue influence is where incentives can influence potential participants (such as vulnerable persons) to accept unreasonable risks, which they would not be keen to undertake without the incentive (Singer and Couper, 2008; Grant and Sugarma, 2004). Grant and Sugarma (2004: 723) noted that undue influence can take place where an excessive and inappropriate incentive is offered to lure individuals to participate in a study “against their better judgement” so as to achieve recruitment and retention in the study. According to Iltis (2009), under the principle of ethics of respect for persons, in order to achieve free and voluntary consent from potential participants, researchers must prevent undue influence and coercion.

With regard to the use of incentives, children can be categorised a delicate group, because they are considered relatively less mature to ruminate risk against benefit, as well as their vulnerability associated with dependency relationships with persons in authoritative positions (Rice and Broome, 2004). However, giving incentives to children and individuals in authoritative positions in research is appropriate and ethical in circumstances when amount of incentives are not excessive, and persons in authoritative positions are not given the chance to profit from signing up the children into the study, incentives are not offered to only a sub-group (for example, highly valued children or persons in authoritative positions who are more challenging to recruit), and incentives do not coerce a child or person in authority to put the child at more than the ordinary risk or compromise the self-respect of the child (Rice and Broome, 2004).

In general, there is no definite standard guideline about the suitable types, quantity and timing of incentives except they should not cause undue influence or be coercive, thus decisions about the nature of incentives are largely based on subjective grounds, which vary extensively between studies (Singer and Couper, 2008; Rice and Broome, 2004).

SUMMARY

In this chapter, I have explained factors which influence the choice of methodological approaches adopted in the study, including: the study setting, study design, methods of participant selection, data collection tools, procedure for participant consents and participant incentives. In the next chapter, I will present a pilot study report of this thesis.

CHAPTER 5: PILOT STUDY

5.0 PILOT STUDY

INTRODUCTION

In this chapter, I will present the preliminary pilot study of this thesis.

As a precursor to the main study survey, I carried out a pilot survey during school time in a low-income secondary school in Lagos, Nigeria in August 2010.

5.1 AIMS AND OBJECTIVES

The main aims of the pilot were to

1). identify and amend problems in the layout and design of the questionnaire;

2). allow for any issues with measurement devices and sequence of assessments to be recognised and solved; and

3). ensure appropriate planning of study practicalities.

In line with the overall study aims, this pilot also aimed to

1). determine the association between socioeconomic characteristics (household wealth index and parents'/carers' education level) and blood pressure in children and adolescents aged 11 to 18 years in Nigeria;

2). determine the association between pubertal maturation status and blood pressure in children and adolescents aged 11 to 18 years in Nigeria;

3). determine the association between anthropometric measures of adiposity (body mass index (BMI) and waist circumference) and blood pressure in children and adolescents aged 11 to 18 years in Nigeria; and

4). determine the prevalence of hypertension in the population of secondary school aged children and adolescents in Nigeria.

5.2 METHODS

5.2.1 STUDY AREA

The study took place in one low-income mixed gender school in the urban area of Lagos State, Nigeria.

5.2.2 STUDY DESIGN

This study was carried out using a random sample school-based cross-sectional study design.

5.2.3 PARTICIPANT SELECTION

Participants were secondary school children and adolescents aged between 11 and 18 years.

SELECTION CRITERIA

INCLUSION CRITERIA

- Secondary school students aged 11 to 18 years.
- From selected schools in Lagos State.
- Consent received from Principal or Head Teacher.
- Consent received from parent/carer.
- Consent received from students themselves.

EXCLUSION CRITERIA

- No consent received from Principal or Head Teacher.
- No consent received from parents/carer.
- No consent received from students themselves.

5.2.4 PROCEDURE

A letter of approval for the study to take place in schools was issued by the Ministry of Education in Lagos State on the 9th of March 2010 (see Appendix 5). Ethical approval was obtained from the College of Medicine, University of Lagos (CMUL), Research Grants and Experimentation Ethics Committee on the 7th of May 2010 (see Appendix 6), and also from the Biomedical Research Ethics Committee of the University of Warwick on the 2nd of June 2010 (sees Appendix 7). A secondary school in Lagos State was then selected purposively. The Principal of the selected secondary (mixed gender) school was approached in July 2010 to participate in the study and handed a letter including information about the study and consent form, information and consent for students, information and consent for parents/carers, and the questionnaire that was used (see Appendix 8). The letter was followed up by a visit to explain the study in more detail, discuss the feasibility of carrying out the study in the schools and to obtain written approval from the Principal. I ensured that the Principal fully understood the purpose and process of the research during the visit at the office

Once consent was obtained from the Principal, a senior teacher was chosen by the Principal and given the responsibility to oversee the project in case of emergencies on the planned day of data collection and also to provide class registers. Participants were randomly selected from across class registers in each form, and letters explaining the purpose and procedures of the study were distributed by the school to the selected students and also sent to their parents/carers (see Appendices 9 and 10) through the students in August 2010. The parent/carer letters included information about the study and a consent form to be signed and returned to the school within the two-week period before the planned data collection day for those who wanted their child/ward to participate.

On the day of data collection the number of parent/carer consents was recorded. Parent/carer consents were received for all selected students. A 4-minute brief talk was given on the research topic and assessments that will take place during data collection. All selected students were given an envelope and a questionnaire booklet. The questionnaire booklet included a consent form, a questionnaire, measurement record information and glossary of terms. Each questionnaire booklet was assigned a unique study number, which was written throughout the questionnaire booklet. Written consent was discussed and obtained from all selected students in 10 minutes. The questionnaire booklets were then pseudonymised by detaching the consent form (which contains the name of a student who consented and a matching unique study number with the remaining components of the questionnaire booklet) from the questionnaire booklet before the start of self-administration of the questionnaire.

All measurements (blood pressure, height, weight and waist circumference) were recorded in the questionnaire booklet. Two separate boxes were provided for the storage of the completed consent forms and questionnaire booklets which were kept in a locked private room. A spread sheet was also provided for recording submissions of completed questionnaire booklets. I took overall responsibility for all consents, measurements and questionnaires. Data collection took place during school time between 10am and 3pm.

5.2.5 TRAINING OF RESEARCH ASSISTANTS

Approximately two weeks before the data collection day, five Research Assistants were trained by me for three days. On the first day, Research Assistants were familiarised with the study instruments and were shown the functionalities and calibrations of the equipment. The rest of the training day included demonstrations of standardised measurement protocol of height, weight, waist circumference and blood pressure measurements by me. This was followed by demonstrations of height, weight, waist and blood pressure measurements by each of the Research Assistants. Height, weight, waist circumference and blood pressure measurements were repeatedly carried out by each of the Research Assistants, until the standardised measurement protocol was understood. The Research Assistants carried out an average of five repeated measurements each. The content of the questionnaire booklets and the process of student consent collection were explained. Copies of the study questionnaires were given to the Research Assistants and they were instructed to have a read through the questionnaire and discuss any sections which may not be fully understood the next day.

On the second day of training, questionnaire contents were thoroughly discussed, each section was explained and any sections which were not well understood were clarified. The process of questionnaire hand-outs, error checks and booklet collection was also explained. There was a weekend break (two days) between the second and third day of training. The third day of training included three repeated height, weight, waist circumference and blood pressure measurements by each of the Research Assistants.

All Research Assistants were able to carry out all measurements according to the standard measurement protocol by this time. The sequence of questionnaire hand outs and error checks, measurements and booklet submission/collection recording was explained. A Standard Operating procedure was also given to all Research Assistants (see Appendix 11).

5.2.6 ASSESSMENT METHOD

QUESTIONNAIRE

Boys and girls were provided with separate questionnaires with a difference in pictorial illustrations on their pubertal maturation status (see Appendices 13 and 14). Boys and girls filled in the questionnaire at separate times. All girls completed their questionnaires at the same time in the same room; the same process applied to the boys.

The questionnaire had three sections. The first section of the questionnaire include socio-demographic information (including age, gender, religion and ethnicity), and health-related information (including associated diagnosis, current and past medical conditions, regular medication, and physical activity levels). The second section consisted of 25 open and closed ended questions (items) on socioeconomic characteristics, including: parent/carer education level and living circumstances (such as source of water supply, source of cooking energy, electricity supply, the number of rooms, landed properties, and household appliances such as radio, refrigerator, and communication methods (such as mobile phone, internet etc.)). This section was adopted from the Household Questionnaire of the Demographic and Health Survey (DHS) (2010).

The third section of the questionnaire assessed pubertal maturation status. This section was adopted from the five Tanner stages of pubertal development (Tanner, 1962). Participants were instructed to pick the number shown on one picture that best describes their pubertal maturation status. The pubertal maturation stages were scored as pre-pubertal stage (Tanner Stage 1), pubertal stage (Tanner Stages 2 and 3) and post-pubertal stage (Tanner Stages 4 and 5) (Reinehr and Toschke, 2009; Harding *et al*., 2008; He *et al*., 2002).

Researchers (myself and trained Research Assistants) handed out the validated questionnaires to students who consented. The participants were then given instructions on how to answer the questions. All questionnaires were self-completed in privacy and in a sitting position by all participants prior to all measurements. Each question was read out and answered by all participants at the same time. Participants were instructed to ask questions where an item in the questionnaire was unclear. Two copies of each pictorial illustration for the answer options to the questions on living conditions ("*what is the main material of the floor in your house?"*, "*what is the main material of the roof of your house?"* and "*what is the main material of the exterior wall of your house?"*) were provided to participants. Research Assistants went round the room to show the pictures to the participants.

There were moderate giggles while participants were answering the question on pubertal maturation status; however, emphasis placed on confidentiality and envelope submission provided more confidence on privacy which lead to a noticeable reduction in giggles for both boys and girls. During questionnaire administration, some of the Research Assistants were explaining items from the questionnaire asked by an individual participant to only the participant. However, as it was likely that some other participants may not fully understand the questions asked, I instructed the Research Assistants to note the question asked by a participant, and explain to all participants. The items which were not clear were repeatedly read out loud and explained, at least two times.

The confidentiality of all answers and instructions on how to answer the questions were continuously reiterated during the questionnaire administration. The questionnaires took approximately 1 hour to complete all together for boys and girls, respectively. The participants were instructed to place completed questionnaires in envelopes. Errors in filling in the questionnaires were checked by Research Assistants in order to avoid several missing values before measurements were undertaken by each participant.

BLOOD PRESSURE MEASUREMENT

Blood pressure measurements immediately followed the questionnaire administration. Researchers (myself and a trained Research Assistant) carried out blood pressure measurements simultaneously using an automated digital blood pressure monitor (Omron HEM-907). The automated digital blood pressure monitor was appropriately calibrated, according to the manufacturer's specification before use in order to ensure the accuracy of the measurements. Before blood pressure measurements commenced, a Research Assistant had her blood pressure measured in front of the students in order to create a relaxed environment and reduce any anxiety. Blood pressure (systolic and diastolic blood pressure) was measured in privacy under quiet conditions with the student in sitting position, back supported, feet on the floor, clothing sleeve rolled back to leave upper arm uncovered, right arm supported, cubital fossa (inner elbow) at heart level, and having rested for at least 5 to 10 minutes before measurement (NHBPEP Working Group, 2004; Health Survey for England, 2008).

The correct cuff sizes were used, where the inflatable bladder width was at least 40 percent of the arm circumference at midpoint of the olecranon and acromion, and the cuff-bladder length covered 100 percent of the arm circumference (NHBPEP Working Group, 2004). Three different readings (Health Survey for England, 2008; NHBPEP Working Group, 2004) were taken 2 minutes apart per student (Ejike *et al*., 2008; Pierin *et al*., 2008; Terra *et al*., 2004; Hegazy and Kader, 2003; White and Anwar, 2001; Schulze *et al*., 2000; Shuler *et al*., 1998; Einsterz *et al*., 1982). The average of the last two readings was used as a record of the blood pressure (systolic and diastolic blood pressure) (Health Survey for England, 2008). The average total duration of blood measurements per student was approximately 6 minutes.

Blood pressure measurement information of all the students was communicated to their parents/carers in writing (see Appendices 15, 16 and 17). A letter was sent to the parents/carers of three students found to have "high normal BP" or pre-hypertensive (according to the United States cut-off) (NHBPEP Working Group, 2004). The letter included information and advising the parents/carers, as a precautionary measure, to have their child's/ward's blood pressure checked next time they have a visit with a doctor (see Appendix 16).

BODY WEIGHT MEASUREMENT

A portable calibrated weighing balance scale (Seca 877) in kilograms (Kg) was used in measure the body weight of each participant. A trained Research Assistant carried out the body weight measurements. Body weight was measured to the nearest 0.1 kilograms (kg) once, with the student standing upright, looking straight ahead, feet flat and together at the centre of the weighing scale, arms hanging loosely at the sides, without wearing shoes and heavy outer garments (such as jackets and cardigans) and with pockets emptied (Health Survey for England, 2008). The body weight measurement took approximately 1 minute to complete.

HEIGHT MEASUREMENT

A trained Research Assistant carried out height measurements. Height was measured in centimetres (cm) using a portable, collapsible stadiometer (Seca Leicester Portable Height Measure), once, with the student standing fully upright, looking straight ahead and on bare feet (Health Survey for England, 2008). The height measurement took approximately 1 minute to complete. Body Mass Index (BMI) was derived from the height and body weight measurement. BMI was calculated using the formula BMI = body weight (kg)/height (m)^2 (World Health Organisation, 2006).

WAIST CIRCUMFERENCE MEASUREMENT

Waist circumference was measured using a flexible tape (Seca 201) in centimetres (cm), placed horizontally, once, midway between the 10th rib and the top of the iliac crest, with the student in upright standing position, looking straight ahead, arms hanging loosely at the sides, breathing normally, without wearing outer garments (such as jackets and cardigans) and with pockets emptied, and all clothing rolled up to leave the stomach area uncovered (Kimani-Murage *et al*., 2010; Health Survey for England, 2008; World Health Organisation, 1995). Waist circumference measurements were carried out in a private room by a trained Research Assistant. The younger girls who were wearing dresses were provided a cloth to cover the lower half of their body below the abdomen. Waist circumference measurement was completed in a minute for each participant.

5.2.7 DATA ENTRY, CLEANING AND QUALITY

Data entry was conducted by myself and a competent Research Assistant. Each case was then compared to its double-entered counterpart and checked for errors. Non-matches were hand searched, verified based on the actual case questionnaire and corrected.

5.2.8 DATA ANALYSIS

Data analysis was carried out using descriptive and inferential statistics.

A multivariate statistical method called “principal components analysis” was carried out in order to obtain a household wealth index (a relative wealth continuous scale) from the data collected on living circumstances (Demographic and Health Survey, 2010; Howe *et al*. 2008; Vyas and Kumaranayake, 2006; Filmer and Pritchett, 2001). The total scores of the participant’s living circumstances derived from the principal components analysis were then categorised into wealth tertiles (high-income, middle-income and low-income) by standardising according to a standard normal distribution with mean and standard deviation of 0 and 1, respectively (Demographic and Health Survey, 2010). These household wealth index tertiles represent the variable of living circumstances, and were used in all further data analysis.

5.2.8.1 DESCRIPTIVE STATISTICS

Data analysis was undertaken using descriptive statistics, expressed as means and standard deviations for continuous variables (age, blood pressure (systolic and diastolic), weight, height, body mass index, waist circumference and physical activity), and frequencies and percentages for categorical variables (gender, religion, ethnicity, pubertal maturation status and socio-economic characteristics (household wealth index and parents'/carers' education level). Exploratory analysis using box plots were produced to assess the distribution of continuous variables (age, weight, height, body mass index, waist circumference and physical activity) within the categorical variables (gender, religion, ethnicity, pubertal maturation status and socio-economic characteristics (household wealth index and parents'/carers' education level)).

5.2.8.2 INFERENTIAL STATISTICS

Chi-square statistics were carried out to assess the association between categorical variables (gender, religion, ethnicity, pubertal maturation status and socio-economic characteristics (household wealth index and parents'/carers' education level)).

One-way analysis of variance (ANOVA) and *t*-test were used to establish any significant difference in mean value of blood pressure (systolic and diastolic blood pressure) within categorical variables (gender, religion, ethnicity, pubertal maturation status and socio-economic characteristics (household wealth index and parents'/carers' education level).

Pearson's Product-moment Correlation coefficient was carried out to estimate the linear association between continuous variables (blood pressure (systolic and diastolic blood pressure), age, weight, height, body mass index, waist circumference and physical activity).

For the purposes of obtaining appropriate categorical variables within a regression analysis, binary dummy variables (where a score of 1 is assigned to one group within a category and a score of 0 is assigned to other groups within a category) (Allison, 1999) were created for the independent categorical variables (gender, religion, ethnicity, pubertal maturation status and socio-economic characteristics (household wealth index and parents'/carers' education level)).

A univariate linear regression analysis was undertaken to investigate the association between blood pressure (systolic and diastolic blood pressure) and selected independent variables (socio-economic characteristics (household wealth index and parents'/carers' education level), pubertal maturation status, body mass index and waist circumference).

Following the findings from the univariate linear regression analysis, a multiple linear regression analysis was undertaken to investigate the association between systolic blood pressure and pubertal maturation status, body mass index and waist circumference, while controlling for the other selected independent variables (age, gender, religion, ethnicity, and physical activity) which are likely confounding and/or mediating variables. A multiple regression model was not created for diastolic BP, because there was no statistically significant association found between diastolic blood pressure and pubertal maturation status, household wealth index, father's education level, mother's education level, body mass index and waist circumference in the univariate regression analysis.

Multicollinearity between independent variables was considered in the multiple regression models; therefore variables which were highly correlated and variables measuring the same participant characteristic were not included in the same multiple regression model (Allison, 1999). Separate multiple regression models were created for measures of adiposity (body mass index and waist circumference). In addition, two separate multiple regression models were produced with age included and omitted, based on the high correlation between age and pubertal maturation status.

All statistical analyses were performed using SPSS for Windows version 17. Alpha level was set at 0.05 to determine statistical significance.

5.3 RESULTS

5.3.1 PROCEDURAL ISSUES

In this pilot study students were randomly selected from across class registers in each form; however, participants will be randomly selected from the class register of a randomly selected class in each form for the main study. The latter selection method is considered to be a more orderly and efficient method given the larger number of participants expected in the main study.

QUESTIONNAIRE

Items from the questionnaire asked by an individual participant were initially explained to only the participant; however, as some of the other participants may not fully understand the questions asked, Research Assistants were instructed to note the question asked by a participant and explain to all participants.

Some of the participants found it difficult to understand the words "*leisure time*", "*household*" and "*seldom*". The word "*household*" which was originally present in the glossary, was rephrased as "*your house, flat, room in multi-tenanted building (for example:* "*face me I face you"), family or people you live with*". "*Leisure time*" was defined as "*free time before or after compulsory activities such as eating, sleeping, going to school, doing homework, house work/chores*"); and "*seldom*" was defined as "*rarely"*.

A number of words ("*very often*", "*often*", "*sometimes*", "*seldom*", "*regularly*" and "*hectares*") were reconsidered and standardised as follows during the pilot as uneven interpretation of these words was likely: "*very often*" (defined as "*very frequent, e.g. within every week*"), "*often*" (defined as "*frequent, e.g. within every 1 month*"), "*sometimes*" (defined as "*from time to time, e.g. within every 2-6 months*"), "*seldom*" (defined as "*rarely – within every 6-12 months*"), "*regularly*" (defined as "*usually, e.g. within every week*"), and "*hectares*" (defined as "*1 hectare = 10,000 square meters* (m^2)").

Although "*Please tick (✓) only one box"* was written at the start of each section of the questionnaire, some of the participants were unsure if they could tick more than one option for some the questions on living conditions. The statement "*Please tick only one box"* was reiterated for all questions on living conditions where more than one answer may be possible.

For one of the questions on living conditions "*what is the main material of the roof of your house?"*, the answer option "*metal"* was translated to "*panu"* (in the local Yoruba language) so that it was better understood by some of the participants. The questions "*Does your household have* "*internet access?", "camera?"*, were explained to exclude phone internet access or camera as this was not clear to all participants.

The two copies of each pictorial illustration for the answer options to the questions on living conditions ("*what is the main material of the floor in your house?"*, "*what is the main material of the roof of your house?"* and "*what is the main material of the exterior wall of your house?"*) provided to participants were not sufficient and to some extent increased the duration of data collection.

BLOOD PRESSURE MEASUREMENT

The initial planned measurement sequence for data collection day was for blood pressure measurement to precede other measurements for all participants; however during data collection it was observed that this sequence would ultimately increase the total duration of data collection. In order to avoid this, the initial sequence of measurements was cancelled. No specific sequence of measurements was set in place, except that a participant had to take up a quiet sitting position at the start of the blood pressure measurement of the participant ahead at any given time.

5.3.2 DESCRIPTION OF PARTICIPANTS

All 30 (15 boys and 15 girls) selected school students participated in the study. Ages ranged from 11 to 18 years. Table 8 shows frequencies for socio-demographic characteristics, pubertal maturation status, and socioeconomic characteristics for participants in the study. Participants were predominantly Yoruba, Muslim, late-pubertal, with the largest proportion of fathers/carers having secondary school highest level of education and mothers/carers having more than secondary school level of education.

Table 8: Characteristics of the pilot study population

Variable		**n (%)**
Gender (N=30)	Male	15 (50)
	Female	15 (50)
Ethnicity (N=30)	Igbo	2 (6.7)
	Yoruba	23 (76.7)
	Other	5 (16.7)
Religion (N=30)	Christian	13 (43.3)
	Muslim	17 (56.7)
Wealth index (N=30)	Poor	10 (33.3
	Middle	10 (33.3)
	Rich	10 (33.3)
Father's education level (N=30)	Did not attend school	3 (15.0)
	Primary school	4 (20.0)
	Secondary school	7 (35.0)
	More than secondary school	6 (15.0)
Mother's education level (N=30)	Did not attend school	4 (21.1)
	Primary school	3 (15.8)
	Secondary school	5 (26.3)
	More than secondary school	7 (36.8)
Pubertal status (N=30)	Pre-puberty	2 (6.7)
	Early puberty	6 (20.0)
	Late puberty	22 (73.3)

The overall mean age was 14.70±2.10years, weight was 46.66±11.59Kg, height 1.57±0.10m, body mass index was 19.09±3.92 Kg/m^2, waist circumference was 66.73±6.07 cm, and physical activity level was 9.61±2.79.

The descriptive data for the participants' age, weight, height, body mass index, waist circumference and physical activity level by gender is shown in Table 9. Girls were older, taller, and had a higher weight, BMI and waist circumference than boys (p>0.05) (Table 9). On the other hand, boys were more physically active than the girls (p>0.05) (Table 9).

Table 9: Mean, Standard deviation and Range of age, weight, height, body mass index waist circumference and physical activity by gender in the study population.

Variable	Male			Female			P-value
	N	Mean	S.D	N	Mean	S.D	
Age (years)	15	14.53	2.13	15	14.87	2.13	0.672
Weight (Kg)	15	45.35	12.85	15	47.98	10.46	0.543
Height (m)	15	1.56	0.12	15	1.58	0.08	0.605
Body mass index (Kg/m^2)	15	18.19	3.26	15	19.09	3.92	0.498
Waist circumference (cm)	15	64.67	6.32	15	68.80	5.21	0.061
Physical activity	15	10.53	2.71	15	8.69	2.65	0.070

*P-value derived from t-test (for difference in means).
*S.D – Standard deviation

5.3.3 BLOOD PRESSURE PATTERN

5.3.3.1 MEAN SYSTOLIC BLOOD PRESSURE OF THE STUDY PARTICIPANTS

The overall mean systolic blood pressure was 106.13±10.73mmHg. The difference in mean systolic BP for participant categorised by gender, ethnicity, religion, household wealth index, father's/carer's education level, mother's/carer's education level and pubertal maturation status is shown in Table 10. Overall a statistically significant difference in mean systolic BP (p<0.05) was found within the pubertal group. Late pubertal participants had significantly higher systolic BP (p<0.05) than pre-pubertal and early-pubertal participants, while no statistically significant difference (p>0.05) was observed between mean systolic BP for pubertal and early-pubertal participants. There was no statistically significant difference (p>0.05) in mean systolic BP between participants grouped by gender, ethnicity, religion, household wealth index, father's/carer's education level and mother's/carer's education level.

Table 10: Difference in Mean Systolic Blood Pressure within categories of selected variables

Variable		N	Mean	Standard Deviation	P-value
Gender (N=30)	Male	15	105.20	11.43	0.642
	Female	15	107.07	10.29	
Ethnicity (N=30)	Igbo	2	108.50	9.19	0.921
	Yoruba	23	106.22	10.36	
	Other	5	104.80	14.76	
Religion (N=30)	Christian	13	105.69	10.45	0.848
	Muslim	17	106.47	11.24	
Wealth index (N=30)	Poor	10	108.90	8.91	0.620
	Middle	10	105.00	11.35	
	Rich	10	104.50	12.23	
Father's education level (N=20)	Did not attend school	3	101.67	10.60	0.558
	Primary school	4	113.75	6.99	
	Secondary school	7	107.86	11.19	
	More than secondary school	6	105.83	13.71	
Mother's education level (N=19)	Did not attend school	4	102.50	8.81	0.733
	Primary school	3	112.00	2.65	
	Secondary school	5	106.20	13.18	
	More than secondary school	7	105.86	12.03	
Pubertal status (N=30)	Pre-puberty	2	88.00	1.41	0.001
	Early puberty	6	98.67	9.27	
	Late puberty	22	109.82	8.77	

*P-value from *t*-tests and ANOVA tests (for difference in means), where the requirements for each test were met.

5.3.3.2 MEAN DIASTOLIC BLOOD PRESSURE OF THE STUDY PARTICIPANTS

The overall mean diastolic blood pressure was 60.40±7.44mmHg. Table 11 shows the difference in mean diastolic BP for participant categorised by gender, ethnicity, religion, household wealth index, father's/carer's education level, mother's/carer's education level and pubertal maturation status. A statistically significant difference in mean diastolic BP ($p<0.05$) was found between boys and girls, with girls having higher diastolic BP than boys. There was no statistically significant difference (p>0.05) in mean diastolic BP between participants grouped by ethnicity, religion, household wealth index, father's/carer's education level, mother's/carer's education level and pubertal maturation status.

Table 11: Difference in Mean Diastolic Blood Pressure within categories of selected variables

Variable		N	Mean	Standard Deviation	P-value
Gender **(N=30)**	Male	15	57.67	6.21	0.042
	Female	15	63.13	7.75	
Ethnicity **(N=30)**	Igbo	2	55.00	8.49	0.266
	Yoruba	23	61.61	6.67	
	Other	5	57.00	10.05	
Religion **(N=30)**	Christian	13	60.92	8.23	0.743
	Muslim	17	60.00	7.00	
Wealth index **(N=30)**	Poor	10	60.80	7.29	0.973
	Middle	10	60.00	9.24	
	Rich	10	60.40	6.28	
Father's education level **(N=20)**	Did not attend school	3	55.00	11.53	0.173
	Primary school	4	64.25	5.25	
	Secondary school	7	63.57	6.24	
	More than secondary school	6	59.17	2.48	
Mother's education level **(N=19)**	Did not attend school	4	56.50	9.88	0.115
	Primary school	3	63.67	5.03	
	Secondary school	5	65.80	6.02	
	More than secondary school	7	59.00	2.52	
Pubertal status **(N=30)**	Pre-puberty	2	59.00	1.41	0.806
	Early puberty	6	58.83	5.71	
	Late puberty	22	60.95	8.20	

*P-value from *t*-tests and ANOVA tests (for difference in means), where the requirements for each test were met.

5.3.4 PREVALENCE OF HYPERTENSION

The prevalence of hypertension in the study population is 0%. Three (10%) of the participants were pre-hypertensive.

5.3.5 LINEAR RELATIONSHIP BETWEEN BLOOD PRESSURE AND CONTINUOUS VARIABLES

The Pearson's Product-moment Correlation coefficients between blood pressure (systolic and diastolic blood pressure), age, height, weight, body mass index, waist circumference, and physical activity for the study participants are shown in Table 12. There were moderate statistically significant correlations ($p<0.05$) observed between systolic BP and age, weight, height, waist circumference, with lower but statistically significant correlations ($p<0.05$) observed between systolic BP and body mass index. No statistically significant correlation ($p>0.05$) was observed between systolic BP and physical activity.

A negative and low statistically significant correlation ($p<0.05$) was observed between diastolic BP and physical activity. No statistically significant correlations ($p>0.05$) were observed between diastolic BP and age, weight, height, body mass index, waist circumference and physical activity.

Table 12: Correlation between Systolic and Diastolic blood pressure and selected continuous variables

		Systolic BP	**Diastolic BP**
Age	**Pearson Correlation**	0.659**	0.112
Weight	**Pearson Correlation**	0.616**	-0.022
Height	**Pearson Correlation**	0.627**	0.040
Body mass index	**Pearson Correlation**	0.414**	-0.030
Waist circumference	**Pearson Correlation**	0.591**	0.229
Physical activity	**Pearson Correlation**	-0.310	-0.375**

** Correlation is significant at $p<0.05$.

5.3.6 UNIVARIATE LINEAR REGRESSION ANALYSIS – ASSOCIATION BETWEEN BLOOD PRESSURE AND SELECTED VARIABLES

A univariate linear regression analysis for the relationship between blood pressure (systolic and diastolic) and pubertal maturation status, household wealth index, father's education level, mother's education level, BMI and waist circumference is shown in Table 13. Pubertal maturation status, BMI and waist circumference were found to be associated with systolic blood pressure ($p<0.05$). Statistically significant differences in blood pressure (systolic and diastolic blood pressure) ($p<0.05$) were observed in the three categories of pubertal maturation status. Early pubertal and pre-pubertal participants had systolic blood pressure lower on average than those in late puberty. No statistically significant association was found between systolic blood pressure and household wealth index, father's education level and mother's education level ($p>0.05$).

There was no statistically significant association found between diastolic blood pressure and pubertal maturation status, household wealth index, father's education level, mother's education level, body mass index and waist circumference ($p>0.05$).

Table 13: Univariate linear regression analysis of selected variables and Blood Pressure.

Variable		**Systolic Blood Pressure (mmHg)**				**Diastolic Blood Pressure (mmHg)**		
		Regression Coefficient	**95% Confidence Interval**	**P-value**		**Regression Coefficient**	**95% Confidence Interval**	**P-value**
Pubertal Status	Pre-puberty	-21.82	-35.01, -8.63	0.002		-1.96	-13.54, 9.63	0.732
*Late puberty	Early puberty	-11.15	-19.37, -2.92	0.010		-2.12	-9.35, 5.10	0.552
Wealth index	Poor	4.40	-5.62, 14.42	0.376		0.40	-6.66, 7.46	0.908
*Rich	Middle	0.50	-9.52, 10.52	0.919		-0.40	-7.46, 6.66	0.908
Father's education level	Did not attend school	-2.65	-16.47, 11.18	0.697		-4.06		0.380
* More than secondary school	Primary school	9.44	-2.85, 21.72	0.126		5.19	-13.41, 5.28	0.210
	Secondary school	3.55	-6.41, 13.50	0.471		4.51	-3.12, 13.49	0.180
Mother's education level	Did not attend school	-3.44	-16.01, 9.12	0.578		-2.72	-10.88, 5.43	0.500
* More than secondary school	Primary school	6.06	-8.12, 20.23	0.388		4.44	-4.76, 13.65	0.330
	Secondary school	0.26	-11.24, 11.75	0.964		6.58	-0.88, 14.04	0.081
BMI (Kg/m^2)		1.24	0.18, 2.30	0.023		-0.06	-0.87, 0.74	0.876
Waist circumference (cm)		1.05	0.49, 1.60	0.001		0.28	-0.18, 0.74	0.223

*Reference category.

5.3.7 MULTIPLE REGRESSION MODELS – ASSOCIATION BETWEEN BLOOD PRESSURE AND SELECTED VARIABLES

I constructed two different models to determine the association between the dependent variable – systolic BP and independent variables – pubertal maturation status, and adiposity (BMI and waist circumference). A multiple regression model was not created for diastolic BP, because there was no statistically significant association found between diastolic blood pressure and pubertal maturation status, household wealth index, father's education level, mother's education level, body mass index and waist circumference in the univariate regression analysis.

Two separate multiple regression models were created for body mass index and waist circumference, as both variables were considered equal measurements of adiposity, given the statistically significant correlation observed between them. Two separate multiple regression models were also produced with age included and omitted, based on the high correlation between age and pubertal maturation status observed in the exploratory analysis.

5.3.7.1 ASSOCIATION BETWEEN BLOOD PRESSURE AND PUBERTAL STATUS AND BMI: MULTIPLE REGRESSION MODEL 1

Table 14 shows a multiple linear regression analysis for the association between systolic blood pressure and pubertal maturation status and body mass index, and other selected variables: age, gender, religion, ethnicity and physical activity. Systolic blood pressure was statistically significantly associated with only age ($p<0.05$) in the model that includes age.

In the model that excludes age, pubertal maturation status were associated with systolic blood pressure ($p<0.05$). Pre-pubertal and early pubertal participants had systolic blood pressure lower on average than those in late puberty; however, a statistically significant difference in systolic blood pressure ($p<0.05$) was only observed between pre-puberty and late puberty. The influence of age within this association is highlighted in Table 14. Body mass index, gender, religion, ethnicity and physical activity had no association with systolic blood pressure ($p>0.05$). The variables included in the regression analysis (including age) explain about 41.2% of the variation in systolic blood pressure. On the other hand the variables included in the regression analysis (excluding age) explain about 22.4% of the variation in systolic blood pressure.

Table 14: Multiple Regression Analysis of selected variables and Blood Pressure – Model 1 (BMI)

Variable		Systolic Blood Pressure (mmHg)				Systolic Blood Pressure (mmHg)‡		
		Regression Coefficient	**95% Confidence Interval**	**P-value**		**Regression Coefficient**	**95% Confidence Interval**	**P-value**
Pubertal Status *Late puberty	Pre-puberty	-13.71	-28.48, 1.05	0.067		-18.61	-34.98, -2.23	0.028
	Early puberty	-3.20	-13.32, 6.93	0.518		-9.76	-19.89, 0.38	0.058
BMI (Kg/m²)		0.10	-1.06, 1.27	0.855		0.46	-0.85, 1.75	0.477
Age (years)		2.84	0.71, 4.98	0.012		-	-	-
Gender *Female	Male	2.90	-4.39, 10.18	0.417		1.36	-6.88, 9.60	0.735
Religion ***Muslim	Christian	-0.65	-9.15, 7.85	0.875		-2.19	-11.84, 7.45	0.641
Ethnicity *Other	Igbo	-9.29	-27.90, 9.32	0.310		1.80	-17.27, 20.86	0.847
	Yoruba	-1.81	-12.23, 8.61	0.721		-1.28	-13.21, 10.65	0.826
Physical activity		-0.58	-2.13, 0.98	0.449		-0.53	-2.31, 1.25	0.542
Adjusted R^2		0.412				0.224		

*Reference category.
‡Age not included in the analysis.

5.3.7.2 ASSOCIATION BETWEEN BLOOD PRESSURE AND PUBERTAL STATUS AND WAIST CIRCUMFERENCE: MULTIPLE REGRESSION MODEL 2

Table 15 shows a multiple linear regression analysis for the association between systolic blood pressure and pubertal maturation status and waist circumference, and other selected variables: age, gender, religion, ethnicity and physical activity. Systolic blood pressure was statistically significantly associated with only age in the model that includes age.

In the model that excludes age, waist circumference was associated with systolic blood pressure ($p<0.05$). Pubertal maturation status, gender, religion, ethnicity and physical activity had no statistically significant association with systolic blood pressure ($p>0.05$). The variables included in the regression analysis (including age) explain about 50.7% of the variation in systolic blood pressure. On the other hand the variables included in the regression analysis (excluding age) explain about 38.1% of the variation in systolic blood pressure.

Table 15: Multiple Regression Analysis of selected variables and Blood Pressure – Model 2 (Waist circumference)

Variable		Systolic Blood Pressure (mmHg)				Systolic Blood Pressure (mmHg)‡		
		Regression Coefficient	**95% Confidence Interval**	**P-value**		**Regression Coefficient**	**95% Confidence Interval**	**P-value**
Pubertal Status *Late puberty	Pre-puberty	-8.61	-23.10, 5.89	0.230		-11.36	-27.35, 4.63	0.154
	Early puberty	1.72	-8.88, 12.33	0.738		-2.32	-13.56, 8.92	0.672
Waist circumference (cm)		0.89	-0.05, 1.82	0.062		1.19	0.18, 2.19	0.023
Age (years)		2.39	-0.42, 4.37	0.020		-	-	-
Gender *Female	Male	6.36	-1.25, 13.96	0.097		6.24	-2.26, 14.73	0.142
Religion *Muslim	Christian	-0.56	-8.34, 7.22	0.883		-1.82	-10.43, 6.79	0.665
Ethnicity *Other	Igbo	-21.93	-43.54, -0.32	0.047		-16.39	-39.98, 7.21	0.163
	Yoruba	-6.60	-17.36, 4.17	0.216		-7.85	-19.82, 4.12	0.187
Physical activity		-0.57	-1.90, 0.76	0.383		-0.65	-2.13, 0.83	0.373
Adjusted R^2		0.507				0.381		

*Reference category.
‡Age not included in the analysis.

5.4 DISCUSSION AND CONCLUSION

In general, questionnaire administration and measurements were adequately carried out. The findings from the pilot study show that pubertal maturation status and adiposity (body mass index and waist circumference) are associated with systolic blood pressure. There were no children and adolescents with hypertension within the study population. If these findings are replicated in a larger study, it may prove appropriate to add additional confounding variables that are well established in literature such as salt intake. Whilst there was a high response rate, the study sample was relatively small and consisted of a low-income population school (resulting in minimal variation in the values within the tertile categories of the household wealth index), therefore, definitive conclusions cannot be drawn about the proportion of children and adolescents with hypertension within the study population as well as the highlighted associations with blood pressure, and most apparent, the socio-economic characteristics associations with blood pressure in children and adolescents. In spite of this, the findings of the pilot study highlight the need for investigation of factors associated with blood pressure in children and adolescents.

SUMMARY

The pilot study has provided important information and insight about the methods and analyses for the larger scale main study. The pilot has also shown that a larger scale main study is feasible and acceptable to participants. All lessons and amendments from the pilot were adopted in the larger main study. The participants in the pilot study were recruited from a low-income secondary school. In the main study, I anticipated substantially wider variation in the values within the tertile categories of the household wealth index, as participants were drawn from low, middle and high-income populations.

In the next chapter, I will describe components of the methods utilised in the main study.

Box 1: Lessons and amendments from the pilot study

In general the pilot went smoothly. Valuable lessons learnt for the main study, and amendments to plans and processes include the following:

1. Participants will be randomly selected from the class register of a randomly selected class in each form.

2. Research Assistants will note items on the questionnaire asked by a participant and explain to all participants.

3. Participants will be instructed to wait in a quiet sitting position at the start of the blood pressure measurement of the participant ahead at any given time.

4. The word "*household*" which was originally present in the glossary, will be rephrased. Seven words will be added to the glossary of three words and phrases including: "*leisure time*", "*very often*", "*often*", "*sometimes*", "*seldom*", "*regularly*", "*hectares*".

5. The local language translation of "*metal"* known as "*panu"* will be added to the answer option. A member of the research team who can translate written words in English language into the local language will be identified in case of a situation where a participant may not adequately understand a written word given in English language.

6. The statement "*Please tick only one box"* was reiterated for some questions on living conditions where more than one answer may be possible. For the main study, "*Please tick (✓) only one box"* will be written before these questions on living conditions.

7. The questions "*Does your household have* "*internet access?",* "*camera?"*, will be explained to exclude phone internet access or camera.

8. An agreement and confirmation of an exact research site-specific picture projection plan will be put in place. Where this is not possible, more copies of pictorial illustrations will be provided to reduce the duration of answering the questions.

CHAPTER 6: METHODS

6.0 METHODS

INTRODUCTION

In this chapter, I describe aspects of the research methods used in this study, including: setting, study design, sample size estimation, participant selection, data collection, data handling, data entry and cleaning, and data analysis.

6.1 STUDY SETTING

The study took place in Lagos Metropolis, the urban area of Lagos State in Nigeria (see Background Chapter (Chapter 2) for more details on the study area).

6.2 STUDY DESIGN

This study was carried out using a stratified randomised cross-sectional survey in schools.

6.3 SAMPLE SIZE CALCULATION

The sample size calculation was designed to allow sub-group analysis of the blood pressure of a population of children and adolescents stratified by socio-economic characteristics into three groups (low-income, middle-income and high-income) in Lagos State, Nigeria. Past experience with similar studies in children and adolescents suggested that blood pressure data would be approximately normally distributed with a standard deviation (S.D) of 20 mmHg. A two-sided pooled *t*-test was used with equal numbers of participants in each group. Assuming a non-response rate of 40% and taking into account multiple comparisons, a sample size of 353 children and adolescents in each socio-economic group leading to a total population sample size of

1,059 children and adolescents (529 boys and 530 girls), would detect a significant difference of 5mmHg between socio-economic groups with 80% power at a p-level of 0.05. The sample size was calculated based on expected normal distribution of blood pressure within the study population and the blood pressure differences between socio-economic groups; it did not consider expected differences in blood pressure based on other independent variables, such as adiposity and pubertal maturation status.

6.4 ETHICAL APPROVAL

The Ministry of Education in Lagos State issued a letter of approval on the 9th of March 2010 for the study to take place in State schools (see Appendix 5). Ethical approval was granted from the College of Medicine, University of Lagos (CMUL), Research Grants and Experimentation Ethics Committee on the 7th of May 2010 (see Appendix 6), and also from the Biomedical Research Ethics Committee of the University of Warwick on the 2nd of June 2010 (see Appendix 7).

6.5 PARTICIPANT SELECTION

6.5.1 SCHOOL SELECTION

All secondary schools in Lagos State, Nigeria were stratified into three socio-economic groups (high-income, middle-income and low-income group) and seven schools were selected purposively for the study. Prior to selection, in order to attain a broad demographic and socio-economic population sample, I obtained the following information from the schools' websites and from local knowledge of the schools and their surrounding catchment areas:

- Amount of school fees paid annually, which reflects the socio-economic background of students in the school.
- Geographical location of the school, which reflects the socio-economic group of school's area and may indicate socio-economic background of students in the school.
- Number of students in the school, in order to achieve a big enough sample.
- Age range and gender of the students, in order to obtain an appropriate demographic sample.

6.5.2 PUPIL SELECTION

Once schools were selected, 1200 secondary school children and adolescents in Lagos State, Nigeria were randomly selected for the study.

SELECTION CRITERIA

INCLUSION CRITERIA

- Secondary school students aged 11 to 18 years.
- From selected schools in Lagos State.
- Consent received from Principal or Head Teacher.
- Consent received from parent/carer.
- Consent received from students themselves.

EXCLUSION CRITERIA

- No consent received from Principal or Head Teacher.
- No consent received from parent/carer.
- No consent received from students themselves.

6.6 PROCEDURE

I approached the Principals of the selected schools between August and September 2010, and handed a letter (see Appendix 8) including information about the study and consent form for the Principal, information and consent for students, information and consent for parents/carers, and the questionnaire that was used. The letter was followed up by a visit to explain the study in more detail, discuss the feasibility of carrying out the study in the schools, make arrangements for dates and times for questionnaire administration and measurements and to obtain written informed approval/consent from the Principal. I ensured that the Principal fully understood the purpose and process of the research during the visit at the office.

I obtained written informed consent from the Principals of seven secondary schools (three high-income, two middle-income and two low-income schools). Three high-income schools as compared to two middle-income and low-income schools were purposively selected for the study because two out of the three high-income schools were single sex schools with a considerable number of students (which may offer variability in the demographic characteristics), relative to other high income schools in Lagos State. Once consent was obtained from the Principal, a senior teacher was chosen by the Principal and given the responsibility to oversee the project in case of emergencies on the planned day of data collection, to provide class registers and also assist in getting the students to the school area assigned for data collection.

One thousand two hundred students (400 each from the high, middle and low-income schools) were selected and invited to participate in the study, based on the sample size estimated for the study with allowance for potential dropouts. I randomly selected a class in each year group and then selected students from the class register, using random number computer generated method. In order to achieve an adequate sample number of students, I extended the number of selected classes to 2 classes in the schools where the number of students per class was not sufficient, and then selected students from the class registers, using random number computer generated method.

In October 2010, the schools distributed letters (see Appendix 9) of invitation, explaining the purpose and procedures of the study to the selected students and also sent out letters of invitation (see Appendix 10) with the same information to their parents/carers through the students and via emails (in School 3 only). The parent/carer letters also included a consent form to be signed and returned to the school within the two to three-week period before the planned data collection day for those who consented to their child/ward participating. Further announcements about the study were made during Parent Teachers Association (PTA) meetings, parents' day and at school assemblies.

On the day of data collection, signed parent/carer consent forms were collected either from a senior teacher or from the students. The number of signed parent/carer consent forms was recorded; and the name of child/ward on the parent/carer consent form was matched with the selected name on the class register. I gave a 2-minute brief talk on the purpose of the study, confidentiality and procedures taking place during data collection. All students with parent/carer consents were given an envelope and a questionnaire booklet. The questionnaire booklet included a consent form, a questionnaire, a measurement record sheet and a glossary of terms. Each questionnaire booklet was assigned a unique study number, which was written throughout the questionnaire booklet.

Researchers (myself and five trained Research Assistants) discussed and obtained written informed consents from the students within a 5-minute period. I was present and took overall responsibility for all consent. The questionnaire booklets were then pseudonymised by detaching the consent form (which contained the name of the student who consented and a matching unique study number which was also on the remaining components of the questionnaire booklet) from the questionnaire booklet before the start of self-administration of the questionnaire. Two separate boxes were provided for the storage of the completed consent forms and questionnaire booklets which were kept in a locked private room. The flow chart shows the general procedure and practical arrangements in each school (see Appendix 12).

6.7 TRAINING OF RESEARCH ASSISTANTS

Approximately two weeks before the first data collection day, I trained five Research Assistants for a three-day period. On the first day, I gave a brief talk on the purpose of study and assessments that were planned to take place during data collection. Research Assistants were familiarised with the study instruments and were shown the functionalities and calibrations of the equipment. The rest of the training day included demonstrations of the standardised measurement protocol of height, weight, waist circumference and blood pressure measurements, and practice of measurement of height, weight, waist and blood pressure measurements by each of the Research Assistants. Height, weight, waist circumference and blood pressure measurements were repeatedly carried out by each of the Research Assistants, until the standardised measurement protocol was understood. The Research Assistants carried out an average of five repeated measurements each. The content of the questionnaire booklets and the process of student consent collection were explained. I handed copies of the study questionnaires to the Research Assistants and they were instructed to read through the questionnaire and to discuss any sections which they did not fully understand the next day.

On the second day of training, questionnaire contents were thoroughly discussed, each section was explained and any sections which were not well understood were clarified. The process of questionnaire hand-outs, the purpose of error checks and the booklet collection record were also explained. There was a weekend break (two days) between the second and third day of training. The third day of training included three repeated height, weight, waist circumference and blood pressure measurements by each of the Research Assistants. All Research Assistants were able to carry out all measurements according to the standard measurement protocol by this time. The sequence of questionnaire hand outs and error checks, measurements and booklet submission/collection recording was explained. I handed a copy of the Standard Operating procedure (see Appendix 11) to all Research Assistants at the end of the training.

6.8 DATA COLLECTION

Data collection took place during school time (between 9am and 3pm) in seven secondary schools (three high-income, two middle-income and two low-income schools) in Lagos, Nigeria for a period of four weeks in November 2010.

6.8.1 MATERIALS

Automated Digital blood pressure monitor: Systolic and diastolic blood pressures were measured using a validated automated digital blood pressure monitor (Omron HEM-907) (Gopinath *et al*., 2011; Chen and Wang, 2009; Health Survey for England, 2008; Jago *et al*., 2006) accompanied with different cuff sizes (Figure 12). The automated digital BP monitor has been validated by El Assaad *et al* (2002) and White and Anwar (2001).

Figure 12: Omron HEM-907 Digital Blood pressure monitor

Weight Scale: A portable calibrated digital weighing scale (Seca 877 Class III) (Figure 13) in kilograms (Kg) was used to measure the body weight of each student (Health Survey for England, 2008).

Figure 13: Seca 877 Class III Weighing scale

Height Rule: A portable, collapsible stadiometer (Seca Leicester Portable Height Measure) made up of a sliding headboard, a base foot plate and three joined measuring scale bars in centimetres (cm) (Figure 14) was used to measure the height of each student (Health Survey for England, 2008).

Figure 14: Seca Leicester Portable Height Measure

Circumference Measuring Tape: Waist circumference was measured using a flexible tape (Seca 201) (Figure 15) in centimetres (cm) (van der Horst *et al*., 2008).

Figure 15: Seca 201 Circumference Measuring Tape

Questionnaire: Two separate self-completion questionnaires were provided; one for boys and one for girls (see Appendices 13 and 14). The difference in the boys' and girls' questionnaires was the pictorial illustration on their pubertal maturation status. The questionnaire consisted of three sections including 44 open and closed ended questions (items) (Box 2).

Box 2: Contents of the Questionnaire

Section	**Question**	**Question number**	**Validation and use in similar or related studies**
Section 1	Socio-demographic information (age, gender, religion and ethnicity), health-related information (associated diagnosis, current and past medical conditions, regular medication).	1 – 5 14 – 17	Merhi *et al*., 2011; Oyewole and Oritogun, 2009; Mijinyawa *et al*., 2008; Taksande *et al*., 2008; Muraguri *et al*., 1997; Alakija, 1979; Ayoola, 1979; Etta and Watson, 1976.
	Health-related information: Physical activity level – Validated Fels Physical Activity Questionnaire for children and adolescents. Salt intake – Habitual Table Salt Question for children.	6 – 13 18	Treuth *et al*., 2005. Adamopoulos *et al*., 1987.
Section 2	Socioeconomic characteristics: Parent/carer education level. Socio-economic characteristics: Living circumstances – Validated Household Questionnaire of the Demographic and Health Survey.	19 – 20 21 – 43	Akinkugbe *et al*., 1999; Akinkugbe *et al*., 1990; Adams-Campbell *et al*., 1987. Demographic and Health Survey (DHS), 2010.
Section 3	Pubertal maturation status – Validated Pictorial Tanner stages of pubertal development.	44	Kimani-Murage *et al*., 2010; Chen and Wang, 2009; Norris and Richter, 2005; Wacharasindhu *et al*., 2002; Kozinetz, 1991; Kozinetz, 1988; Williams *et al*., 1988; Duke *et al*., 1980; Tanner, 1962.

6.8.2 ASSESSMENT METHOD

I was present and took overall responsibility for all measurements and questionnaires. All measurements were carried out in accordance with the standardised measurement protocol. A spread-sheet was provided for recording submissions of completed questionnaire booklets (including a questionnaire and measurements record sheet).

QUESTIONNAIRE

The questionnaires were self-completed by students seated at a desk/table prior to all measurements (Figure 16). The self-completed questionnaire was conducted for boys and girls separately, as a section of the questionnaire was potentially embarrassing since it related to pubertal maturation. Researchers (myself and trained Research Assistants) handed out the questionnaires consisting of items on socio-demographic information (including: age, gender, religion and ethnicity), health-related information (including: current medical conditions, regular medication, physical activity level and salt intake), socio-economic characteristics (including: living circumstances and parent/carer education level) and pubertal maturation status), envelopes, and pencils to the students. The students were then given instructions on how to complete the questionnaire. The students were also instructed to ask questions where an item in the questionnaire was unclear and to go into the private room made available to fill the third (last) section of the questionnaire which assessed pubertal maturation status. Items which were not clear were read out loud and explained to individuals.

Physical activity level and salt intake were self-reported using the validated Fels Physical Activity Questionnaire for children and adolescents (Treuth *et al*., 2005) and habitual use of table salt question (Adamopoulos *et al*., 1987), respectively. The routine use of table salt was classified into three groups: Group 1 (“high salt users” – students who usually add salt to cooked food before having a taste), Group 2 (“moderate salt users” – students who usually add salt to cooked food after having a taste) and Group 3 (“low salt users” – students who usually eat food as it was cooked, without adding salt) (Adamopoulos *et al*., 1987).

Living circumstances (a proxy for socio-economic characteristics) were self-reported using the Household Questionnaire of the Demographic and Health Survey (DHS) (2010). Some items of the Household Questionnaire required description of the student's dwelling; copies of each pictorial illustration for the answer options to these items ("*what is the main material of the floor in your house?"*, "*what is the main material of the roof of your house?"* and "*what is the main material of the exterior wall of your house?"*) were provided to students in order to obtain a more accurate answer. Parent's/carer's education level was also self-reported as a proxy for their socio-economic characteristics (Akinkugbe *et al*., 1999; Akinkugbe *et al*., 1990; Adams-Campbell *et al*., 1987). Parent/carer education level was defined as the highest level attained by parent/carer. Six levels of education were distinguished, ranging from no education to university education. The parental/carer education levels were sub-classified into four groups for the purpose of analyses: did not attend school, primary school, secondary school, more than secondary school.

The students also self-reported their stage of pubertal maturation using five pictorial illustrations of Tanner stages of breast development for girls and genital development for boys (Tanner, 1962). The pubertal maturation stages were sub-classified into three groups for the purpose of analyses: pre-pubertal stage (Tanner Stage 1), early pubertal stage (Tanner Stages 2 and 3); and late-pubertal stage (Tanner Stages 4 and 5) (Reinehr and Toschke, 2009; Harding *et al*., 2008; He *et al*., 2002).

A member of the research team translated verbal and written words in the English language into the local language in a situation where a student did not adequately understand verbal explanations or written information given in English. The confidentiality of all answers and instructions on how to answer the questions was reiterated throughout the questionnaire administration. The students were asked to place completed questionnaires in envelopes immediately the pubertal maturation status question was completed. The questionnaires took approximately 30 minutes to complete. Once the questionnaires were completed, we (myself and a trained Research Assistant) checked for errors in completing the questionnaires in privacy in order to clarify answers and to avoid missing values before physical measurements were undertaken for each student.

Figure 16: Students filling out the questionnaire.

BLOOD PRESSURE MEASUREMENT

Researchers (myself and trained Research Assistants) carried out blood pressure (systolic and diastolic blood pressure) measurements simultaneously using automated digital blood pressure monitors. The automated digital blood pressure monitor was appropriately calibrated, according to the manufacturer’s specification every day before use, in order to ensure the accuracy of the measurements. A volunteer Research

Assistant had his/her blood pressure measured in front of the students, so as to create a relaxed environment and reduce any anxiety before blood pressure measurements commenced.

Blood pressure (systolic and diastolic blood pressure) was measured in privacy in quiet conditions with the student in a sitting position, back supported, feet flat on the floor, clothing sleeve rolled back to leave upper arm uncovered, right arm supported and cubital fossa (inner elbow) approximately at heart level (Figure 17), having sat quietly for at least 5 to 10 minutes to rest before measurement (Health Survey for England, 2008; NHBPEP Working Group, 2004). The students were asked to relax and not to speak for the total duration of their blood measurements as speaking may affect readings (Health Survey for England, 2008).

The correct cuff sizes were used based on the range indicated on the cuff (Table 16), where the inflatable bladder width was at least 40 percent of the arm circumference and the cuff-bladder length covered 100 percent of the arm circumference (NHBPEP Working Group, 2004). The cuff was wrapped not too tightly (leaving allowance for insertion of two fingers between cuff and arm) around the upper arm, about 1-2 cm above the cubital fossa (inner elbow), with the air tube aligned with the brachial artery (Health Survey for England, 2008). Three different readings (Health Survey for England, 2008; NHBPEP Working Group, 2004) were taken 2 minutes apart per student (Ejike *et al*., 2008; Pierin *et al*., 2008; Terra *et al*., 2004; Hegazy and Kader, 2003; White and Anwar, 2001; Schulze *et al*., 2000; Shuler *et al*., 1998; Einsterz *et al*., 1982). The average of the last two readings was used as a record of the blood pressure (systolic and diastolic blood pressure) (Health Survey for England, 2008). The average total duration of blood measurements per student was approximately 6 minutes.

Table 16: Recommended Dimensions for BP Cuff Bladders.

Age Range	**Width (cm)**	**Length (cm)**	**Maximum arm circumference (cm)***
New Born	4	8	10
Infant	6	12	15
Child	9	18	22
Small Adult	10	24	26
Adult	13	30	34
Large Adult	16	38	44

*Calculated so that the largest arm would still allow the bladder to encircle arm by at least 80%.

Source: NHBPEP Working Group (2004)

Figure 17: Student undergoing Blood Pressure measurement.

All information obtained from the students was kept confidential; however, as a condition of ethics approval, I had to communicate blood pressure measurement information for all the students to their parents/carers. I sent out three different types of letters (see Appendices 15, 16 and 17) to all parents/carers through the students, based on the blood pressure measurement level (“normal BP”, “high normal BP” or “high BP”) (according to the United States cut-off) (NHBPEP Working Group, 2004) of their child/ward. The letter also included recommendations on further medical assessments where a child/ward had “high normal BP” or “high BP” (according to the United States cut-off) (NHBPEP Working Group, 2004). In addition to the letter, I directly contacted (via mobile phone) the parents/carers of children/wards with “high BP” (according to the United States cut-off) (NHBPEP Working Group, 2004).

BODY WEIGHT MEASUREMENT

Researchers (myself or a trained Research Assistant) carried out the body weight measurements. Body weight was measured to the nearest 0.1 kilogram (kg), once, with the student standing upright, looking straight ahead, feet flat and together at the centre of the weighing scale, arms hanging loosely at the sides, without wearing shoes and heavy outer garments (such as jackets and cardigans) and with pockets emptied (Health Survey for England, 2008) (Figure 18). The body weight measurement took approximately 1 minute to complete per student.

Figure 18: Student undergoing weight measurement.

HEIGHT MEASUREMENT

Researchers (myself or a trained Research Assistant) carried out height measurements. Height was measured to the nearest 0.1 centimetre (cm), once, with the student standing fully upright, looking straight ahead, without wearing shoes, feet flat and together at the centre of the stadiometer base foot plate, heels against the stadiometer rod, arms hanging loosely at the sides and stadiometer headboard resting on the student's head (Health Survey for England, 2008) (Figure 19). The height measurement took approximately 1 minute to complete per student. Body Mass Index (BMI) was derived from the height and body weight measurement. BMI was calculated using the formula BMI = body weight (kg)/height $(m)^2$ (World Health Organisation, 2006).

Figure 19: Student undergoing Height measurement.

WAIST CIRCUMFERENCE MEASUREMENT

Waist circumference was measured to the nearest 0.1 centimetre (cm) with the circumference measuring tape placed horizontally, once, midway between the 10th rib and the top of the iliac crest, with the student in upright standing position, looking straight ahead, arms hanging loosely at the sides, breathing normally, without wearing outer garments (such as jackets and cardigans) and with pockets emptied, and all clothing rolled up to leave the stomach area uncovered (Kimani-Murage *et al*., 2010; Health Survey for England, 2008; World Health Organisation, 1995) (Figure 20).

Researchers (myself or a trained Research Assistant) carried out waist circumference measurements in a private room. The importance of removing any clothing around the abdomen in order to obtain an accurate value was explained to all the students before measurement (Health Survey for England, 2008). Female researchers carried out waist measurements for the female students; this protocol was similarly applied for the male researchers and students. Waist circumference measurement took approximately 1 minute to complete per student.

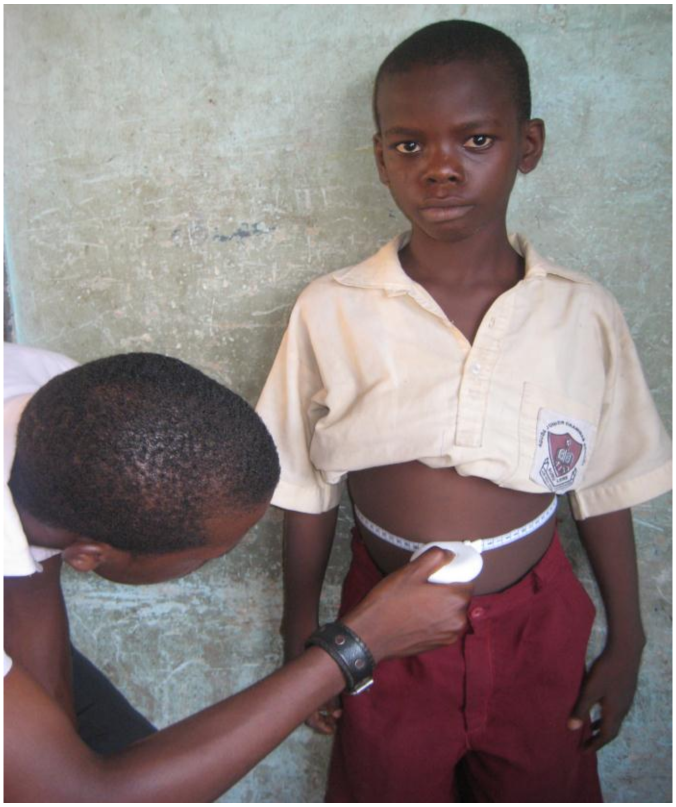


Figure 20: Student undergoing Waist circumference measurement.

6.9 DATA HANDLING

The collection, storage, disclosure and use of the data collected by Researchers complied with all legislation relating to data protection and with current guidelines of Warwick University data management directive. Measures to prevent accidental breaches of confidentiality were taken, by pseudonymising data by means of unique study number codes, keeping data safely in password-protected files and keeping confidential printed files in a locked filing cabinet to which only immediate relevant Researchers had access. In addition, provisions were made for continuing data security and eventual data destruction within three years of the end of the study.

6.10 DATA QUALITY, ENTRY AND CLEANING

Each Research Assistant carried out a specific measurement on all students in order to minimise Research Assistant variation (for example all height measurement was undertaken by one Researcher). I carried out all the data entries. All data were entered onto an SPSS version 18 database. One hundred of the data entries were selected using random number computer generated method and double entered onto the database by a competent Research Assistant. Each of the 100 data entries (containing 160 variables in each case) was then matched against its double-entered counterpart and checked for errors by running syntax on SPSS which highlights non-matches. Non-matches were systematically confirmed by hand searching and checking the questionnaire booklets, and then carefully corrected by Researchers (myself and a competent Research Assistant).

6.11 DATA ANALYSIS

Prior to the key data analysis (including descriptive and inferential statistics) for the study, I carried out a principal components analysis to derive a household wealth index from the living circumstances information. I also undertook exploratory analysis of the study data.

6.11.1 PRINCIPAL COMPONENTS ANALYSIS FOR HOUSEHOLD WEALTH INDEX

A multivariate statistical method called "principal components analysis" was used to obtain a household wealth index (a relative wealth continuous scale) from the data collected on living circumstances (Demographic and Health Survey, 2010; Howe *et al*. 2008; Vyas and Kumaranayake, 2006; Filmer and Pritchett, 2001). The principal components analysis (PCA) is a technique used to shrink data (Kolenikov and Angeles, 2008; Vyas and Kumaranayake, 2006; Filmer and Pritchett, 2001). It identifies the primary indicators that explain the principal correlation within a whole dataset, in order to substitute the large number of variables within the dataset with a lower number of components (linear index of variables) which are used to determine household wealth status (Bell *et al*., 2007; Fung *et al*., 2007; Vyas and Kumaranayake, 2006; Filmer and Pritchett, 2001).

I used the principal components analysis technique to determine how data from several indicators on living circumstances can be most effectively combined to measure a students' relative household wealth status. The principal components analysis identifies the combinations of indicators on living circumstances (known as "components") are most active in measuring relative household wealth in the study population. The components produced from the analysis are ordered in a way that the first component explains the highest amount of variation in the dataset, thus it was used as the single component where scores obtained for the student were used in creating the household wealth index (Howe *et al*., 2008; Fung *et al*., 2007; Vyas and Kumaranayake, 2006; Filmer and Pritchett, 2001).

The household wealth index assigns a score to each student, representing household wealth status of a student relative to other students. The higher the score, the richer the student's living circumstances relative to all others with lower scores. After the household wealth index was estimated by using the PCA, I categorised the students into wealth tertiles (high-income, middle-income and low-income) by standardising according to a standard normal distribution with mean and standard deviation of 0 and 1, respectively (Demographic and Health Survey, 2010). These wealth tertiles represent the indicator of living circumstances, and were used in all further data analysis.

6.11.2 EXPLORATORY ANALYSIS

In the exploratory analysis of the study data, box plots were produced to assess the distribution of continuous variables (age, weight, height, body mass index, waist circumference and physical activity) within the categorical variables (gender, religion, ethnicity, salt intake, pubertal maturation status, household wealth index, school fee level, father's education level and mother's education level) (see Appendix 18). Scatter plot matrix was also created to assess the linear relationship between continuous variables age, weight, height, BMI, waist circumference and physical activity score (see Appendix 18).

6.11.3 DESCRIPTIVE STATISTICS

I used descriptive statistics for categorical variables expressed as frequencies and percentages to provide the study response rates, prevalence of hypertension, and a general description of the study participants including the socio-demographic, socio-economic (household wealth index, school fee level, father's education level and mother's education level), pubertal maturation, anthropometric (BMI group and waist circumference group) and other important characteristics, such as salt intake and physical activity level.

Continuous variables – physical characteristics (age, weight, height, body mass index, waist circumference and physical activity score) and blood pressure (systolic and diastolic) of the study participants were expressed using descriptive statistics of means and standard deviations.

6.11.4 INFERENTIAL STATISTICS

Chi-square test statistics were carried out to assess statistically significant difference in the blood pressure status category within categorical variables (age group, gender, religion, ethnicity, salt intake, physical activity level, pubertal maturation status, household wealth index, school fee level, father's education level, mother's education level, BMI group and waist circumference group).

Chi-square test statistics were also carried out to assess the association between categorical variables (gender, religion, ethnicity, salt intake, pubertal maturation status, household wealth index, school fee level, father's education level and mother's education level) (see Appendix 18).

A one-way analysis of variance (ANOVA) and student's t-statistics were used to determine statistically significant differences in mean values of blood pressure (systolic and diastolic) within categorical variables (age group, gender, religion, ethnicity, salt intake, physical activity level, pubertal maturation status, household wealth index, school fee level, father's education level, mother's education level, BMI group and waist circumference group).

The association between blood pressure (systolic and diastolic) and other selected continuous variables (age, body mass index, waist circumference and physical activity score) were determined by Pearson's Product-moment Correlation coefficient.

For the purposes of obtaining appropriate categorical variables within a regression analysis, binary dummy variables (where a score of 1 is assigned to one group within a category and a score of 0 is assigned to other groups within a category) (Allison, 1999) were created for the independent categorical variables (gender, religion, ethnicity, salt intake, pubertal maturation status, household wealth index, school fee level, father's education level and mother's education level).

Four different multiple regression models were created to establish association between dependent variables (systolic BP and diastolic BP) and pubertal maturation status, household wealth index, school fee level, body mass index and waist circumference, while controlling other independent variables. Variables with significance level (p-value) of less than 0.10 from the ANOVA and t-tests for the difference in mean values of blood pressure (systolic and diastolic) within categorical variables (gender, religion, ethnicity, salt intake, physical activity level, pubertal maturation status, household wealth index, school fee level, father's education level and mother's education level) were included in the multiple regression models. Continuous independent variables with a statistically significant correlation with systolic BP and diastolic BP (from the Pearson's Product-moment Correlation coefficient) were also included in the multiple regression models.

Separate multiple regression models were created for dependent variables – systolic and diastolic blood pressures. In the multiple regression models for systolic blood pressure, independent variables (age, gender, ethnicity, salt intake, school fee level, household wealth index, pubertal maturation status, body mass index and waist circumference) were included, while, in the multiple regression models for diastolic blood pressure, independent variables (age, gender, school fee level, household wealth index, pubertal maturation status, body mass index and waist circumference) were included.

Multicollinearity between independent variables was considered before undertaking the multiple regression models; therefore variables which were highly correlated and variables measuring the same participant characteristics (such as the variables of adiposity and variables of socio-economic characteristics) were not included in the same multiple regression model (Allison, 1999). Separate combination of variables of adiposity (body mass index and waist circumference) and socio-economic characteristics (household wealth index and school fee level) were included in each multiple regression model. In addition, I considered interactions between independent variables (age, gender, pubertal maturation status, household wealth index, school fee level, body mass index and waist circumference) with significance level of $p<0.10$ from the ANOVA and t-tests for the difference in mean values of blood pressure (systolic and diastolic) (Allison, 1999). No statistically significant interactions were found ($p>0.10$).

All statistical analyses were performed using SPSS for Windows version 18. Alpha level was set at 0.05 to determine statistical significance.

SUMMARY

In this chapter, I described the methods undertaken in the study in order to achieve the study aims and objectives. I described the estimate for the study sample size, criteria in which participants were selected, procedure of participant selection, training of Research Assistants on standardised protocols for the study, data collection tools and process and methods in which data was handled, entered, cleaned and analysed.

In the next chapter, I will present the results of the study, including descriptive and inferential results.

CHAPTER 7: RESULTS

7.0 RESULTS

INTRODUCTION

In the previous chapter, I described my methods of data analysis. In this chapter, I will present the main findings of the study in line with the study aims and objectives. The findings will include both descriptive and inferential results.

7.1 RESPONSE RATES

One thousand and eighty six (1086) students out of the 1200 initially selected students from seven secondary schools (three high-income, two middle-income and two low-income schools) participated in the study, giving a total response rate of 90.5% (Table 17). Response rates were generally high, ranging from 86.5% to 95.0% at each school with a mean response rate of 90.9%. Middle-income schools generally had higher total response rates (91.8%).

Table 17: Characteristics and Response rates for each school

School	School ownership	Gender	Income group	Number of participants	Number of students selected	Response rate (%)
School 1	Private	Female	High	95	100	95.0
School 2	Private	Male	High	91	100	91.0
School 3	Private	Mixed	High	179	200	89.5
School 4	Private	Mixed	Middle	183	200	91.5
School 5	Federal Government	Mixed	Middle	184	200	92.0
School 6	State Government	Mixed	Low	181	200	90.5
School 7	State Government	Mixed	Low	173	200	86.5
Total				1086	1200	90.5

7.2 DESCRIPTIVE STATISTICS

7.2.1 SOCIO-DEMOGRAPHIC, SOCIO-ECONOMIC AND OTHER IMPORTANT CHARACTERISTICS OF STUDY PARTICIPANTS

Table 18 provides a general description of the study participants, including socio-demographic, socio-economic, pubertal maturation, anthropometric and other important characteristics. Approximately equal proportions of boys and girls (538 (49.5%) and 548 (50.5%), respectively) aged 11 to 18 years participated in the study. Almost half of the participants (47.2%) were between the ages of 13 and 15 years. Most of the participants were Christians (83.3%). The most common ethnicity was Yoruba (48.2%). Just under 70% of the participants characterised themselves as low salt users. The majority of the participants stated that their father (77.4%) or mother (73.5%) was educated to a level higher than secondary school. Just over half (54.5%) of the participants characterised themselves as late pubertal. Participants were almost evenly distributed within each of the physical activity levels, school fee levels and household wealth index groups.

A total of 85 (7.8 %) participants stated that they had long standing disease or illness. Of the disease items included in the questionnaire, the most common reported was asthma.

Table 18: Socio-demographic, socio-economic, pubertal maturation, anthropometric and other important characteristics of the study participants

Variable		**N (%)**
Age group (N=1086)	11-12	377 (34.7)
	13-15	513 (47.2)
	16-18	196 (18.1)
Gender (N=1086)	Male	538 (49.5)
	Female	548 (50.5)
Ethnicity (N=1086)	Hausa	23 (2.1)
	Igbo	335 (30.8)
	Yoruba	523 (48.2)
	Other	205 (18.9)
Religion (N=1086)	Christian	905 (83.3)
	Muslim	180 (16.6)
	Other	1 (0.1)
Salt-intake (N=1086)	High salt users	155 (14.3)
	Moderate salt user	179 (16.5)
	Low salt user	752 (69.2)
Physical Activity Level (N=1086)	Low	356 (32.8)
	Medium	354 (32.6)
	High	376 (34.6)
School fee level (N=1086)	Low-income schools	354 (32.6)
	Middle-income schools	367 (33.8)
	High-income schools	365 (33.6)
Wealth index (N=1086)	Poor	362 (33.3)
	Middle	348 (32.0)
	Rich	376 (34.7)
Father's education level (N=1055)	Did not attend school	12 (1.1)
	Primary school	35 (3.3)
	Secondary school	191 (18.1)
	More than secondary school	817 (77.4)
Mother's education level (N=1056)	Did not attend school	23 (2.2)
	Primary school	38 (3.6)
	Secondary school	219 (20.7)
	More than secondary school	776 (73.5)
Pubertal status (N=1084)	Pre-puberty	44 (4.1)
	Early puberty	449 (41.4)
	Late puberty	591 (54.5)
BMI group (N=1086)	Underweight	17 (1.6)
	Normal weight	797 (73.4)
	Overweight	160 (14.7)
	Obese	112 (10.3)
Waist circumference group (N=1086)	Normal waist circumference	925 (85.2)
	Central obesity	161 (14.8)
Long standing disease or illness (N=1086)	Present	85 (7.8)
	Absent	1001 (92.2)

7.2.2 PHYSICAL CHARACTERISTICS OF STUDY PARTICIPANTS

Overall the mean age of the study participants was 13.4±1.9years, mean weight was 52.6±14.4Kg, mean height was 1.6±0.1m, mean body mass index was 19.1±3.9Kg/m^2, mean waist circumference was 66.7±6.1cm, and mean physical activity score was 8.7±1.9.

About 10% (boys (10.2%) and girls (10.4%)) of the study participants were characterised as obese (Table 18) (using the WHO (2007) definition and BMI reference data) (see Appendix 3). Just under 15% (boys (14.1%) and girls (15.5%)) of the study participants were characterised as having central obesity (Table 18) (using the Fernández *et al* (2004) definition and waist circumference reference data) (see Appendix 4).

Table 19 presents the physical characteristics by gender of the participants. The t-test was used to determine statistical significant difference ($p<0.05$) in physical characteristics between males and females.

Boys were statistically significantly ($p<0.05$) taller than girls. On the other hand, girls had a statistically significantly ($p<0.05$) higher BMI than the boys (Table 19). There was no statistically significant difference ($p>0.05$) between boys and girls in age, body weight, waist circumference or physically activity level (Table 19).

Participants were selected from secondary schools stratified into three socio-economic groups (high-income, middle-income and low-income group) according to school fee level (as discussed in the Methods section). Table 20 presents the physical characteristics by school fee level of the participants. An ANOVA test was used to assess statistically significant differences ($p<0.05$) in physical characteristics between low, middle and high income schools.

Participants from high-income schools were the tallest and had the highest body weight, BMI and waist circumference compared to those from the middle and low-income schools (Table 20). A statistically significant difference ($p<0.05$) in body weight was found between participants from high-income schools, middle and low-income schools (Table 20); however, a statistically significant difference ($p<0.05$) in height, BMI and waist circumference was only observed between participants from high-income and low-income schools. Participants from low-income schools were statistically significantly ($p<0.05$) older and had a higher physical activity score than those from the middle and high-income schools (Table 20).

Table 19: Physical Characteristics of the study participants, by gender

Variable	Male			Female			P-value
	N	Mean	95% CI	N	Mean	95% CI	
Age (years)	538	13.6	13.4, 13.8	548	13.5	13.3, 13.6	0.361
Weight (Kg)	538	52.6	51.3, 53.9	548	52.6	51.5, 53.7	0.941
Height (m)	538	1.6	1.60, 1.62	548	1.6	1.58, 1.60	0.003
Body mass index (Kg/m^2)	538	19.9	19.5, 20.20	548	20.6	20.24, 20.92	0.003
Waist circumference (cm)	538	69.2	68.0, 70.0	548	68.6	67.9, 69.3	0.260
Physical activity score	538	8.8	8.6, 8.9	548	8.6	8.4, 8.7	0.150

*P-value derived from t-test (for difference in means). Significance level, p<0.05

Table 20: Physical Characteristics of the study participants, by school fee level

Variable	Low-income schools			Middle-income schools			High-income schools			P-value
	N	Mean	95% CI	N	Mean	95% CI	N	Mean	95% CI	
Age (years)	354	14.2	14.0, 14.4	367	13.2	13.0, 13.3	365	13.25	13.1, 13.4	0.000
Weight (Kg)	354	46.5	45.4, 47.7	367	53.9	52.5, 55.3	365	57.2	55.5, 58.8	0.000
Height (m)	354	1.6	1.56, 1.58	367	1.6	1.60, 1.62	365	1.6	1.61, 1.63	0.000
Body mass index (Kg/m^2)	354	18.6	18.3, 18.9	367	20.6	20.2, 21.0	365	21.4	21.0, 21.9	0.000
Waist circumference (cm)	354	65.1	64.5, 65.7	367	70.0	69.03, 70.90	365	71.5	70.5, 72.6	0.000
Physical activity score	354	9.2	9.0, 9.4	367	8.5	8.3, 8.7	365	8.3	8.1, 8.4	0.000

*P-value derived from ANOVA test (for difference in means). Significance level, p<0.05

7.3 PREVALENCE OF HYPERTENSION

Twenty seven (2.5%) out of the 1086 participants (17 (3.2%) males and 10 (1.8%) females) were defined as hypertensive, having a systolic blood pressure (SBP) and/or diastolic blood pressure (DBP) that is greater or equal to the 95th percentile for a given age, gender and height (according to the definition and reference data from the NHBPEP Working Group on Children and Adolescents) (2004)) (see Appendices 1 and 2 for BP reference data). There was a statistically significant difference ($p<0.05$) in the blood pressure status between males and females (Table 21). Twenty three (2.1%) participants had only systolic hypertension, 2 (0.2%) participants had only diastolic hypertension, and 2 (0.2%) participants had both systolic and diastolic hypertension.

One hundred and six participants (9.8%) (71 (13.2%) males and 35 (6.4%) females) were defined as pre-hypertensive, having a blood pressure between the 90th and 95th percentile or greater or equal to 120/80mmHg (regardless of whether the BP is less than 90th percentile) (according to the definition and reference data from the NHBPEP Working Group on Children and Adolescents) (2004)) (see Appendices 1 and 2 for BP reference data).

Table 21 shows the blood pressure status of the study participants by socio-demographic, socio-economic, pubertal maturation, anthropometric and other important characteristics. A statistically significant difference ($p<0.05$) in blood pressure status was observed within age group, school fee level, pubertal maturation status, BMI and waist circumference groups (Table 21). Participants aged 16 to 18 years had the highest prevalence of hypertension (6.1%). Participants from high-income schools had the highest prevalence of hypertension (3.0%), as did those participants who described themselves as late pubertal (3.9%). The highest rate of prevalence of hypertension was observed in those participants categorised as obese participants and in those with central obesity (9.8% and 8.1%, respectively).

There was no statistically significant difference (p>0.05) in blood pressure status by ethnicity, religion, salt intake, physical activity level, household wealth index or parent's education level (Table 21). However, the highest prevalence of hypertension was observed in the Igbos within the ethnicity category, Christians within the religious category, moderate salt users within the salt intake category, participants with high physical activity level within the physical activity level category, rich participants within the household wealth index and participants who have fathers or mothers with no level of education (Table 21).

Please note that all the findings for salt intake and physical activity level throughout the report should be treated with caution. As highlighted in the methodological issues section, the self-report questionnaire used to assess level of physical activity was considered to have a relatively low validity. Also, assessment of salt intake using a self-report of table salt use has been suggested to be useful in indicating discretionary use of salt and is thought not be indicative of total dietary salt intake (Charlton *et al*., 2007).

Table 21: Blood Pressure status of study participants

Variable		Normal BP n (%)	Pre-hypertension n (%)	Hypertension n (%)	P-value
Age group (N=1086)	11-12	361 (95.7)	15 (4.0)	1 (0.3)	0.000
	13-15	454 (88.5)	45 (8.8)	14 (2.7)	
	16-18	138 (70.4)	46 (23.5)	12 (6.1)	
Gender (N=1086)	Male	450 (83.6)	71 (13.2)	17 (3.2)	0.000
	Female	503 (91.8)	35 (6.4)	10 (1.8)	
Ethnicity (N=1086)	Hausa	22 (95.7)	1 (4.3)	0 (0)	0.230
	Igbo	288 (86.0)	35 (10.4)	12 (3.6)	
	Yoruba	469 (89.7)	43 (8.2)	11 (2.1)	
	Other	174 (84.9)	27 (13.2)	4 (2.0)	
Religion (N=1086)	Christian	790 (87.3)	89 (9.8)	26 (2.9)	0.300
	Muslim	162 (90.0)	17 (9.4)	1 (0.6)	
	Other	1 (100)	0 (0)	0 (0)	
Salt-intake (N=1086)	High salt users	133 (85.8)	17 (11.0)	5 (3.2)	0.545
	Moderate salt users	154 (86.0)	18 (10.1)	7 (3.9)	
	Low salt users	666 (88.6)	71 (9.4)	15 (2.0)	
Physical Activity Level (N=1086)	Low	316 (88.8)	34 (9.6)	6 (1.7)	0.766
	Medium	311 (87.9)	34 (9.6)	9 (2.5)	
	High	326 (86.7)	38 (10.1)	12 (3.2)	
School fee level (N=1086)	Low-income schools	311 (87.9)	34 (9.6)	9 (2.5)	0.018
	Middle-income schools	337 (91.8)	23 (6.3)	7 (1.9)	
	High-income schools	305 (83.6)	49 (13.4)	11 (3.0)	
Wealth index (N=1086)	Poor	318 (87.8)	37 (10.2)	7 (1.9)	0.385
	Middle	313 (89.9)	26 (7.5)	9 (2.6)	
	Rich	322 (85.6)	43 (11.4)	11 (2.9)	
Father's education level (N=1055)	Did not attend school	11 (91.7)	0 (0)	1 (8.3)	0.082
	Primary school	27 (77.1)	5 (14.3)	3 (8.6)	
	Secondary school	163 (85.3)	25 (13.1)	3 (1.6)	
	More than secondary school	721 (88.2)	76 (9.3)	20 (2.4)	
Mother's education level (N=1056)	Did not attend school	18 (78.3)	4 (17.4)	1 (4.3)	0.078
	Primary school	35 (92.1)	2 (5.3)	1 (2.6)	
	Secondary school	180 (82.2)	32 (14.6)	7 (3.2)	
	More than secondary school	695 (89.6)	63 (8.1)	18 (2.3)	
Pubertal status (N=1084)	Pre-puberty	43 (97.7)	1 (2.3)	0 (0)	0.000
	Early puberty	433 (96.4)	12 (2.7)	4 (0.9)	
	Late puberty	475 (80.4)	93 (15.7)	23 (3.9)	
BMI group (N=1086)	Underweight	17 (100)	0 (0)	0 (0)	0.000
	Normal weight	721 (90.5)	67 (8.4)	9 (1.1)	
	Overweight	136 (85.0)	17 (10.6)	7 (4.4)	
	Obese	79 (70.5)	22 (19.6)	11 (9.8)	
Waist circumference group (N=1086)	Normal waist circumference	834 (90.2)	77 (8.3)	14 (1.5)	0.000
	Central obesity	119 (73.9)	29 (18.0)	13 (8.1)	

*P-value from chi-square test and Monte Carlo method, where the requirements for each test were met. Significance level, $p<0.05$

7.4 BLOOD PRESSURE PATTERN

7.4.1 MEAN SYSTOLIC AND DIASTOLIC BLOOD PRESSURE OF THE STUDY PARTICIPANTS

Overall the mean systolic blood pressure was 105.2±12.6mmHg and diastolic blood pressure was 57.9±8.1mmHg.

Tables 22 and 23 show the mean systolic and diastolic blood pressure, respectively, within categories of socio-demographic, socio-economic, pubertal maturation, anthropometric and other important variables. Generally the mean systolic BP and diastolic BP showed a statistically significant ($p<0.05$) increasing trend with age. Males had a statistically significant higher systolic BP than females ($p<0.05$), while females had statistically significant higher diastolic BP ($p<0.05$) than males. Mean systolic BP and diastolic BP showed an increasing trend with household wealth index, pubertal maturation status, BMI group and waist circumference group, and the differences between categories in each group were statistically significant ($p<0.05$).

Participants from the high-income schools had statistically significant higher systolic BP and diastolic BP ($p<0.05$) than those from the low and middle-income schools; however, no statistically significant difference in mean systolic BP and diastolic BP was observed between participants from low and middle-income schools ($p>0.05$). Moderate salt users had the highest mean systolic BP, however, only the difference in mean systolic blood pressure between low and moderate salt-users was statistically significant ($p<0.05$). There was no statistically significant difference in the mean diastolic BP within the salt intake group.

There was no statistically significant difference ($p>0.05$) in mean systolic BP and diastolic BP between physical activity levels groups. The differences in mean systolic and diastolic BP by parent education level were not statistically significant ($p>0.05$) (Tables 22 and 23).

Table 22: Mean Systolic Blood Pressure of the study participants

Variable		n	Mean	95% Confidence Interval	P-value
Age group (N=1086)	11-12	377	98.2	97.2, 99.2	0.000
	13-15	513	107.1	106.1, 108.0	
	16-18	196	113.9	112.1, 115.8	
Gender (N=1086)	Male	538	106.2	105.0, 107.4	0.012
	Female	548	104.3	103.4, 105.2	
Ethnicity (N=1086)	Hausa	23	100.4	95.6, 105.2	0.004
	Igbo	335	105.7	104.3, 107.1	
	Yoruba	523	104.3	103.2, 105.3	
	Other	205	107.5	105.8, 109.2	
Religion (N=1086)	Christian	905	105.5	104.7, 106.4	0.223
	Muslim	180	103.8	102.0, 105.5	
	Other	1	100.0	-	
Salt-intake (N=1086)	High salt users	155	106.8	104.8, 108.8	0.007
	Moderate salt users	179	107.2	105.3, 109.1	
	Low salt users	752	104.4	103.5, 105.3	
Physical Activity (N=1086)	Low	356	104.4	103.1, 105.7	0.304
	Medium	354	105.4	104.1, 106.7	
	High	376	105.8	104.5, 107.2	
School fee level (N=1086)	Low-income schools	354	104.5	103.1, 105. 9	0.002
	Middle-income schools	367	104.1	102.9, 105.3	
	High-income schools	365	107.1	105.8, 108.4	
Wealth index (N=1086)	Poor	362	104.4	103.1, 105.8	0.049
	Middle	348	104.7	103.4, 106.0	
	Rich	376	106.5	105.2, 107.8	
Father's education level (N=1055)	Did not attend school	12	102.9	95.5, 110.3	0.287
	Primary school	35	108.9	103.5, 114.3	
	Secondary school	191	105.7	103.9, 107.5	
	More than secondary school	817	105.0	104.2, 105.9	
Mother's education level (N=1056)	Did not attend school	23	108.5	102.7, 114.2	0.257
	Primary school	38	107.6	104.4, 110.9	
	Secondary school	219	105.8	103.9, 107.7	
	More than secondary school	776	104.9	104.0, 105.7	
Pubertal status (N=1084)	Pre-puberty	44	91.7	88.6, 94.8	0.000
	Early puberty	449	99.3	98.3, 100.2	
	Late puberty	591	110.8	109.8, 111.7	
BMI group (N=1086)	Underweight	17	92.6	87.3, 97.9	0.000
	Normal weight	797	103.7	102.9, 104.5	
	Overweight	160	109.1	107.2, 111.0	
	Obese	112	112.5	109.8, 115.2	
Waist circumference group (N=1086)	Normal waist circumference	925	104.1	103.3, 104.8	0.000
	Central obesity	161	112.0	109.9, 114.1	

*P-value from t-tests and ANOVA tests (for difference in means), where the requirements for each test were met. Significance level, $p<0.05$

Table 23: Mean Diastolic Blood Pressure of the study participants

Variable		n	Mean	95% Confidence Interval	P-value
Age group (N=1086)	11-12	377	55.7	54.9, 56.4	0.000
	13-15	513	58.3	57. 7, 59.0	
	16-18	196	61.0	59.7, 62.2	
Gender (N=1086)	Male	538	57.0	56.4, 57.7	0.001
	Female	548	58.7	58.0, 59.4	
Ethnicity (N=1086)	Hausa	23	58.3	55.2, 61.3	0.514
	Igbo	335	57.9	57.0, 58.8	
	Yoruba	523	57.6	56.9, 58.3	
	Other	205	58.6	57.5, 59.7	
Religion (N=1086)	Christian	905	58.1	57.6, 58.6	0.470
	Muslim	180	56.7	55.7, 57.8	
	Other	1	47.0	-	
Salt-intake (N=1086)	High salt users	155	58.6	57.3, 59.9	0.267
	Moderate salt user	179	58.3	57.2, 59.4	
	Low salt user	752	57.6	57.0, 58.2	
Physical Activity (N=1086)	Low	356	57.9	57.1, 58.8	0.967
	Medium	354	57.8	56.9, 58.7	
	High	376	57.9	57.1, 58.7	
School fee level (N=1086)	Low-income schools	354	57.2	56.3, 58.1	0.004
	Middle-income schools	367	57.4	56.6, 58.2	
	High-income schools	365	59.0	58.2, 59.8	
Wealth index (N=1086)	Poor	362	57.1	56.2, 58.0	0.004
	Middle	348	57.5	56.7, 58.3	
	Rich	376	59.0	58.2, 59.8	
Father's education level (N=1055)	Did not attend school	12	57.2	52.2, 62.2	0.810
	Primary school	35	57.7	54.3, 61.0	
	Secondary school	191	57.4	56.2, 58.5	
	More than secondary school	817	58.0	57.4, 58.6	
Mother's education level (N=1056)	Did not attend school	23	56.8	52.6, 60.9	0.595
	Primary school	38	57.7	55.4, 60.0	
	Secondary school	219	57.2	56.0, 58.4	
	More than secondary school	776	58.0	57.4, 58.5	
Pubertal status (N=1084)	Pre-puberty	44	52.7	50.2, 55.2	0.000
	Early puberty	449	55.4	54.7, 56.1	
	Late puberty	591	60.1	59.5, 60.8	
BMI group (N=1086)	Underweight	17	51.8	48.1, 55.5	0.000
	Normal weight	797	56.9	56.3, 57.4	
	Overweight	160	60.1	59.0, 61.3	
	Obese	112	62.6	61.0, 64.2	
Waist circumference group (N=1086)	Normal waist circumference	925	57.1	56.6, 57.6	0.000
	Central obesity	161	62.6	61.3, 63.8	

*P-value from t-tests and ANOVA tests (for difference in means), where the requirements for each test were met. Significance level, p<0.05

Please note that age, body mass index, waist circumference and physical activity score were treated as continuous variables in further analysis.

7.5 LINEAR RELATIONSHIP BETWEEN BLOOD PRESSURE AND CONTINUOUS VARIABLES

Table 24 shows the Pearson correlation coefficient between systolic and diastolic blood pressure and continuous variables. The Pearson correlation coefficients between height and weight, and systolic and diastolic blood pressure were not presented, because height and weight values were used to derive the body mass index of study participants. There were statistically significant ($p<0.05$) low to moderate positive correlations between systolic BP and age, body mass index and waist circumference. The positive correlation observed between systolic blood pressure and physical activity score was not statistically significant ($p>0.05$).

Statistically significant ($p<0.05$) low to moderate positive correlations were observed between diastolic BP and age, body mass index and waist circumference, while a negative correlation was observed between diastolic blood pressure and physical activity score, but this was not statistically significant ($p>0.05$) (Table 24).

Table 24: Correlation between Systolic and Diastolic blood pressure and selected continuous variables

Variable	**Systolic Blood Pressure (mmHg)**	**Diastolic Blood Pressure (mmHg)**
Age (years)	0.475*	0.241*
Body mass index (Kg/m^2)	0.459*	0.354*
Waist circumference (cm)	0.512*	0.363*
Physical activity score	0.037	-0.013

*Correlation is significant at $p<0.05$.

7.6 SELECTION OF VARIABLES FOR THE MULTIPLE REGRESSION MODEL

I created separate multiple regression models for dependent variables – systolic and diastolic blood pressure (as discussed in the Methods section). I included variables with significance level (p-value) of less than 0.10 from the ANOVA and t-tests in Table 22 and 23, and those with a statistically significant correlation with SBP and DBP in Table 24 in the multiple regression models (as discussed in the Methods section). Age, gender, ethnicity, salt intake, school fee level, household wealth index, pubertal maturation status, body mass index and waist circumference were included in the multiple regression models for systolic blood pressure. In the multiple regression models for diastolic blood pressure, age, gender, school fee level, household wealth index, pubertal maturation status, body mass index and waist circumference were included.

7.6.1 SELECTION OF VARIABLES OF ADIPOSITY FOR THE MULTIPLE REGRESSION MODEL

Two anthropometric measures (body mass index and waist circumference) were used to assess adiposity of the study population, and these variables had a statistically significant correlation with SBP and DBP in Table 24. I considered multicollinearity between variables of adiposity prior to undertaking the multiple regression models. In order to determine whether to include both variables of adiposity in a multiple regression model or separately with just one variable of adiposity at a time in a multiple regression model, the linear relationship between variables of adiposity was determined. Table 25 shows the Pearson correlation between body mass index and waist circumference. There was a high positive statistically significant correlation

($p<0.05$) between body mass index and waist circumference. Thus, I included body mass index and waist circumference in separate multiple regression models.

Table 25: Correlation between BMI and waist circumference

Variable	**Body mass index (Kg/m^2)**
Waist circumference (cm)	0.910*

*Correlation is significant at $p<0.05$.

7.6.2 SELECTION OF VARIABLES OF SOCIO-ECONOMIC CHARACTERISTICS FOR THE MULTIPLE REGRESSION MODEL

Three proxy measures (school fee level, household wealth index and parental (father or mother) level of education) were used to assess socio-economic characteristics of the study population; however, only two of the variables of socio-economic characteristics (school fee level and household wealth index) had a significance level (p-value) of less than 0.10 from the ANOVA tests in Table 22 and 23. I considered multicollinearity between these variables of socio-economic characteristics prior to undertaking the multiple regression models. In order to determine whether to include both variables of socio-economic characteristics in a multiple regression model or separately with just one variable of socio-economic characteristics at a time in a multiple regression model, the association between the proxy measures of socio-economic characteristics was determined.

Table 26 show the association between school fee level and household wealth index. A statistically significant association ($p<0.05$) was found between school fee level and household wealth index. Thus, I included these proxy measures in separate multiple regression models.

Table 26: Association between school fee level and wealth index

Variable		Low-income schools n (%)	Middle-income schools n (%)	High-income schools n (%)	Total Number of participants N (%)	P-value
Wealth index (N=1086)	Poor	307 (84.8)	45 (12.4)	10 (2.8)	362 (100)	0.000
	Middle	46 (13.2)	190 (54.6)	112 (32.2)	348 (100)	
	Rich	1 (0.3)	132 (35.1)	243 (64.6)	376 (100)	

*P-value from chi-square test and Monte Carlo method, where the requirements for each test were met. Significance level, $p<0.05$

7.7 MULTIPLE REGRESSION MODELS – ASSOCIATION BETWEEN BLOOD PRESSURE AND SELECTED VARIABLES

I constructed four different models to determine the association between the dependent variable – systolic BP and independent variables (socio-economic characteristics, pubertal maturation status, and adiposity), and the association between the dependent variable – diastolic BP and independent variables (socio-economic characteristics, pubertal maturation status, and adiposity) (as described in the Methods Chapter (Chapter 6)). Each model included a separate combination of variables of adiposity and socio-economic characteristics (as described in the Methods Chapter (Chapter 6) and sections 7.6.1 and 7.6.2).

7.7.1 ASSOCIATION BETWEEN BLOOD PRESSURE AND WEALTH INDEX, PUBERTAL STATUS AND BMI: MULTIPLE REGRESSION MODEL 1

Table 27 shows separate multiple linear regression models for the association between systolic blood pressure and household wealth index, pubertal maturation status and BMI (while controlling for independent variables: age, gender, ethnicity, salt intake, household wealth index, pubertal maturation status and BMI); and the association between diastolic blood pressure and household wealth index, pubertal maturation status and BMI (while controlling for independent variables: age, gender, household wealth index, pubertal maturation status and BMI).

After adjusting for other variables, pubertal maturation status, BMI, age and gender were statistically significantly associated with systolic BP and diastolic BP ($p<0.05$). Household wealth index showed no statistically significant association with systolic and diastolic BP ($p>0.05$). Ethnicity and salt intake showed no statistically significant association with systolic BP ($p>0.05$).

The variables included in the multiple regression analysis explain about 41.6% of the variation in SBP and 18.0% of the variation in DBP (Table 27). Age accounted for the highest variation (22.7%) in SBP and BMI accounted for the highest variation (12.5%) in DBP (Table 28).

Table 27: Multiple Regression Analysis of selected variables and Blood Pressure – Model 1 (BMI and Wealth Index)

Variable		**Systolic Blood Pressure (mmHg)**			**Diastolic Blood Pressure (mmHg)**		
		Regression Coefficient	**95% Confidence Interval**	**P-value**	**Regression Coefficient**	**95% Confidence Interval**	**P-value**
Pubertal Status *Late puberty	Pre-puberty	-9.78	-12.99, -6.57	0.000	-3.84	-6.27, -1.41	0.002
	Early puberty	-6.13	-7.50, -4.77	0.000	-2.87	-3.90, -1.84	0.000
Wealth index *Rich	Poor	-0.06	-1.60, 1.49	0.944	-0.38	-1.55, 0.79	0.525
	Middle	-0.30	-1.72, 1.13	0.685	-0.70	-1.78, 0.38	0.207
BMI (Kg/m²)	Male				-	-	-
	Female				-	-	-
	Both	1.04	0.87, 1.20	0.000	0.54	0.42, 0.66	0.000
Age (years)		1.77	1.40, 2.14	0.000	0.41	0.13, 0.70	0.004
Gender *Female	Male	2.54	1.38, 3.71	0.000	-1.26	-2.14, -0.38	0.005
Ethnicity *Other	Hausa	-1.94	-6.13, 2.26	0.366	-	-	-
	Igbo	-0.76	-2.46, 0.93	0.377	-	-	-
	Yoruba	-1.59	-3.16, -0.23	0.047	-	-	-
Salt-intake *Low salt users	High salt users	1.01	-0.70, 2.70	0.244	-	-	-
	Moderate salt users	0.85	-0.74, 2.43	0.296	-	-	-
Adjusted R^2		0.416			0.180		

*Reference category. Significance level, $p<0.05$

Table 28: Individual contribution of selected variables to the variation in Blood Pressure – Model 1

Variable	Systolic Blood Pressure (mmHg)		Diastolic Blood Pressure (mmHg)	
	R Square Change	P-value	R Square Change	P-value
Puberty	0.049	0.000	0.047	0.000
BMI	0.133	0.000	0.125	0.000
Age	0.227	0.000	0.006	0.005
Gender	0.010	0.000	0.006	0.005

7.7.2 ASSOCIATION BETWEEN BLOOD PRESSURE AND WEALTH INDEX, PUBERTAL STATUS AND WAIST CIRCUMFERENCE: MULTIPLE REGRESSION MODEL 2

Table 29 shows separate multiple linear regression models for the association between systolic blood pressure and household wealth index, pubertal maturation status and waist circumference (while controlling for independent variables: age, gender, ethnicity, salt intake, household wealth index, pubertal maturation status and waist circumference); and the association between diastolic blood pressure and household wealth index, pubertal maturation status and waist circumference (while controlling for independent variables: age, gender, household wealth index, pubertal maturation status and waist circumference).

After adjusting for other variables, pubertal maturation status, waist circumference, age and gender were statistically significantly associated with systolic BP and diastolic BP ($p<0.05$). Household wealth index showed no statistically significant association with systolic and diastolic BP ($p>0.05$). Ethnicity and salt intake showed no statistically significant association with systolic BP.

The variables included in the multiple regression analysis explain about 43.8% of the variation in SBP and 18.8% of the variation in DBP (Table 30). Waist circumference accounted for the highest variation in SBP (26.3%) and DBP (13.1%) (Table 30).

Table 29: Multiple Regression Analysis of selected variables and Blood Pressure – Model 2 (Waist circumference and Wealth Index)

Variable		**Systolic Blood Pressure (mmHg)**			**Diastolic Blood Pressure (mmHg)**		
		Regression Coefficient	**95% Confidence Interval**	**P-value**	**Regression Coefficient**	**95% Confidence Interval**	**P-value**
Pubertal Status *Late puberty	Pre-puberty	-9.00	-12.16, -5.84	0.000	-3.50	-5.93, -1.07	0.005
	Early puberty	-5.79	-7.13, -4.45	0.000	-2.73	-3.76, -1.70	0.000
Wealth index *Rich	Poor	0.25	-1.26, 1.76	0.745	-0.32	-1.47, 0.84	0.592
	Middle	-0.54	-1.93, 0.86	0.450	-0.84	-1.91, 0.23	0.122
Waist circumference (cm)		0.52	0.44, 0.59	0.000	0.26	0.20, 0.31	0.000
Age (years)		1.69	1.33, 2.05	0.000	0.38	0.10, 0.66	0.007
Gender *Female	Male	1.47	0.33, 2.61	0.011	-1.81	-2.68, -0.93	0.000
Ethnicity *Other	Hausa	-1.94	-6.06, 2.18	0.355	-	-	-
	Igbo	-0.94	-2.60, 0.72	0.266	-	-	-
	Yoruba	-1.51	-3.05, -0.03	0.055	-	-	-
Salt-intake *Low salt users	High salt users	1.14	-0.52, 2.80	0.180	-	-	-
	Moderate salt users	0.81	-0.74, 2.37	0.306	-	-	-
Adjusted R^2		0.438			0.188		

*Reference category. Significance level, $p<0.05$

Table 30: Individual contribution of selected variables to the variation in Blood Pressure – Model 2

Variable	Systolic Blood Pressure (mmHg)		Diastolic Blood Pressure (mmHg)	
	R Square Change	P-value	R Square Change	P-value
Puberty	0.042	0.000	0.041	0.000
Waist circumference	0.263	0.000	0.131	0.000
Age	0.132	0.000	0.006	0.005
Gender	0.004	0.008	0.013	0.000

7.7.3 ASSOCIATION BETWEEN BLOOD PRESSURE AND SCHOOL FEE LEVEL, PUBERTAL STATUS AND BMI: MULTIPLE REGRESSION MODEL 3

Table 31 shows separate multiple linear regression models for the association between systolic blood pressure and school fee level, pubertal maturation status and BMI (while controlling for independent variables: age, gender, ethnicity, salt intake, school fee level, pubertal maturation status and BMI); and the association between diastolic blood pressure and school fee level, pubertal maturation status and BMI (while controlling for independent variables: age, gender, school fee level, pubertal maturation status and BMI).

After adjusting for other variables, pubertal maturation status, BMI, age and gender were statistically significantly associated with systolic BP and diastolic BP ($p<0.05$). School fee level was statistically significantly associated with systolic BP ($p<0.05$) but not with diastolic BP ($p>0.05$). Middle-income schools were statistically significantly different ($p<0.05$) from high-income schools, however, low-income schools were not statistically significantly different ($p>0.05$) from high-income schools. For diastolic BP, middle-income schools were borderline statistically significantly different ($p = 0.055$)

from high-income schools, and low-income schools were not statistically significantly different ($p>0.05$) from high-income schools.

Ethnicity and salt intake showed no statistically significant association with systolic BP, after controlling for other variables.

The variables included in the multiple regression analysis explain about 41.9% of the variation in SBP and 18.2% of the variation in DBP (Table 32). Age accounted for the highest variation (22.7%) in SBP and BMI accounted for the highest variation (12.5%) in DBP (Table 32).

Table 31: Multiple Regression Analysis of selected variables and Blood Pressure – Model 3 (BMI and School fee level)

Variable		**Systolic Blood Pressure (mmHg)**			**Diastolic Blood Pressure (mmHg)**		
		Regression Coefficient	**95% Confidence Interval**	**P-value**	**Regression Coefficient**	**95% Confidence Interval**	**P-value**
Pubertal Status *Late puberty	Pre-puberty	-9.60	-12.81, 6.39	0.000	-3.82	-6.25, -1.39	0.002
	Early puberty	-6.10	-7.46, -4.72	0.000	-2.87	-3.91, -1.84	0.000
School fee level *High-income schools	Low-income schools	-0.92	-2.50, 0.66	0.255	-0.45	-1.64, 0.73	0.454
	Middle-income schools	-1.53	-2.96, -0.91	0.037	-1.05	-2.12, 0.02	0.055
BMI (Kg/m^2)		1.02	0.86, 1.18	0.000	0.55	0.42, 0.67	0.000
Age (years)		1.80	1.42, 2.17	0.000	0.40	0.11, 0.68	0.006
Gender *Female	Male	2.50	1.34, 3.67	0.000	-1.27	-2.15, -0.39	0.005
Ethnicity *Other	Hausa	-2.08	-6.27, 2.11	0.330	-	-	-
	Igbo	-0.67	-2.37, 1.03	0.437	-	-	-
	Yoruba	-1.34	-2.93, 0.24	0.096	-	-	-
Salt-intake *Low salt users	High salt users	1.13	-0.56, 2.82	0.191	-	-	-
	Moderate salt users	0.85	-0.74, 2.43	0.295	-	-	-
Adjusted R^2		0.419			0.182		

*Reference category. Significance level, $p<0.05$

Table 32: Individual contribution of selected variables to the variation in Blood Pressure – Model 3

Variable		**Systolic Blood Pressure (mmHg)**		**Diastolic Blood Pressure (mmHg)**	
		R Square Change	**P-value**	**R Square Change**	**P-value**
Puberty		0.049	0.000	0.047	0.000
School fee level ***** High-income schools	Middle-income schools	0.002	0.044	-	-
BMI		0.133	0.000	0.125	0.000
Age		0.227	0.000	0.006	0.005
Gender		0.010	0.000	0.006	0.005

*Reference category.

7.7.4 ASSOCIATION BETWEEN BLOOD PRESSURE AND SCHOOL FEE LEVEL, PUBERTAL STATUS AND WAIST CIRCUMFERENCE: MULTIPLE REGRESSION MODEL 4

Table 33 shows separate multiple linear regression models for the association between systolic blood pressure and school fee level, pubertal maturation status and waist circumference (while controlling for independent variables: age, gender, ethnicity, salt intake, school fee level, pubertal maturation status and waist circumference); and the association between diastolic blood pressure and school fee level, pubertal maturation status and waist circumference (while controlling for independent variables: age, gender, school fee level, pubertal maturation status and waist circumference).

After adjusting for other variables, pubertal maturation status, school fee level, waist circumference, age and gender were statistically significantly associated with systolic BP and diastolic BP ($p<0.05$). For both systolic BP and diastolic BP, middle-income schools were statistically significantly different ($p<0.05$) from high-income schools, however, low-income schools were not statistically significantly different ($p>0.05$) from high-income schools. Ethnicity and salt intake showed no statistically significant association with systolic BP.

The variables included in the multiple regression analysis explain about 44.0% of the variation in SBP and 19.0% of the variation in DBP (Table 34). Waist circumference accounted for the highest variation in SBP (26.3%) and DBP (13.1%) (Table 34).

Table 33: Multiple Regression Analysis of selected variables and Blood Pressure – Model 4 (Waist circumference and School fee level)

Variable		**Systolic Blood Pressure (mmHg)**			**Diastolic Blood Pressure (mmHg)**		
		Regression Coefficient	**95% Confidence Interval**	**P-value**	**Regression Coefficient**	**95% Confidence Interval**	**P-value**
Pubertal Status *Late puberty	Pre-puberty	-8.87	-12.02, -5.71	0.000	-3.50	-5.93, -1.07	0.005
	Early puberty	-5.79	-7.14, -4.45	0.000	-2.75	-3.79, -1.72	0.000
School fee level *High-income schools	Low-income schools	-0.43	-1.98, 1.13	0.590	-0.30	-1.49, 0.88	0.617
	Middle-income schools	-1.64	-3.04, -0.23	0.023	-1.10	-2.16, -0.04	0.043
Waist circumference (cm)		0.51	0.44, 0.58	0.000	0.26	0.21, 0.31	0.000
Age (years)		1.69	1.33, 2.06	0.000	0.36	0.08, 0.64	0.013
Gender *Female	Male	1.46	0.32, 2.59	0.012	-1.82	-2.69, -0.95	0.000
Ethnicity *Other	Hausa	-2.04	-6.14, 2.07	0.331	-	-	-
	Igbo	-0.89	-2.56, 0.77	0.294	-	-	-
	Yoruba	-1.25	-2.81, 0.30	0.114	-	-	-
Salt-intake *Low salt users	High salt users	1.28	-0.38, 2.94	0.130	-	-	-
	Moderate salt users	0.82	-0.74, 2.37	0.303	-	-	-
Adjusted R^2		0.440			0.190		

*Reference category. Significance level, $p<0.05$

Table 34: Individual contribution of selected variables to the variation in Blood Pressure – Model 4

Variable		**Systolic Blood Pressure (mmHg)**		**Diastolic Blood Pressure (mmHg)**	
		R Square Change	**P-value**	**R Square Change**	**P-value**
Puberty		0.042	0.000	0.041	0.000
School fee level ***** High-income schools	Middle-income schools	0.003	0.013	0.003	0.042
Waist circumference		0.263	0.000	0.131	0.000
Age		0.132	0.000	0.006	0.005
Gender		0.004	0.008	0.013	0.000

*Reference category.

Tables 35 and 36 show the variables that contributed to variations in systolic and diastolic blood pressure in each multiple regression model. There was a statistically significant relationship between diastolic blood pressure and school fee level in multiple regression model 4 (where waist circumference was the variable of adiposity). However, in the multiple regression model 3 (where BMI was the variable of adiposity), school fee level was not statistically significantly associated with diastolic blood pressure. This may be due to a high correlation between BMI and school fee level within the regression model; which was revealed in a multiple regression model with all the variables in model 3 included, and excluding BMI (see Appendix 19), where school fee level was statistically significantly associated with diastolic blood pressure.

Therefore, overall, diastolic blood pressure was statistically significantly associated with school fee level.

Table 35: Variables that contribute to variations in systolic blood pressure in the four multiple regression models

Variable		Model 1 R Square Change	Model 2 R Square Change	Model 3 R Square Change	Model 4 R Square Change
Puberty		0.049	0.042	0.049	0.042
School fee level * High-income schools	Middle-income schools	~	~	0.002	0.003
BMI		0.133	~	0.133	~
Waist circumference		~	0.263	~	0.263
Age		0.227	0.132	0.227	0.132
Gender		0.010	0.004	0.010	0.004

~ Not included in the multiple regression model

Table 36: Variables that contribute to variations in diastolic blood pressure in the four multiple regression models

Variable		Model 1 R Square Change	Model 2 R Square Change	Model 3 R Square Change	Model 4 R Square Change
Puberty		0.047	0.041	0.047	0.041
School fee level * High-income schools	Middle-income schools	~	~	-	0.003
BMI		0.125	~	0.125	~
Waist circumference		~	0.131	~	0.131
Age		0.006	0.006	0.006	0.006
Gender		0.006	0.013	0.006	0.013

~ Not included in the multiple regression model

Table 37 shows the percentage variation in SBP and DBP explained by the multiple regression models. The multiple regression models 2 and 4 (with waist circumference included), explained a higher percentage of the variation in SBP and DBP than the multiple regression models 1 and model 3 (with included BMI).

Waist circumference accounted for a higher percentage variation in SBP and DBP than BMI (Tables 28, 30, 32 and 34).

Table 37: The percentage variation in SBP and DBP explained by the four multiple regression models

Variable	Systolic Blood Pressure (mmHg)	Diastolic Blood Pressure (mmHg)
	Adjusted R^2	**Adjusted R^2**
Model 1	0.416	0.180
Model 2	0.438	0.188
Model 3	0.419	0.182
Model 4	0.440	0.190

SUMMARY

In this chapter, I have presented the findings of the study. I have described the study response rate, estimated the prevalence rate of hypertension in the study population, and assessed the differences in blood pressure (systolic and diastolic) within categories of socio-demographic, socio-economic, pubertal maturation, adiposity and other important variables. I have also created different multiple regression models to assess the association between blood pressure (systolic and diastolic) and pubertal maturation status, socio-economic characteristics and adiposity, while controlling for other variables. In addition, I have estimated the proportion of variation in systolic and diastolic blood pressure determined by pubertal maturation status, socio-economic characteristics and adiposity in the study population.

A proportion (2.5%) of participants was found to have the American population definition of hypertension in this study. In these children and adolescents with hypertension, quite a number were older children (aged 16 to 18 years) and also obese children. There was a predominance of isolated systolic hypertension found in the study sample. Quite a proportion of participants (9.8%) were defined as pre-hypertensive. Blood pressure increased with age; and gender differences were found in blood pressure, as males had higher systolic blood pressure as compared to females, and females had higher diastolic blood pressure as compared to males. Overall, a significant independent relationship was indicated between blood pressure (systolic and diastolic) and pubertal maturation status, socio-economic characteristics and adiposity. Of the three proxy measures of socio-economic characteristics employed in this study, only school fee level had a statistically significant relationship with systolic and diastolic blood pressure. The two anthropometric measures of adiposity (BMI and waist circumference) had a statistically significant relationship with systolic and diastolic blood pressure. However, waist circumference contributed to a higher percentage variation in both systolic and diastolic blood pressure than BMI.

In the next chapter, I will discuss the findings of the study in comparison to similar studies in the literature. I will highlight the merits and limitations of the present study. I will also provide recommendations for health policy, practice and future research. To finish, I will present my conclusive view on the study.

CHAPTER 8: DISCUSSION AND CONCLUSION

8.0 DISCUSSION

INTRODUCTION

In this chapter, I will summarise the main findings from each section of the thesis in relation to the original research questions. I will discuss the relationship between the findings and the results of previous research. I will also summarise the strengths and limitations of the present study. I will then discuss the implications for policy, practice and future research. Finally, I will draw out broad conclusions.

8.1 PRINCIPAL FINDINGS OF THE THESIS

I have described my study area, including the demographic, health and socio-economic characteristics, and discussed the perspective of the study. I have undertaken a broad review of literature encompassing my four research questions, including: the association between anthropometric measures of adiposity and blood pressure, the association between socio-economic characteristics and blood pressure, the association between pubertal maturation status and blood pressure in children and adolescents, and the prevalence of hypertension in children and adolescents in Nigeria. I have also presented the justification of this study, and stated my research questions, aims and objectives and the null hypotheses of the study. I have discussed the methodological issues including the study design, participant selection and assessment methods; and I have described the procedural methods of participant selection, training of Research Assistants, data collection tools and assessment method and data analysis. Finally, I presented the findings of the study.

In summary, from the literature I highlighted that countries worldwide are experiencing a rising prevalence of chronic non-communicable diseases (including cardiovascular disease) and decrease in communicable diseases and poverty-related diseases, a process in modernisation known as “an epidemiological transition” (BeLue *et al*., 2009). This transition is associated with socio-economic development, socio-cultural transitions, rapid urbanisation, globalisation, westernisation and changing lifestyle factors occurring worldwide (Longo-Mbenza *et al*., 2007). The epidemiological transition is more evident in the developing countries, mainly affecting the wealthy middle-aged adults during the initial stage of transition but gradually reaching the poorer population with on-going socio-economic transitions in these countries (Suchday *et al*., 2008; Mendez *et al*., 2003; Colhoun *et al*., 1998). Chronic non-communicable diseases (including cardiovascular disease) are increasingly recognised as essential health and development problems in the global health agenda (United Nations, 2011; World Health Organisation, 2011a) and they are presently being considered for addition to the Millennium Development successor Goals in 2015 (United Nations, 2010).

The evolving epidemic of cardiovascular disease (CVD) in developing countries is at the centre of the epidemiological transition (Raj and Kumar, 2010). In these countries the highest percentage of deaths from CVD fall more on the younger population (mostly those under 70 years of age) (World Health Organisation, 2012; Abegunde *et al*., 2007). The increasing burden of CVD indicates an increasing prevalence of CVD risk factors, and particularly hypertension (Ejike *et al*., 2008; Moura *et al*., 2004). Hypertension or high blood pressure is recognised globally as a significant health problem in the adult population, including the Nigerian population (World Health Organisation, 2011a). Hypertension is increasingly recognised among children and adolescents throughout the world, including Nigeria (Mijinyawa *et al*., 2008). A convincing body of evidence from the United States of America and Europe indicate that adult hypertension may have its beginning in childhood (Chen and Wang, 2008). However, the tracking phenomenon of high blood pressure continuing from childhood and adolescence to adulthood in an individual has not yet been established in an African setting.

The influence of the epidemiological transition and its environmental changes (socio-economic development and urbanisation) and life style changes (such as more available and increased consumption of poor quality food along with a more sedentary lifestyle – a likely precursor of increased adiposity (obesity)) on the pattern of blood pressure in youngsters in Nigeria is uncertain. In addition, certain physiological sexual maturation changes which may have an impact on blood pressure have been noted to take place in teenagers (Meininger *et al*., 2004). As my study population includes children and adolescents, I considered it necessary to assess the association between pubertal maturation status and blood pressure.

My review of literature for the four research questions (Chapter 3) for the present study indicated a body of research with variation in sample sizes and representativeness of data; inconsistent methods and differing instrument used for blood pressure measurement; inconsistent criteria for classifying hypertension in children and adolescents; variation in the indicators of socio-economic characteristics and pubertal maturation status; and conflicting findings. There was very little published literature about blood pressure variations among children and adolescents of different socio-economic characteristics from Nigeria. In addition, no evidence of the relationship between pubertal maturation status and blood pressure in an African population or setting was found. Furthermore, the literature review indicates that the specific prevalence of child and adolescent hypertension worldwide (including Nigeria) is unknown. It varies in different regions of the world, and within the same country. The relationship between anthropometric measures of adiposity and blood pressure has been recognised in literature. Given the anticipated worldwide obesity epidemic, further study of the relationship between anthropometric measures of adiposity and blood pressure is important, particularly in developing countries, where the prevalence of obesity is rising (Lobstein *et al*., 2004).

A number of the studies in the review of literature lacked methodological rigour (mainly in terms of method of participant selection, reporting of participant response rates, the lack of standardised methods used for blood pressure measurement, and rationale for measures of assessing socioeconomic characteristics and pubertal maturation). Good quality primary epidemiological studies for adiposity-BP, socioeconomic characteristics-BP, pubertal maturation status-BP relationship, and prevalence of hypertension from African countries as well as other countries worldwide are needed in order to provide a strong evidence-base for blood pressure in children and adolescents. Such studies will support appropriate preventive strategies for blood pressure in children and adolescents, and may ultimately allow societies to tackle the burden of hypertension in adulthood.

I selected the study design for the present research including the methods of participant selection and the method of data collection and statistical data analysis, following the review of literature. I have discussed the challenges encountered in the choice of methods employed in the present study and the contextual reasons for my chosen methods in the Methodological Issues Chapter (Chapter 4). Prior to the main study, I carried out a pilot (Chapter 5), which provided important information and insight into data collection methods and analyses for the larger scale main study, and all the lessons and amendments were incorporated in the main study. Detailed procedural steps in the study design for the main study are presented in the Methods Chapter (Chapter 6).

I have highlighted the existence of hypertension in the study sample. A surprisingly high percentage (2.5%) of children and adolescents with hypertension was found, even though the definition was based on American data and may not be appropriate for an African population. In these children and adolescents with hypertension, I found that quite a number were older children and also obese children. There was a predominance of isolated systolic blood pressure hypertension in those with hypertension. Blood pressure increased with age; and gender differences were found in blood pressure, as males had higher systolic blood pressure as compared to females, and females had higher diastolic blood pressure as compared to males.

The findings also revealed a significant independent association between blood pressure (systolic and diastolic) and pubertal maturation status, socio-economic characteristics (measured by school fee level but not as measured by household wealth index and parental education level) and anthropometric measures of adiposity (BMI and waist circumference). I observed that waist circumference accounted for a higher percentage of variation in blood pressure (systolic and diastolic) than BMI; indicating that waist circumference may be a stronger indicator of blood pressure than BMI within this Nigerian study population.

My study shows that factors influencing the epidemiological transition which encourage the progression of blood pressure may already have been in operation as early as the teenage years. The present study also provides original evidence of the relationship between pubertal maturation status and blood pressure in an African population.

8.2 STRENGTHS AND LIMITATIONS

This study has several strengths, but also suffers some limitations.

This study relied on an extensive literature review of past studies to arrive at the study research questions. It was limited to some degree in being a cross-sectional study. The cross-sectional nature (that is, where exposures and outcome are assessed at a single point in time) of the study prevented the establishment of a sequential cause and effect relationship among the variables of interest and blood pressure levels (that is whether exposures preceded or resulted from the outcome variable) (Rothman *et al*., 2008). A longitudinal study with repeated measures of variables of interest and blood pressure would be required in the future to establish such a relationship satisfactorily.

The study setting is a diverse multi-ethnic, multi-cultural and multi-socio-economic urban area, and the sample population characteristics took this into account. Schools were purposively selected from each group of schools stratified into three school fee levels (high-income, middle-income and low-income group). This may increase the likelihood of selection bias occurring in the study; however, the random selection of students within schools representative of the different categories of schools, relatively large sample size, and good response rate demonstrated that the study sample was representative of the child and adolescent school attenders in the study area.

Schooling at secondary school level is obligatory in Nigeria, but not all children and adolescents attend. The population of children and adolescents who do not attend school were missed out in the present study. They are either too poor to afford school uniforms or shoes or have to stay home to carry out house chores or trade (self or employed), especially those who are the major family household income earner. According to results of the last national census in 2006, about 4% of children and adolescents aged 10–19 years in Lagos had never attended school (Nigeria National Population Commission, 2006). The non-inclusion of out-of-school children and adolescents in the present study may restrict the external validity/generalisability of the findings. In addition, no information was collected about students who did not participate in the study. It can therefore not be determined whether there is any difference between the study participants and those who refused to participate, that is, whether there might have been selection bias. However, the refusal rate was very low in this study.

Blood pressure and anthropometric measurement were carried out by myself and well-trained Research Assistants. All measurements were carried out using consistent/standardised protocols and the same type of instruments (see Methods Chapter (Chapter 6)) to avoid measurement bias; though inter-observer and intra-observer reliability was not assessed. I used two anthropometric measures of adiposity (BMI and waist circumference) in this study in order to increase the accuracy of assessment of adiposity.

An automated digital monitor was used to assess blood pressure. The automated digital blood pressure monitor (Omron HEM-907) used in the study has been validated against the standard mercury sphygmomanometer by two authors (El Assaad *et al*., 2002; White and Anwar, 2001) and used in many studies. This confirms a good level of accuracy and validity of the blood pressure measurements. The automated blood pressure monitor device eliminates potential inter-observer and/or intra-observer bias, terminal digit preference and errors of interpretation and also avoids the decision over the choice to use the fourth Korotkoff sound (K4) or fifth Korotkoff (K5) sound in determining diastolic blood pressure in children and adolescents. This avoids differences in the prevalence of diastolic hypertension resulting from discrepancies in choice of Korotkoff sound, which may cause problems in comparing studies.

Before blood pressure measurements commenced, a Research Assistant had his/her blood pressure measured in front of the students in order to create a relaxed environment and reduce any anxiety. I also did a lot of reassurance to minimise the likelihood of a white coat hypertension (the tendency for blood pressure to increase in the presence of a health professional) in the study participants. I measured blood pressure in a single visit, using multiple readings (three times), with the last two readings recorded as the level of blood pressure. Blood pressure measurements obtained at a single visit may tend to overestimate usual blood pressure (Chiolero *et al*., 2007c). However, multiple blood pressure readings in a single visit have been considered suitable for large scale population studies (Huang and Morisk, 1999). It has been suggested that multiple blood pressure readings produce more precise measurement values than one reading (Wingfield *et al*., 2002; Gillman and Cook, 1995). A more precise blood pressure estimate may have been obtained from multiple measures over three visits (NHBPEP Working Group, 2004).

In the absence of established normative blood pressure reference values in Nigeria, I relied on cut-off of the 95th percentile, based on the American reference values (NHBPEP Working Group, 2004) to define high blood pressure. This may cause misclassification of blood pressure in the present study, as there are likely to be important differences in blood pressure levels for different ages, gender and height between the American and Nigerian population. The American reference values may not be appropriately generalisable to the Nigerian child and adolescent population.

The study relied upon self-report information on pubertal maturation status, socio-economic characteristics, salt intake, and physical activity level. The use of a self-report is generally known to be prone to recall bias and report bias. I used self-assessment method of the Tanner stages of pubertal development to assess pubertal maturation. The most accurate measure of pubertal maturation is reproductive endocrine hormone levels, however, their measurement has considerable practical challenges and has not been standardised for epidemiological studies. The Tanner stages of pubertal development is the most acknowledged standard measure of pubertal development in epidemiological studies (Norris and Richter, 2008). The self-assessment method has been suggested to have considerable validity with notable agreement with the health professional physical assessment of maturation stage rating of pubertal development.

The three proxy measures of socio-economic characteristics measures (school fee level, household wealth index, and parent/carer education level) used in the present study may not wholly encompass the potentially important multidimensional indices of socio-economic characteristics which may have an association with blood pressure. However, I used these multiple proxy measures of socio-economic characteristics to compensate for the various measurement errors which are often observed for each proxy measure (see Methodological Issues Chapter (Chapter 4)), thereby increasing the accuracy of socio-economic characteristics assessment. I used the DHS Household Questionnaire (2010) to derive a household wealth index (one of the proxy measures of socio-economic characteristics). This questionnaire provides a list of assets, but does not capture differences in the quality and quantity of many of the assets owned by households. Nonetheless, I adopted it in this study because it is a well acknowledged and validated questionnaire recommended for use in many developing countries (such as Nigeria) with no standardised socio-economic characteristics scales.

I did not use a Nigerian specific standard questionnaire to measure physical activity level in children and adolescents in this study, as no such questionnaire exists. However, I used a validated Fels Physical Activity Questionnaire for children and adolescents from rural Maryland, United States. I considered the questionnaire suitable for all children and adolescents (irrespective of the socio-economic group) in Lagos, Nigeria, because it consists of items on sports activities, leisure activities and household chores, relevant to society in Lagos, Nigeria. In the present study, the 24-hour urinary sodium excretion test, which is the “gold standard” method to assess salt intake would have been impractical. I therefore assessed salt intake using questions on habitual use of table salt. The self-reported habitual use of table salt has been suggested to be strongly associated with actual use (Mittelmark and Sternberg, 1985); however, it is only valuable in indicating discretionary use of salt and not total dietary salt (Charlton *et al.*, 2007).

Several variables such as, age, gender, adiposity (BMI and waist circumference), physical activity, habitual use of table salt (salt intake), pubertal maturation status, and socio-economic characteristics (parents'/carers' education level, school fee level, and household wealth index) were adjusted for in the present study; but I did not take into account other factors that might have an association with blood pressure levels such as nutritional intakes, family history of hypertension, smoking, alcohol use, lipid profile, and birth weight. I selected the variables that I considered most relevant to my research questions from the published literature.

8.3 COMPARISON WITH PREVIOUS STUDIES

The data presented in this study indicate that blood pressure in children and adolescents is statistically significantly related to pubertal maturation status, socio-economic characteristics (measured as school fee level) and anthropometric measures of adiposity (BMI and waist circumference). In addition, an overall prevalence of hypertension of 2.5% was found in the study sample. The findings of the study also show that a large proportion of the population variance in blood pressure can be explained by the variables examined in the present study, and suggests that these factors may have an impact on blood pressure at a relatively young age.

The present findings demonstrate age and gender differences in the blood pressure of children and adolescents. In accordance with previous studies performed on different populations, blood pressure in the study sample rises with age (Durrani and Fatima, 2011; Merhi *et al*., 2011; Akor *et al* 2010; Agyemang *et al*., 2009; Bayat *et al*., 2009; Rao and Apte, 2009; Ejike *et al*., 2008; Gundogdu, 2008; Mijinyawa et al 2008; Taksande *et al*., 2008; Falkner *et al*., 2006; Kelishadi *et al*., 2006; Monyeki et al., 2006; Mohan *et al*., 2004; Ghannem *et al*., 2001; Ghannem *et al*., 2000; Hamidu *et al*., 2000; Akinkugbe *et al*., 1999; Irgil *et al*., 1998; Daniels *et al*., 1998; Muraguri *et al*., 1997; Anand and Tandon, 1996; Obika *et al*., 1995; Ng'amdu, 1992; Akinkugbe *et al*., 1990; Balogun *et al*., 1990b; Gliksman *et al*., 1990; M'buyamba-Kabangu *et al*., 1986; Andy *et al*., 1985; Abu-Bakare and Oyaide, 1983; Eferakeya and Ekeocha, 1982; Ayoola, 1979; Abdurrahman and Ochoga, 1977; Blankson *et al*., 1977; Akinkugbe and Ojo, 1968).

A notably higher systolic BP was found in males as compared to females, and a reverse pattern for diastolic BP was observed in the present study. It is interesting to note that the same pattern has been reported by other investigators (Agyemang *et al*., 2009; Ashrafi *et al*., 2005; Al-Sendi *et al*., 2003; Ghannem *et al*., 2001; Leccia *et al*., 1999; Balogun *et al*., 1990b; Sinaiko *et al*., 1989; Vartiainen *et al*., 1986; Orchard *et al*., 1980; Miller and Shekelle, 1976). There is no clear explanation for this varying blood pressure patterns in boys and girls. Other authors have however observed no gender differences (Akor *et al*., 2010; Gundogdu, 2008; Taksande *et al*., 2008; Hamidu *et al*., 2000; Ekunwe and Odujinrin, 1989; Andy *et al*., 1985; Eferakeya and Ekeocha, 1982; Ayoola, 1979; Abdurrahman and Ochoga, 1977).

I collected a range of variables measuring socio-economic characteristics; however, school fee level was the only variable related to blood pressure. The positive association between socio-economic characteristics and blood pressure values observed in the present study has been highlighted in studies both from developed countries (Falkner *et al*., 2006; Soylu *et al*., 2000) and developing countries (Akor *et al*., 2010; Rao and Apte, 2009; Akinkugbe *et al*., 1990).

Some authors have reported mixed findings within their studies on the direction of the gradient of the relationship between socio-economic characteristics and blood pressure in children and adolescents. Kelishadi *et al* (2006) reported that socio-economic characteristics (measured as school type) was positively related to blood pressure (both systolic BP and diastolic BP); while a negative relationship with diastolic BP was reported their other measure of socio-economic characteristics (mother's education level). Akinkugbe *et al* (1999) found that diastolic BP was positively related to father's education level in only the older female children, while systolic BP was negatively related to father's education level in only the older female children.

This positive association between socio-economic characteristics and blood pressure values observed in the present study is at variance with findings from other Nigerian studies (Akinkugbe *et al*., 1990; Balogun *et al*., 1990a; Adams-Campbell *et al*., 1987; Eferakeya and Ekeocha, 1982) and studies from other countries (see Literature Review Chapter (Chapter 3)).

As mentioned earlier in the Literature Review Chapter (Chapter 3), comparison of findings between studies is hindered due to differences in blood pressure measurement methods and socio-economic characteristics assessment methods. The present findings should be interpreted with caution, since the relationship between socio-economic characteristics and blood pressure varies according to the socio-economic characteristics variable used. The explanatory pathways with regards to the associations are thus complex. It may be thought that the children and adolescents in this study are too young to have physically acquired the biological consequences of their socio-economic characteristics.

However, multiple factors may contribute to socio-economic characteristics differences in blood pressure within the study population. It could be that with social-cultural transitions occurring during the process of socio-economic development in developing countries (including Nigeria), variations in environment, lifestyle and diet affect children, leading to changes in physical activity and diet similar to those observed in the adult population. Indicators of socio-economic characteristics assessed in this study may be higher compared to those in children and adolescents reported in other Nigerian studies. Thus, it seems plausible that the reason for the lack of association observed in most of the previous Nigerian studies is that Lagos State population generally has a higher socio-economic characteristics level than the rest of the country, and that the rate of epidemiological transition is likely to vary within Nigeria.

A high percentage of children and adolescents in this study reported that their parents had more than secondary school education. This was partly corroborated since more children and adolescents from middle and high income schools (based on school fee level) reported this. However, this may have limited the discriminatory value of parental education level as a viable measure of socio-economic characteristics within the study population. It may be due to the fact that the study is based in an urban setting, where educational achievement is considered highly desirable and where there are more educational opportunities; it could be possible that inclusion of children and adolescents from more deprived areas, where educational achievement is less relevant, may have produced a different result in terms of parent education level.

It is also possible that children have inaccurately assigned their parents' education level and wealth assets (most likely to upgrade their parents' status), because of their awareness of social classes and reluctance to admit to having limited assets or resources. However, the crude assignment of children according to their school fee level correlated with other socio-economic characteristics measures (see Results Chapter (Chapter 7)) thereby diminishing the likelihood of measurement errors and bias associated with these socio-economic characteristics measures.

It is noteworthy that the prevalence of obesity (based on BMI reference data) was about 10%, and was about 15% based on based on waist circumference reference data in the present study. These prevalence figures fall within the range (between 2.3% and 17.2%) reported by other recent investigators in Nigeria (Ejike *et al*., 2010; Goon *et al*., 2010; Opara *et al*., 2010; Senbanjo *et al*., 2009; Akinpelu *et al*., 2008).

In the present study, the positive association between anthropometric measures of adiposity (BMI and waist circumference) and blood pressure values observed is in accordance with earlier investigations (Durrani and Fatima, 2011; Gopinath *et al*., 2011;

Merhi *et al*., 2011; Ejike and Ugwu, 2010; Mazicioglu *et al*., 2010; Agyemang *et al*., 2009; Bayat *et al*., 2009; Karatzi *et al*., 2009; Oyewole and Oritogun, 2009; Ejike *et al*., 2008; Gundogdu, 2008; Monyeki *et al*., 2008; Nur *et al*., 2008; Taksande *et al*., 2008; Barba *et al*., 2006; Falkner *et al*., 2006; Fuiano *et al*., 2006; Kelishadi *et al*., 2006; Monyeki *et al*., 2006; Nichols and Cadogan, 2006; Janssen *et al*., 2005; Al-Sendi *et al*., 2003; Maffeis *et al*., 2001; Savva *et al*., 2000; Muraguri *et al*., 1997; Ng'amdu, 1992; Clarke *et al*., 1986; Liebman *et al*., 1986; Blankson *et al*., 1977; Miller and Shekelle, 1976).

In contrast to the present finding, only a few studies have reported no significant association between anthropometric measures of adiposity (BMI and waist circumference) and blood pressure (Hamidu *et al*., 2000; Akinkugbe *et al*., 1999; Akinkugbe *et al*., 1990; Ekpo *et al*., 1990; Andy *et al*., 1985). Gopinath *et al* (2011) found no significant association between waist circumfence and blood pressure (both systolic BP and diastolic BP) for only the female participants. Other authors have found no association for only diastolic BP (Paradis *et al*., 2004; Balogun *et al*., 1990b).

Although BMI is the most widely recommended indicator to classify adiposity levels among children and adolescents, worldwide (de Onis *et al*., 2007; Kuczmarski *et al*., 2002; Cole *et al*., 2000); it is interesting to note that in the present study waist circumference was more related to blood pressure than BMI, other researchers have noted similar findings (Barba *et al*., 2006; Janssen *et al*., 2005). An explanation for the stronger association observed for waist circumference is that BMI does not differentiate between fat and lean mass, while waist circumference measurements assesses the actual amount of fat situated centrally in the body (Mazicioglu *et al*., 2010; Flores-

Huerta *et al*., 2009; Must and Anderson, 2006), and it is this fat which has been linked to the risk of cardiovascular disease events in adults (de Koning *et al*., 2007).

The exact mechanism for explaining the relationship between blood pressure and anthropometric measures of adiposity (BMI and waist circumference) is poorly understood. However, this consistent observation with the literature emphasises the importance of adiposity as associated with blood pressure at an early age. With an anticipated global obesity epidemic, this may represent the role of dietary intake and low physical activity level (accompanying lifestyle changes of the epidemiological transition) in increasing blood pressure of children and adolescents.

Pubertal maturation was an important independent determinant of blood pressure levels in this study population, in accordance with earlier findings in other countries (Chen and Wang, 2009; Reinehr and Toschke, 2009; Remsberg *et al*., 2005; Shankar *et al*., 2005; Meininger *et al*., 2004; Cho *et al*., 2001; Koziel *et al*., 2001; Armstrong *et al*., 1992; Kozinetz, 1991; Kotchen *et al*., 1989; Kozinetz, 1988; Tell, 1985; Lauer *et al*., 1984; Orchard *et al*., 1980; Voors *et al*., 1979). The observation in the present study is at variance with findings in other studies, where it has been suggested that the association observed between pubertal maturation and blood pressure is as a result of the influence of body size on pubertal maturation (Leccia *et al*., 1999; Daniels *et al*., 1998; Daniels *et al*., 1996; Hansen *et al*., 1990; Weir *et al*., 1988; Halfon *et al*., 1987). Some other investigators have noted no important association between pubertal maturation and blood pressure (Harding *et al*., 2010; Harding *et al*., 2008; Hoffman *et al*., 2005; Frontini *et al*., 2003; He *et al*., 2002; Savva *et al*., 2000; Lattuada *et al*., 1986; Vartiainen *et al*., 1986; Londe *et al*., 1975).

The findings of the present study stand as new and original evidence on the relationship between pubertal maturation status and blood pressure, not only in Nigeria but also in the African continent. The findings indicate that pubertal maturation is an important factor to be considered during blood pressure assessment in children and adolescents. For example, if a 15 year old boy has his blood pressure assessed and his blood pressure is identified to be higher than his peer group, his pubertal maturation status should be considered, in addition to his gender, age and height, before ascertaining his blood pressure classification status; because he may have more advanced secondary sexual characteristics compared to his peers; thus a comparison based on gender, age and height may be inappropriate.

This implies that health care professionals have to develop a cautious attitude to a pubertal child with increased blood pressure relative to his peers. However, if a higher blood pressure is found in a pre-pubertal child or pubertal child, this should be taken as a suspicious finding which deserves attention.

I found a high percentage (2.5%) of children and adolescents with the American population definition of hypertension. This was unexpected, given that in the discussion with the PhD upgrade committee I was told that I was unlikely to find hypertension. Although a high percentage of children and adolescents were found to have hypertension in the present study, the value of hypertension prevalence is at the lower end of the range of the hypertension prevalence recorded from other Nigerian population studies. The prevalence of hypertension in Nigerian studies ranged from 1.2% to 11.2% (see Literature Review Chapter (Chapter 3)). The wide variation in the prevalence of hypertension in different parts of Nigeria may be attributed to heterogeneous nature of the population characteristics, and methodological differences in studies including: sample sizes, method of participant selection, response rate, methods used to measure blood pressure, and hypertension reference cut-off points.

The prevalence of hypertension in the present study is similar to that observed by authors from Nigeria, Europe and India. A Nigerian study (Adams-Campbell *et al*., 1987) including persons aged 12 to 17 years from Edo State reported 2.3% hypertension prevalence. Bayat *et al* (2009) reported 2.4% hypertension prevalence in children and adolescents aged 6 to 17 years in Turkey. Chiolero *et al* (2007a) involving participants aged 10 to 15 years in Switzerland, reported a 2.2% prevalence of hypertension. Thakor *et al* (1998) reported 2.3% prevalence of hypertension in participants aged 10 to 16 years in India.

With reference to studies on the Lagos child and adolescent population, my study reported the highest prevalence as compared to other studies from Lagos carried out the two to three decades ago (Ekunwe and Odujinrin, 1989; Johnson, 1971). Ekunwe and Odujinrin (1989) and Johnson (1971) reported a hypertension prevalence of 1.7% and 2.0%, respectively. The age range of children and adolescents included in these studies were similar to that of my study. However, these two studies are quite old.

My finding of higher hypertension prevalence as compared to the older studies involving a Lagos population may imply an increase in the prevalence of hypertension within this population in the last 20 years. This may be explained by the on-going economic and social change and the epidemiological transition within the general population. However, further evidence is needed to support this notion. It is worth noting that the differences in the techniques of blood pressure measurement methods and varying criteria for defining hypertension may have also contributed to the differences in the prevalence of hypertension between my study and the older Lagos population studies.

Of note in my study is the predominance of isolated systolic hypertension (23 (2.1%) study participants). This corroborates previous studies in children and adolescents (Dinc *et al*., 2009; Karatzi *et al*., 2009; Chiolero *et al*., 2007a; Chiolero *et al*., 2007b; Paradis *et al*., 2004; Sorof *et al*., 2002; O'Quin *et al*., 1992; Epstein *et al*., 1981; Norero *et al*., 1981; Muñoz *et al*., 1980). Other studies have found a higher prevalence level of isolated diastolic hypertension (Flores-Huerta *et al*., 2009; Mijinyawa *et al*., 2008; Akinkugbe *et al*., 1999; Sinako *et al*., 1989; Johnson, 1971). To the best of my knowledge no investigators have examined this issue of predominance of isolated systolic hypertension in children and adolescents.

About 10% of my study participants were defined as pre-hypertensive. This is an interesting observation as pre-hypertension is considered to be an indication of increased risk for developing hypertension in later life and an important predictor of CVD morbidity and mortality in later life (NHBPEP Working Group on Children and Adolescents, 2004). In addition, pre-hypertension status indicates a need for preventive health-related lifestyle changes (Ejike *et al*., 2010; NHBPEP Working Group on Children and Adolescents, 2004). There is little or no information on children and adolescents with pre-hypertension, including Nigeria. To the best of my knowledge, only one study from Nigeria (Ejike *et al*., 2010) had reported pre-hypertension prevalence. Ejike and colleagues included persons aged 13 to 18 years from semi-urban and urban area of Kogi State, and reported a pre-hypertension prevalence of 22.2% and 25.0% in the semi-urban and urban area, respectively. Further evidence is needed to support these findings.

8.4 IMPLICATIONS FOR POLICY

The findings of this study have important implications for the inclusion of chronic non-communicable diseases in the global health and development agenda (United Nations Millennium Development Goals (MDGs)). The findings of this study are expected to be valuable in paediatric public health policy formulation and action.

There is a need to raise the awareness and understanding of the Nigerian Health Ministries on the correlates of blood pressure in children and adolescents, so that appropriate health policy can be executed. The Nigerian Health Ministries also need to know that hypertension is an increasing public health problem, it is present as early as childhood, and it has an effect on ill-health in adult life.

Based on the fact that waist circumference was the stronger independent anthropometric determinant of blood pressure in this study, waist circumference measurements may be considered in Nigerian settings. Waist circumference measurements would help to identify children at risk of developing hypertension and allow for institution of measurements to lower morbidity and mortality burden in later life, as early detection will enable early preventive intervention measures to be taken. Waist circumference is cheap and easy to measure, and does not involve further complex calculations, and thus may be suitable for settings with scarce resources and limited health care capacity. It should be noted that the United Kingdom has implemented a school based BMI surveillance programme known as the National Child Measurement

Programme (NCMP). This could possibly be adapted in a Nigerian setting using waist circumference measurements.

Public health policies and interventions should be targeted at the whole child and adolescent population. According to the Rose hypothesis, interventions aimed at a whole population are more effective, as a small reduction in risk among a large proportion of people may prevent a lot more cases (Rose, 2008).

8.5 IMPLICATIONS FOR PRACTICE

The findings of this study will be valuable in designing future health-care strategies at the local and national level so as to reduce the burden of hypertension. Health care professionals should be prepared to play a key role in the prevention of hypertension and its related risk factors in order to prevent future burden.

Blood pressure measurement of children and adolescents could be incorporated as part of the routine paediatric physical examination in a hospital or primary health care setting (as recommended by the NHBPEP Working Group (2004)) for early detection of individuals with hypertension or at high risk of developing hypertension.

Based on the findings of this study, it is suggested that pubertal maturation status should be considered when assessing the blood pressure of children and adolescents in a hospital or primary health care setting. The National High Blood Pressure Education Program (NHBPEP) Working Group on Children and Adolescents has not provided a practical approach to address this.

8.6 IMPLICATIONS FOR RESEARCH

Future research on blood pressure in children and adolescents should include:

1). Large representative epidemiological surveys with standardised methods to further assess the prevalence of hypertension in Nigerian children and adolescents.

2). Epidemiological surveys with standardised methods that can be used to develop Nigerian specific normative ranges of blood pressure values for children and adolescents. There is a need for standardised population-specific blood pressure standards due to biological differences between populations. This is important to quantify the extent of the problem, have standardised diagnostic criteria for hypertension, and enhance comparability between studies. The population national specific normative ranges of blood pressure values should be age, height and gender specific, similar to the standard United States national database on normative blood pressure levels by the NHBPEP Working Group (2004).

3). Epidemiological surveys with standardised methods in Nigeria and other African countries which would assess the association between pubertal maturation status and blood pressure. To the best of my knowledge, this is the first study to determine the association between pubertal maturation status and blood pressure in an African setting.

The findings of my study have suggested that pubertal maturation status may be a significant biological marker for differences in BP among children and adolescents. The NHBPEP Working Group (2004) does not consider pubertal maturation status in its BP reference standards. There is a need to provide a practical approach to address this issue. Such approach will serve as the basis for future guidelines for classifying childhood and adolescent blood pressure.

4). Epidemiological studies with standardised protocols to investigate the effect of other factors which may affect blood pressure, including: salt intake of the pupils (using the gold standard method – 24-hour urine test), physical activity level (using a gold standard method – laboratory-based calorimetry), dietary food intake, genetics (such as family history of hypertension), anthropometric measures (such as birth weight), alcohol use, and smoking. Such studies would provide solid evidence and valuable insights concerning the social, environmental, behavioural, and biological factors that may be associated with blood pressure.

5). Longitudinal studies with a standardised protocols to investigate the long term consequences of primary higher than average blood pressure in the population of Nigerian children and adolescents. There is presently a dearth of long-term follow-up blood pressure tracking studies in African settings which investigate later blood pressure values, and complications of sustained high blood pressure into adulthood.

6). Longitudinal studies with standardised methods to assess future trends in relationship between blood pressure and social, environmental, behavioural, and biological factors. This will be significant in evaluating the importance of these factors in the evolution of hypertension in later life in Nigeria so as to curtail the negative influences of the epidemiological transition.

7). Studies evaluating the efficacy and cost-effectiveness of public health interventions such as healthy lifestyle promotion school programmes and anthropometric measure of adiposity (such as waist circumference) surveillance programmes.

8). Epidemiological surveys including Nigerian child and adolescent population that can be used to develop Nigerian population-specific and international waist circumference reference standard data to define criteria for obesity in children and adolescents. This is important given that waist circumference was the stronger independent anthropometric determinant of blood pressure my study.

8.7 CONCLUSION

Children are the future of the Nigerian nation, and the preservation of their health is of the utmost priority. This study suggests that the epidemiological transition exists and is having measurable effects in school children and adolescents in Nigeria. This has long term implications for an extra burden of chronic non-communicable diseases related to hypertension in Nigeria. This study provides information on the prevalence of hypertension and blood pressure correlates in the Nigerian child and adolescent population. It provides additional data towards the definition of a national blood pressure standard for children and adolescents in Nigeria. The present study confirms that hypertension is an important public health problem and highlights the need for the inclusion of blood pressure measurement in children and adolescents in the routine paediatric physical examination in a hospital or primary health care setting.

The study provides further evidence showing that anthropometric measures of adiposity are associated with blood pressure in youngsters. It also provides new and original evidence on the association between blood pressure and pubertal maturation status in the African continent, and advocates that pubertal maturation status be taken into consideration when assessing blood pressure during childhood and adolescence. In addition, the findings from this study expand the insufficiently explored relationship between blood pressure and socio-economic characteristics in the Nigerian child and adolescent population. The findings imply that the pattern of the relationship between socio-economic characteristics and blood pressure in children and adolescents in Nigeria mimics that already described for adults in developing countries.

From a public health perspective, early identification of factors that are associated with blood pressure in young people cannot be overemphasised as it is a principal step towards guided health policies and preventive interventions at the local and national level. Public health policies and preventive interventions aimed to reduce the risk for hypertension and discourage the negative lifestyle changes (unhealthy diets and sedentary lifestyles) that occur with the epidemiological transition should be encouraged for all children and their families.

Such public health policies and preventive interventions could include: regular standardised waist circumference measurement surveillance programme in schools; healthy eating programmes in schools (through school canteen policy); compulsory physical education classes to limit sedentary behaviours in schools; health club initiative in schools; creation of surroundings that enhance physical activity and provision of recreational facilities that are accessible to youngsters in the community; and public enlightenment campaigns (through community public education and telemedia advertising messages) to improve public awareness of hypertension.

The government, health care professionals (including school nurses), school officials, community, and parents/carers have a crucial responsibility to ensure the application of the public health policies and preventive interventions at community, home and school level. In addition, parents and carers could be encouraged to be exemplary in the promotion of healthy diets and physical activity within the home environment, so that they may be emulated by their children and adolescents.

REFERENCES

Abdurraham, M.B. and Ochoga, S.A. (1977). Casual Blood Pressure in School Children in Kaduna, Nigeria. Tropical and Geographical Medicine, **30**(3):325-329.

Abegunde, D.O., Mathers, C.D., Adam, T., Ortegon, M. and Strong, K. (2007). The burden and costs of chronic diseases in low-income and middle-income countries. Lancet, **370**:1929-1938.

Abolfotouh, M.A., Sallam, S.A., Mohammed, M.S., Loutfy, A.A. and Hasab, A.A. (2011). Prevalence of Elevated Blood Pressure and Association with Obesity in Egyptian School Adolescents. International Journal of Hypertension, **2011**:1-8.

Abu-Bakare, A. and Oyaide, S.M. (1983). Blood Pressure Levels in Nigerian School Girls. Journal of Tropical Pediatrics, **29**:225-229.

Adamopoulos, P.N., Chaniotis, F., Kodoyianis, S., Boutsicakis, J., Madalos, P., Kassos, D., Gatos, A. and Moulopoulos, S. (1987). Table salt and Blood pressure in Greek children. Journal of Human Hypertension, **1**(3):209-213.

Adams, A.M., Evans, T.G. and Mohammed, R. (1997). Socio-economic Stratification by Wealth Ranking: Is it Valid? World Development, **25**(7):1165-1172.

Adams-Campbell, L.L., Ukoli, F.A., Silverman, J.A., Omene, J.A., Nwankwo, M.U. and Kuller, L.H. (1992). Tracking of blood pressure and anthropometric measures in Nigerian children. Journal of Human Hypertension, **6**:47-51.

Adams-Campbell, L.L., Ukoli, F., Young, M.P., Omene, J., Nwankwo, M., Haile, G.T. and Kuller, L.H. (1987). An epidemiological assessment of blood pressure determinants in an adolescent population of Nigerians. Journal of Hypertension, **5**(5):575-80.

Addo, J., Smeeth, L. and Leon, D.A. (2007). Hypertension in sub-Saharan Africa: A systematic review. Hypertension, **50**:1012-1018.

Adedoyin, O.T., Ojuawo, A. and Johnson, A.B. (2006). Knowledge, attitude and perception of adults on childhood hypertension in a rural community in Nigeria. Nigerian Postgraduate Medical Journal, **13**(3):216-219.

Adler, N. E., Boyce, T., Chesney, M. A., Cohen, S., Folkman, S., Kahn, R. L., and Syme, L. (1994). Socio-economic status and health: The challenge of the gradient. American Psychologist, **49**:15-24.

Adler, N.E. and Ostrove, J.M. (1999). Socio-economic status and health: what we know and what we don't. Annals of the New York Academy of Sciences, **896**:3-15.

Agunwamba, A., Bloom, D., Friedman, A., Ozolins, M., Rosenberg, L., Steven, D. and Weston, M. (2009). Nigeria: The Next Generation – Literature. British Council and Harvard University. http://www.nextgenerationnigeria.org/wp-content/uploads/2009/06/NigeriaLiteratureReview-28may09-Final.pdf. Accessed 20th June 2011.

Agyemang, C., Oudeman, E., Zijlmans, W., Wendte, J. and Stronks, K. (2009). Blood pressure and body mass index in an ethnically diverse sample of adolescents in Paramaribo, Suriname. BMC Cardiovascular Disorders, **9**:19.

Agyemang, C., Redekop, W.K., Owusu-Dabo, E. and Bruijnzeels, M.A. (2005). Blood pressure patterns in rural, semi-urban and urban children in Ashanti region of Ghana, West Africa. BMC Public Health, **5**:114-121.

Akinkugbe, F.M., Akinwolere, A.O.A. and Kayode, C.M. (1999). Blood Pressure Patterns in Nigerian Adolescents. West African Journal of Medicine, **18**(3):196-202.

Akinkugbe, F.M., Akinwolere, A.O.A. and Oyewole, A.I.M. (1990). Blood Pressure in three socio-economic groups of black children in Nigeria. Tropical Cardiology, **16**(61):7-16.

Akinkugbe, O.O. (1969). School Survey of Arterial Pressure and Proteinuria in Ibadan, Nigeria. East African Medical Journal, **46**(5):257-261.

Akinkugbe, O.O. and Ojo, A.O. (1968). The Systemic Blood Pressure in a rural Nigerian population. Tropical and Geographical Medicine, **20**(4):347-356.

Akinpelu, A.O., Oyewole, O.O. and Oritogun, K.S. (2008). Overweight and Obesity: Does It Occur In Nigerian Adolescents in an Urban Community? International Journal of Biomedical and Health Sciences, **4**(1):11-17.

Akor, F., Okolo, S.N. and Okolo, A.A. (2010). Blood pressure and anthropometric measurements in healthy primary school entrants in Jos, Nigeria. South African Journal of Child Health, **4**(2):42-45.

Alakija, W. (1979). A Pilot Study of Blood Pressure Levels in Benin City, Nigeria. East African Medical Journal, **56**(4):182-186.

Al-Sendi, A.M., Shetty, P., Musaiger, A.O. and Myatt, M. (2003). Relationship between body composition and blood pressure in Bahraini adolescents. British Journal of Nutrition, **90**:837-844.

Allison, P.D. (1999). Multiple Regression: a primer. Pine Forge Press: California.

Amuna, P. and Zotor, F.B. (2008). The epidemiological and nutrition transition in developing countries: evolving trends and their impact in public health and human development. Proceedings of the Nutrition Society, **67**:82-90.

Anand, N.K. and Tandon, L. (1996). Prevalence of Hypertension in school going children. Indian Pediatrics, **33**: 377-381.

Andy, J.J., Ladipo, G.O.A., Owolabi, S.P., Teniola, S.O., Ajayi, A.A., Akinola, N.O and Morakinyo, O. (1985). Blood Pressure Distribution of Nigerians in First Two Decades of Life. Annals of Tropical Paediatrics, **5**:113-118.

Armstrong, N., Balding, J., Gentle, P. and Kirby, B. (1992). Serum lipids and blood pressure in relation to age and sexual maturity. Annals of Human Biology, **19**(5):477-487.

Ashrafi, M.R., Abdollahi, M., Ahranjani, B.M. and Shabanian, R. (2005). Blood pressure distribution among healthy schoolchildren aged 6–1 years in Tehran. Eastern Mediterranean Health Journal, **11**(5/6):968-976.

Ayoola, E.A. (1979). Prevalence of Adolescent Hypertension in Nigeria. Nigerian Journal of Paediatrics, **6**(1):18-26.

Azevedo, J.C.V., Brasil, L.M.P., Macedo, T.B.M.A., Pedrosa, L.F.C. and Arrais, Ricardo F. (2009). Comparison between objective assessment and self-assessment of sexual maturation in children and adolescents. Jornal de Pediatria, **85**(2):135-142.

Balen, J., McManus, D.P., Li, Y., Zhao, Z., Yuan, L., Utzinger, J., Williams, G.M., Li, Y., Ren, M., Liu, Z., Zhou, J. and Raso, G. (2010). Comparison of two approaches for measuring household wealth via an asset-based index in rural and peri-urban settings of Hunan province, China. Emerging Themes in Epidemiology, **7**:7-23.

Balogun, J.A., Obajuluwa, V.A., Abereoje, O.K., Olaogun, M.O., Oyeyemi, A.Y., Adeolu, O.O. and Balogun, M.O. (1990a). Influence of parental socioeconomic status on casual blood pressure of Nigerian school children. International Journal of Cardiology, **29**:63-69.

Balogun, J.A., Obajuluwa, V.A., Abereoje, O.K., Olaogun, M.O., Oyeyemi, A,Y., Balogun, M.O. and Adeolu, O.O. (1990b). Anthropometric determinants of resting blood pressure and heart rate of Nigerian School Children. Annals of Tropical Paediatrics, **10**:425-431.

Barba G., Troiano E., Russo, P., Strazzullo, P. and Siani, A. (2006). Body mass, fat distribution and blood pressure in Southern Italian children: Results of the ARCA project. Nutrition, Metabolism and Cardiovascular Diseases, **16**:239-248.

Bayat, M., Erdem, E., Barik, Ö., Bas¸Er, M. and Tas¸Ci, S. (2009). Blood pressure, height, weight and body mass index of primary school students in a low socio-economic district in Turkey. International Nursing Review, **56**:375-380.

Bell, N., Schuurman, N. and Hayes, M.V. (2007). Using GIS-based methods of multicriteria analysis to construct socio-economic deprivation indices. International Journal of Health Geographics, **6**:17-35.

BeLue, R., Okoror, T.A., Iwelunmor, J., Taylor, K.D., Degboe, A.N., Agyemang, C. and Ogedegbe, G. (2009). An overview of cardiovascular risk factor burden in sub-Saharan African countries: a socio-cultural perspective. Globalisation and Health, **5**:10-22.

Ben-Bassey, U.P., Oduwwole, A.O. and Ogundipe, O.O. (2007). Prevalence of overweight and obesity in Eti-Osa LGA, Lagos, Nigeria. Obesity Reviews, **8**(6):475-479.

Bentley, B. (2006). A Review of Methods to Measure Dietary Sodium Intake. Journal of Cardiovascular Nursing, **21**(1):63-67.

Biro, F.M., Daniels, S.R., Similo, S.L., Barton, B.A., Payne, G.H. and Morrison, J.A. (1996). Differential classification of blood pressure by fourth and fifth Korotkoff phases in school-aged girls. The National Heart, Lung, and Blood Institute Growth and Health Study. American Journal of Hypertension, **9**(3):242-247.

Blane D, Hart CL, Smith GD, Gillis CR, Hole DJ, Hawthorne VM. (1996). Association of cardiovascular disease risk factors with socioeconomic position during childhood and during adulthood. British Medical Journal, **313**(7070):1434-1438.

Blankson, J.M., Larbi, E.B. and Pobee, J.O.M. (1977). Blood Pressure levels of African children. Journal of Chronic Diseases, **30**:735-743.

Bollen, K.A., Glanville, J.L. and Stecklov, G. (2001). Socioeconomic Status and Class in Studies of Fertility and Health in Developing Countries. Annual Review of Sociology, **27**:153-185.

Booysen, F.R. (2002). Using demographic and health surveys to measure poverty: An application to South Africa. Journal for Studies in Economics and Econometrics, **26**(3):53-70.

Booysen, F., van der Berg, S., Berger, R., von Maltitz, M. and du Rand, G. (2005). Using Asset Index to Assess Trends in Poverty in Seven Sub-Saharan African Countries. Conference paper at the International Conference on the Many Dimensions of Poverty, Brasilia, Brazil 29-31 August 2005. http://www.ipc-undp.org/md-poverty/papers/frikkie.pdf. Accessed 5th May 2011.

Borus, M.E. and Nestel, G. (1973). Response Bias in Reports of Father's Education and Socio-economic Status. American Statistical Association Journal, **68**(344):816-820.

Braveman, P.A., Cubbin, C., Egerter, S., Chideya, S., Marchi, K.S., Metzler, M. and Posner, S. (2005). Socio-economic Status in Health Research: One Size Does Not Fit All. Journal of the American Medical Association, **294**(22):2879-2888.

Brooks-Gunn, J., Warren, M.P., Rowo, J. and Gargiulo. J. (1987). Validity of Self-Report Measures of Girls' Pubertal Status. Child Development, **58**:829-841.

Bunker, C.H., Ukoli, F.A., Nwankwo, M.U., Omene, J.A., Currier, G.W., Holifield-Kennedy, L., Freeman, D.T., Vergis, E.N., Yeh, L.L. and Kuller, L.H. (1992). Factors associated with hypertension in Nigerian civil servants. Preventive Medicine, **21**(6):710-722.

Caggiula, A.W., Wing, R.R., Nowalk, M.P., Milas, N.C., Lee, S. and Langford, H. (1985). The measurement of sodium and potassium intake. American Journal of Clinical Nutrition, **42**:391-398.

Cândido, A.P.C., Benedetto, R., Castro, A.P.P., Carmo, J.S., Nicolato, R.L.C., Nascimento-Neto, R.M., Freitas, R.N., Freitas, S.N., Caiaffa, W.T. and Machado-Coelho, G.L.L. (2009). Cardiovascular risk factors in children and adolescents living in an urban area of Southeast of Brazil: Ouro Preto Study. European Journal of Pediatrics, **168**:1373-1382.

Chan, N., Sung, R.Y., Kong, A.P., Goggins, W.B., So, H.K. and Nelson, A.S. (2008). Reliability of pubertal self-assessment in Hong Kong Chinese children. Journal Pediatrics and Child Health, **44**:353-358.

Charlton, K.E., Steyn, K., Levitt1, N.S., Jonathan, D., Zulu, J.V. and Nel, J.H. (2007). Development and validation of a short questionnaire to assess sodium intake Public Health Nutrition, **11**(1):83-94.

Chen, X. and Wang, Y. (2008). Tracking of Blood Pressure from Childhood to Adulthood: A Systematic Review and Meta–Regression Analysis. Circulation, **117**:3171-3180.

Chen, X. and Wang Y. (2009). The Influence of Sexual Maturation on Blood Pressure and Body Fatness in African-American Adolescent Girls and Boys. American Journal of Human Biology, **21**(1):105-112.

Chiolero, A., Cachat, F., Burnier, M., Paccaud, F. and Bovet, P. (2007a). Prevalence of hypertension in schoolchildren based on repeated measurements and association with overweight. Journal of Hypertension, **25**:2209-2217.

Chiolero, A., Madeleine, C., Gabriel, A., Burnier, M., Paccaud, F. and Bovet, P. (2007b). Prevalence of elevated blood pressure and association with overweight in children of a rapidly developing country. Journal of Human Hypertension, **21**:120-127.

Chiolero, A., Bovet, P., Paradis, G. and Paccaud, F. (2007c). Has Blood Pressure Increased in Children in Response to the Obesity Epidemic? Pediatrics, **119**:544-553.

Cho, S.D., Mueller, W.H., Meininger, J.C., Liehr, P. and Chan, W. (2001). Blood pressure and sexual maturity in adolescents: The Heartfelt Study. American Journal of Human Biology, **13**:227-234.

Chu, N., Wang, D. and Shieh, S. (2001). Obesity, Leptin and Blood Pressure among Children in Taiwan: The Taipei Children's Heart Study. American Journal of Hypertension, **14**(2):135-140.

City Mayor Statistics (2011). The world's fastest growing cities and urban areas from 2006 to 2020. http://www.citymayors.com/statistics/urban_growth1.html. Accessed 5th May 2011.

Clarke, W.R., Woolson, R.F. and Lauer, R.M. (1986). Changes in Ponderosity and Blood Pressure in childhood: The Muscatine Study. American Journal of Epidemiology, **124**(2):195-206.

Cohen, R. S., and Orum, A. M. (1972). Parent-Child Consensus on Socioeconomic Data Obtained from Sample Surveys. Public Opinion Quarterly, **36**(1):95-98.

Cole, T.J., Bellizzi, M.C., Flegal, K.M. and Dietz, W.H. (2000). Establishing a standard definition for child overweight and obesity world-wide: international survey. British Medical Journal, **320**(7244):1240-1243.

Colhoun, H.M., Hemingway, H. and Poulter, N.R. (1998). Socio-economic status and blood pressure: an overview analysis. Journal of Human Hypertension, **12**:91-110.

Cooper, R.S., Rotimi, C.N., Kaufman, J.S., Muna, W.F.T. and Mensah, G.A. (1998). Hypertension treatment and control in Sub-Saharan Africa: the epidemiological basis for policy. British Medical Journal, **316**:614-617.

Cortinovis, I., Vella, V. and Ndiku, J. (1993). Construction of a socio-economic index to facilitate analysis of health data in developing countries. Social Science and Medicine, **36**(8):1087-1097.

Courser, M.W., Shamblen, S.R., Lavrakas, P.J., Collins, D. and Ditterline, P. (2009). The Impact of Active Consent Procedures on Nonresponse and Nonresponse Error in Youth Survey Data: Evidence from a New Experiment. Evaluation Review, **33**(4):370-395.

Curhan, G.C., Chertow, G.M., Willett, W.C., Spiegelman, D., Colditz, G.A., Manson, J.E., Speizer, F.E. and Stampfer, M.J. (1996a). Birth weight and adult hypertension and obesity in women. Circulation, **94**(6):1310-1315.

Curhan, G.C., Willett, W.C., Rimm, E.B., Spiegelman, D., Ascherio, A.L. and Stampfer, M.J. (1996b). Birth weight and adult hypertension, diabetes mellitus, and obesity in US men. Circulation, **94**(12):3246-3250.

Currie, C.E., Elton, R.A., Todd, J. and Platt, S. (1997). Indicators of socioeconomic status for adolescents: the WHO Health Behaviour in School-aged Children Survey. Health Education Research, **12**(3):385-397.

da Silva, M.A.M., Rivera, I.R., de Souza, M.G.B., Carvalho, A.C.C. (2007). Blood Pressure Measurement in Children and Adolescents: Guidelines of High Blood Pressure Recommendations and Current Clinical Practice. Arquivos Brasileiros Cardiologia, **88**(4):434-437.

Dalglish, S. (2009). Statistics out of their element: The link between socio-economic status and health in West Africa. Radical Statistics, **98**:15-24. http://www.radstats.org.uk/no098/Dalglish98.pdf. Accessed 20th March 2011.

Daniels, S.R., McMahon, R.P., Obarzanek, E., Waclawiw, M.A., Similo, S.L., Biro, F.M., Schreiber, G.B., Kimm, S.Y.S., Morrison, J.A. and Barton, B.A. (1998). Longitudinal correlates of change in blood pressure in adolescent girls. Hypertension, **31**:97-103.

Daniels, S.R., Obarzanek, E., Barton, B.A., Kimm, S.Y., Similo, S.L. and Morrison, J.A. (1996). Sexual maturation and racial differences in blood pressure in girls: The National Heart, Lung, and Blood Institute Growth and Health Study. Journal of Pediatrics, **129**:208-213.

Daniels, S.R., Khoury, P.R. and Morrison, J.A. (2000). Utility of Different Measures of Body Fat Distribution in Children and Adolescents. American Journal of Epidemiology, **152**(12):1179-1184.

de Araujo, T.L., Lopes, M.V.O., Moreira, R.P., Cavalcante, T.F., Guedes, N.G. and da Silva, V.M. (2007). Blood pressure of children and teenagers from a public school in Fortaleza.Ceará. Acta Paulista de Enfermagen, **20**(4):476-82.

de Koning, L., Merchant A.T., Pogue, J. and Anand, S.S. (2007). Waist circumference and waist-to-hip ratio as predictors of cardiovascular events: meta-regression analysis of prospective studies. European Heart Journal, **28**:850-856.

de Onis, M., Onyango, A.W., Borghi, E., Siyam, A., Nishida, C. and Siekmann, J. (2007). Development of a WHO growth reference forschool-aged children and adolescents. Bulletin of the World HealthOrganisation, **85**:660-667.

Demographic and Health Survey (2008). Final Report, Nigeria. http://pdf.usaid.gov/pdf_docs/PNADQ923.pdf. Accessed 30th March 2011.

Demographic and Health Survey (DHS): Household Questionnaire (2010). http://www.measuredhs.com/pubs/pub_details.cfm?ID=981&srchTp=type#dfiles. Accessed 6th March 2010.

Demographic and Health Survey (2011) http://www.measuredhs.com/aboutdhs/start.cfm. Accessed 16th January 2011.

Desmangles, J.C., Lappe, J.M., Lipaczewski, G. and Haynatzki, G. (2006). Accuracy of pubertal Tanner staging self-reporting. Journal of Pediatric Endocrinology and Metabolism, **19**:213-221.

Dietz, W.H. and Bellizzi, M.C. (1999). Workshop on childhood obesity: summary of the discussion. American Journal of Clinical Nutriiton, **70**(1):173S-175S.

Dinc, G., Saatli, G., Baydur, H. and Ozcan, C. (2009). Hypertension and overweight among Turkish adolescents in a city in Aegean region of Turkey: a strong relationship in a population with a relatively low prevalence of overweight. Anadolu Kardiyoloji Dergisi, **9**:450-456.

Duke, P.M., Litt, I.F. and Gross, R.T. (1980). Adolescents' Self-Assessment of Sexual Maturation. Pediatrics, **66**:918-920.

Durkin, M.S., Islam, S., Hasan, Z.M. and Zaman, S.S. (1994). Measures of socioeconomic status for child health research: comparative results from Bangladesh and Pakistan. Social Science and Medicine, **38**(9):1289-1297.

Durrani, A.M. and Fatima, W. (2011). Determinants of blood pressure distribution in school children. European Journal of Public Health, 1-4. http://eurpub.oxfordjournals.org/content/early/2011/04/07/eurpub.ckr036.full.pdf+html. Accessed 30th September 2011.

Dwyer, T., Coonan, W., Worsley, A. and Leitch, D. (1980). Sex, social status and ethnic origin in relation to coronary heart disease risk factors in Adelaide schoolchildren. Medical Journal of Australia, **2**(6):331-334.

Eferakeya, A.E. and Ekeocha, O.C. (1982). Arterial blood pressure in children and adolescents. Acta Paediatrica Scandanavica, **66**:439-443.

Einsterz, E.M., Hutchinson, T. and Flegel, K. (1982). Survey of Blood Pressure in Nigerian Children. Tropical Doctor, **12**(Part1):172-175.

Eisenmann, J.C. (2004). Physical activity and cardiovascular disease risk factors in children and adolescents: An overview. The Canadian Journal of Cardiology, **20**(3):295-301.

Ejike, C. and Ugwu, C. (2010). Hyperbolic Relationship Between Blood Pressure And Body Mass Index In A Nigerian Adolescent Population. WebmedCentral Hypertension, **1**(10):WMC00797.

Ejike, C.E.C.C., Ugwu, C.E. and Ezeanyika, L.U.S. (2010). Variations in the prevalence of point (pre) hypertension in a Nigerian school-going adolescent population living in a semi-urban and an urban area. BMC Pediatrics, **10**:13-19.

Ejike, C.E.C.C., Ugwu, C.E., Ezeanyika, L.U.S. and Olayemi, A.T. (2008). Blood pressure patterns in relation to geographic area of residence: a cross-sectional study of adolescents in Kogi state, Nigeria. BMC Public Health, **8**:411-420.

Ekpo, E.B., Udofia, O. and Andy, J.J. (1990). A disappearing urban/rural blood pressure difference in Nigerian children: an evaluation of possible determining factors. Annals of Tropical Paediatrics, **10**(2):211-219.

Ekunwe, E.O. and Odujinrin, O.M.T. (1989). Proteinuria and Blood Pressure Profile of Lagos School Children. Nigerian Journal of Paediatrics, **16**:15-22.

El Assaad, M.A., Topouchian, J.A., Darne, B.M. and Asmar, R.G. (2002). Validation of the Omron HEM-907 device for blood pressure measurement. Blood Pressure Monitoring, **7**:237-241.

Epstein, L., Tamir, A. and Pearlman, S. (1981). Blood Pressure and Hypertension in Israeli High School Students. Journal of Chronic Diseases, **34**:321-329.

Etta, K.M. and Watson, R.S. (1976). Casual Blood Pressures and their possible relation to age, body weight, Quetelet's index, serum cholesterol, percentage of body fat and mid-arm muscle circumference in three groups of Northern Nigerian residents. African Journal of Medicine and Medical Sciences, **5**:255-262.

Fabamwo, A.O. and Okonofua, F.E. (2010). An Assessment of Policies and Programs for Reducing Maternal Mortality in Lagos State, Nigeria. African Journal of Reproductive Health (Special Issue), **14**(3):55-63.

Facchini, F., Fiori, G., Bedogni, G., Galletti, L., Ismagulov, O., Ismagulova, A., Sharmanov, T., Tsoy, I., Belcastro, M.G., Rizzoli, S. and Goldoni, M. (2008). Puberty in modernizing Kazakhstan: a comparison of rural and urban children. Annals of Human Biology, **35**(1):50-64.

Fadare, W. and Oduwaye, L. (2009). Rebranding Lagos through Regeneration. REAL CORP 2009 Proceedings. http://www.corp.at/archive/CORP2009_18.pdf. Accessed 5th April 2011.

Falkingham, J. and Namazie, C. (2002). Measuring health and poverty: a review of approaches to identifying the poor. London: DFID Health Systems Resource Centre.

http://94.126.106.9/r4d/PDF/Outputs/HOppsIssuesPaperFalkingham.pdf. Accessed 30th June 2011.

Falkner, B., Gidding, S.S., Ramirez-Garnica, G., Wiltrout, S.A., West, D. and Rappaport, E.B. (2006). The Relationship of Body Mass Index and Blood Pressure In Primary Care Pediatric Patients. Journal of Pediatrics, **148**:195-200.

Falkner, B. and Sadowski, R.H. (1995). Hypertension in Children and Adolescents. American Journal of Hypertension, **8**(12 Pt2):106s-110s.

Ferguson, B., Tandon, A., Gakidou, E. and Murray, C.J.L. (2002). Estimating permanent income using indicator variables. World Health Organisation, Geneva. http://www.who.int/healthinfo/paper44.pdf. Accessed 25th June 2011.

Fernández, J.R., Redden, D.T., Pietrobelli, A. and Allison DB. (2004). Waist circumference percentiles in nationally representative samples of African-American, European-American, and Mexican-American children and adolescents. Journal of Pediatrics, **145**(4):439-44.

Filmer, D. and Pritchett, L. (1998). Estimating Wealth Effects With-out Expenditure Data-Or Tears: With an Application to Edu-cational Enrollments in States of India. World Bank Policy Re-search Working Paper 1994, Development Economics Research Group, World Bank, Washington, DC. http://websie.eclac.cl/mmp/doc/Filmer%20and%20Pritchett%202001.pdf. Accessed 12th June 2011.

Filmer, D. and Pritchett, L.H. (2001). Estimating wealth effects without expenditure data--or tears: an application to educational enrollments in states of India. Demography, **38**(1):115-132.

Flores-Huerta, S., Klu¨nder-Klu¨nder, M., de la Cruz, L.R. and Santosc, J.I. (2009). Increase in Body Mass Index and Waist Circumference Is Associated with High Blood Pressure in Children and Adolescents in Mexico City. Archives of Medical Research, **40**:208-215.

Frankel, M. (2010). Sampling Theory. In Marsden, P.V. and Wright, J.D. (ed). Handbook of Survey Research. Emerald Group Publishing Limited. Bingley. Second edition. pp 83-138.

Freedman, D., Dietz, W., Srinivasan, S. and Berenson, G. (1999). The relation of overweight to cardiovascular risk factors among students and adolescents: the Bogalusa heart study. Pediatrics, **103**:1175-1182.

Frontini, M.G., Srinivasan, S.R. and Berenson, G.S. (2003). Longitudinal changes in risk variables underlying metabolic Syndrome X from childhood to young adulthood in female subjects with a history of early menarche: The Bogalusa Heart Study. International Journal of Obesity Related Metabolic Disorders, **27**:1398-1404.

Fuiano, N., Luciano, A., Pilotto, L. and Pietrobelli, A. (2006). Overweight and hypertension: longitudinal study in school-aged children. Minerva Pediatrica, **58**(5):451-459.

Fung, W.K., Gu, H., Xiang, L. and Yau, K.K.W. (2007). Assessing local influence in principal component analysis with application to haematology study data. Statistics in Medicine, **26**:2730-2744.

Galobardes, B., Smith, G.D. and Lynch, J.W. (2006). Systematic Review of the Influence of Childhood Socioeconomic Circumstances on Risk for Cardiovascular Disease in Adulthood. Annals of Epidemiology, **16**(2):91-104.

Garcia, F.D., Terra, A.F., Queiroz, A.M., Correia, C.A., Ramos, P.S., Ferreira, Q.T., Rocha, R.L. and Oliveira, E.A. (2004). Evaluation of risk factors associated with increased blood pressure in children. Journal of Pediatrics, **80**(1):29-34.

Gardner, L.S. and Heady, J.A. (1973). Some effects of within-person variability in epidemiological studies. Journal of Chronic Diseases, **26**:781-795.

Gelbrich, G., Blüher, S., Reich, A., Müller, G. and Kiess, W. (2008). Prevalence of Obesity and Elevated Blood Pressure as well as Onset of Puberty in German School Children Attending Different Educational Tracks. Hormone Research, **70**:340-348.

Ghannem, H., Khlifa, K., Harrabi, I., Abdelaziz, A.B. and Gaha, R. (2000). Study of cardiovascular disease risk factors among urban schoolchildren in Sousse, Tunisia. Eastern Mediterranean Health Journal, **6**(5/6):1046-1054.

Ghannem, H., Trabelsi, L., Gaha, R., Harrabi, I. and Essoussi, A.S. (2001). Study of cardiovascular disease risk factors among rural schoolchildren in Sousse, Tunisia. Eastern Mediterranean Health Journal, **7**(4/5):617-624.

Gidding, S.S. (2008). Measuring Children's Blood Pressure Matters. Circulation, **117**:3163-3164.

Gilberts, E.C., Arnold, M.J. and Grobbee, D.E. (1994). Hypertension and determinants of blood pressure with special reference to socioeconomic status in a rural south Indian community. Journal of Epidemiology and Community Health, **48**:258-261.

Gillman, M.W. and Cook, N.R. (1995). Blood Pressure Measurement in Childhood Epidemiological Studies. Circulation, **92**:1049-1057.

Gillum, R.F. (1996). The epidemiology of cardiovascular disease in black Americans. New England Journal of Medicine, **335**(21):1597-1599.

Gillum, R.F., Prineas, R.J., Gomez-Marin, O., Finn, S. and Chang, P. (1985). Personality, Behavior, Family Environment, Family Social Status and Hypertension Risk Factors in Children: The Minneapolis Children's Blood Pressure Study. Journal of Chronic Diseases, **38**(2):187-194.

Gliksman, M.D., Dwyer, T. and Wlodarczyk, J. (1990). Differences in Modifiable Cardiovascular Disease Risk Factors in Australian Schoolchildren: The Results of a Nationwide Survey. Preventive Medicine, **19**(3):291-304.

Goon, D.T., Toriola, A.L. and Shaw, B.S. (2010). Screening for body-weight disorders in Nigerian children using contrasting definitions. Obesity Reviews, **11**, 508-515.

Gopinath, B., Baur, L.A., Garnett, S., Pfund, N., Burlutsky, G., and Mitchell, P. (2011). Body Mass Index and Waist Circumference Are Associated With Blood Pressure in Preschool-Aged Children. Annals of Epidemiology, **21**:351-357.

Grant, R.W. and Sugarma, J. (2004). Ethics in Human Subjects Research: Do Incentives Matter? Journal of Medicine and Philosophy, **29**(6):717-738.

Greil, H. and Kahl, H. (2005). Assessment of developmental age: cross-sectional analysis of secondary sexual characteristics. Anthropologischer Anzeiger, **63**:63-75.

Gulati, S. (2006). Childhood Hypertension. Journal of Indian Pediatrics, **43**:326-333.

Gundogdu, Z. (2008). Relationship between BMI and blood pressure in girls and boys. Public Health Nutrition, **11**(10):1085-1088.

Gwatkin, D.R., Rutstein, S., Johnson, K., Suliman, E., Wagstaff, A. and Amouzou, A. (2007). Socio-economic differences in health, nutrition, and population within developing countries: An overview. World Bank. http://siteresources.worldbank.org/INTPAH/Resources/IndicatorsOverview.pdf. Accessed 18th March 2011.

Halfon, S.T., Tamir, D. and Bronner, S. (1987). Determinants of blood pressure in 7th grade Jerusalem school children. European Journal of Epidemiology, **3**:39-45.

Hamidu, L.J., Okoro, E.O. and Ali, M.A. (2000). Blood Pressure profile in Nigerian children. East African Medical Journal, **77**(4):180-184.

Hansen, H.S., Hyldebrandt, N., Nielsen, J.R. and Froberg, K. (1990). Blood pressure distribution in a school-age population aged 8–10 years: The Odense Schoolchild Study. Journal of Hypertension, **8**:641-646.

Harding, S., Maynard, M.J., Cruickshank, K. and Teyhan, A. (2008). Overweight, obesity and high blood pressure in an ethnically diverse sample of adolescents in Britain: the Medical Research Council DASH study. International Journal of Obesity, **32**:82-90.

Harding, S., Whitrow, M., Lenguerrand, E., Maynard, M., Teyhan, M., Cruickshank, J.K. and Der, G. (2010). Emergence of Ethnic Differences in Blood Pressure in Adolescence: The Determinants of Adolescent Social Well-Being and Health Study. Hypertension, **55**:1063-1069.

Hardy, R., Kuh, D., Langenberg, C. and Wadsworth, M.E.J. (2003). Birthweight, childhood social class, and change in adult blood pressure in the 1946 British birth cohort. The Lancet, **362**(9391):1178-1183.

Hargreaves, J.R., Morison, L.A., Gear, J.S.S., Kim, J.C., Makhubele, M.B., Porter, J.D.H., Watts, C. and Pronyk, P.M. (2007). Assessing household wealth in health studies in developing countries: a comparison of participatory wealth ranking and survey techniques form rural South Africa. Emerging Themes in Epidemiology, **4**:4.

Harrabi, I., Belarbia, A., Gaha, R., Essoussi, A.S. and Ghannem, H. (2006). Epidemiology of hypertension among a population of school children in Sousse, Tunisia. Canadian Journal of Cardiology, **22**(3):212-216.

Hashimoto, T., Yagami, F., Owada, M., Sugawara, T. and Kawamura, M. (2008). Salt Preference According to a Questionnaire vs. Dietary Salt Intake Estimated by a Spot Urine Method in Participants at a Health Check-up Center. Internal Medicine, **47**:399-403.

Hauser, R.M. (1994). Measuring Socioeconomic Status in Studies of Child Development. Child Development, **65**(6):1541-1545

He, Q., Horlick, M., Fedun, B., Wang, J., Pierson, R.N., Heshka, S. and Gallagher, D. (2002). Trunk fat and blood pressure in children through puberty. Circulation, **105**:1093-1098.

He, F.J. and MacGregor, G.A. (2006). Importance of Salt in Determining Blood Pressure in Children: Meta-Analysis of Controlled Trials. Hypertension, **48**:861-869.

Health Survey for England (2008). Physical Activity and Fitness. Volume 2: Methods and Documentation, pp 177-181. http://www.ic.nhs.uk/webfiles/publications/HSE/HSE08/Volume_2_Methods_and_Documentation.pdf. Accessed 1st April 2010.

Hegazy, A.M. and Kader, B.A.A. (2003). Clinic Blood Pressure Measurements Versus Ambulatory Blood Pressure Monitoring. Kuwait Medical Journal, **35**(2):111-117.

Hergenroeder, A.C., Hill, R.B., Wong, W.W., Sangi-Haghpeykar, H. and Taylor, W. (1999). Validity of self-assessment of pubertal maturation in African American and European American adolescents. Journal of Adolescent Health, **24**:201-205.

Hewison, J., and Haines, A. (2006). Overcoming barriers to recruitment in health research. British Medical Journal, **333**:300-302.

Hill, K., Vapattanawong, P., Prasartkul, P., Porapakkham, Y., Lim, S.S. and Lopez, A.D. (2007). Epidemiologic transition interrupted: a reassessment of mortality trends in Thailand, 1980–2000. International Journal of Epidemiology, **36**(2):374-384.

Hoffman, W.H., Barbeau, P., Litaker, M.S., Johnson, M.H., Howe, C.A. and Gutin, B. (2005). Tanner Staging of Secondary Sexual Characteristics and Body Composition, Blood Pressure, and Insulin in Black Girls. Obesity Research, **13**(12):2195-2201.

Houweling, T.A., Kunst, A.E. and Mackenbach, J.P. (2003). Measuring health inequality among children in developing countries: does the choice of the indicator of economic status matter? International Journal of Equity Health, **2**(1):8.

Howe, L.D., Hargreaves, J.R. and Huttly, S.R.A. (2008). Issues in the construction of wealth indices for the measurement of socio-economic position in low-income countries. Emerging Themes in Epidemiology, **5**:3-16.

Huang, Y. and Morisk, D.E. (1999). Stability of blood pressure: is a sequential blood pressure reading protocol efficient for a large-scale community screening programme. Journal of Human Hypertension, **13**(9):637-642.

Hulanicka, B., Lipowicz, A., Kozieł, S. and Kowalisko, A. (2007). Relationship between early puberty and the risk of hypertension/overweight at age 50: Evidence for a modified Barker hypothesis among Polish youth. Economics and Human Biology, **5**:48-60.

Hunter, S.M., Frerichs, R.R., Webber, L.S. and Berenson, G.S. (1979). Social Status and Cardiovascular Disease Risk Factor Variables In Children: The Bogalusa Heart Study. Journal Chronic Diseases, **32**:441-449.

Iltis, A.S. (2009). Payments to Normal Healthy Volunteers in Phase 1 Trials: Avoiding Undue Influence While Distributing Fairly the Burdens of Research Participation. Journal of Medicine and Philosophy, **33**:1-23.

Ippisch, H.M. and Daniels, S.R. (2008). Hypertension in overweight and obese children. Progress in Pediatric Cardiology, **25**:177-182.

Irgil, E., Erkenci, Y., Aytek, N. and Aytekin, H. (1998). Prevalence of hypertension among schoolchildren aged 13-18 years in Gemlik, Turkey. European Journal of Public Health, **8**(2):176-178.

Jago, R., Harrell, J.S., McMurray, R.G., Edelstein, S., El Ghormli, L. and Bassin, S. (2006). Prevalence of abnormal lipid and blood pressure values among an ethnically diverse population of eighth-grade adolescents and screening implications. Pediatrics, **117**(6):2065-2073.

Janssen, I., Katzmarzyk, P.T. and Ros, R. (2004). Waist circumference and not body mass index explains obesity-related health risk. American Journal of Clinical Nutrition, **79**:379-384.

Janssen, I., Katzmarzyk, P.T., Srinivasan, S.R., Chen, W., Malina, R.M., Bouchard, C. and Berenson, G.S. (2005). Combined Influence of Body Mass Index and Waist Circumference on Coronary Artery Disease Risk Factors Among Children and Adolescents. Pediatrics, **115**:1623-1630.

Janz, K.F., Lutuchy, E.M., Wenthe, P. and Levy, S.M. (2008). Measuring activity in children and adolescents using self-report: PAQ-C and PAQ-A. Medicine and Science in Sports and Exercise, **40**(4):767-772.

Johnson, T.O. (1971). Arterial Blood Pressures and Hypertension in an urban African population sample. British Journal of Preventive and Social Medicine, **25**:26-33.

Julia, M., van Weissenbruch, M.M., Delemarre-van de Waal, H.A. and Surjono, A. (2006). The influence of socioeconomic status on blood pressure of Indonesian prepubertal children. Journal of Human Hypertension, **20**:546-548.

Junghans, C., Feder, G., Hemingway, H., Timmis, A. and Jones, M. (2005). Recruiting patients to medical research: double blind randomised trial of opt-in versus opt-out strategies. British Medical Journal, **331**:940-943.

Kadiri, S. (2005). Tackling cardiovascular disease in Africa. British Medical Journal, **331**:711-712.

Kaplan, G.A. and Keil, J.E. (1993). Socioeconomic factors and cardiovascular disease: a review of the literature. Circulation, **88**:1973-1998.

Karatzi, K., Protogerou, A. and Stergiou, G.S. (2009). Home and office blood pressure in children and adolescents: the role of obesity. The Arsakeion School Study. Journal of Human Hypertension, **23**(8):512-520.

Karaye, K.M., Okeahialam, B.N. and Wali, S.S. (2009). Impact of income on the profile of cardiovascular risk factors among hypertensives in a Nigerian tertiary health centre: a cross-sectional study. Cardiovascular Journal of Africa, **20**:251-255.

Kayser, B.D. and Summers, G.F. (1973). The Adequacy of Student Reports of Parental SES Characteristics. Sociological Methods and Research, **1**(3):303-315.

Kazeem, A., Jensen, L. and Stokes, S.C. (2010). School Attendance in Nigeria: Understanding the Impact and Intersection of Gender, Urban-Rural Residence, and Socioeconomic Status. Comparative Education Review, **54**(2):295-319.

Kearney, P.M., Whelton, M., Reynolds, K., Muntner, P., Whelton, P.K. and He, J. (2005). Global burden of hypertension: analysis of worldwide data. The Lancet, **365**(9455):217-223.

Kelishadi, R., Ardalan, G., Gheiratmand, R., Majdzadeh, R., Delavari, A., Heshmat, R., Gouya, M.M., Razaghi, E.M., Motaghian, M., Mokhtari, M.R., Barekati, H. and Arabi, M.S. (2006). Blood pressure and its influencing factors in a national representative sample of Iranian children and adolescents: the CASPIAN Study. European Journal of Cardiovascular Prevention Rehabilitation, **13**(6):956-63.

Kerckhoff, A. C., Mason, W. M., and Poss, S. S. (1973). On The Accuracy of Children's Reports of Family Social Status. Sociology of Education, **46**(2):219-247

Khoury, P.R., Morrison, J.A., Laskarzewski, P., Kelly, K., Mellies, M.J., King, P., Larsen, R. and Glueck, C.J. (1981). Relationships of Education And Occupation To Coronary Heart Disease Risk Factors In Schoolchildren And Adults: The Princeton School District Study. American Journal of Epidemiology, **113**:378-95.

Kim, H.J., Paik, H.Y., Lee, S.Y., Shim, J.E. and Kim, Y.S. (2007). Salt usage behaviors are related to urinary sodium excretion in normotensive Korean adults. Asia Pacific Journal of Clinical Nutrition, **16**(1):122-128.

Kimani-Murage, E.W., Kahn, K., Pettifor, J.M., Tollman, S.M., Dunger, D.B., Gomez-Olive, F.X. and Norris, S.A. (2010). The prevalence of stunting, obesity, and metabolic disease risk in contemporary rural South African children. BMC Public Health, **10**:158-170.

King, C.A., Meadows, B.B., Engelke, M.K. and Swanson, M. (2006). Prevalence of Elevated Body Mass Index and Blood Pressure in a Rural School-Aged Population: Implications for School Nurses. Journal of School Health, **76**(4):145-149.

Kivimaki, M., Smith, G.D., Juonala, M., Ferrie, J.E., Keltikangas-Ja¨rvinen, L., Elovainio, M., Pulkki-Ra°back, L., Vahtera, J., Leino, M., Viikari, J.S.A. and Raitakari, O.T. (2006). Socioeconomic position in childhood and adult cardiovascular risk factors, vascular structure, and function: cardiovascular risk in young Finns study. Heart, **92**:474-480.

Kohl, H.W., Fulton, J.E. and Casperson, C.J. (2000). Assessment of physical activity among children and adolescents: a review and synthesis. Preventive Medicine, **31**:S54-S76.

Kolenikov, S. and Angeles, G. (2008). Socio-economic status measurement with discrete proxy variables: Is principal component analysis a reliable answer? University of North Carolina. http://web.missouri.edu/~kolenikovs/papers/polychoric-technical-4.pdf. Accessed 30th April 2011.

Kollias, A., Antonodimitrakis, P., Grammatikos, E., Chatziantonakis, N., Grammatikos, E.E. and Stergiou, G.S. (2009). Trends in high blood pressure prevalence in Greek adolescents. Journal of Human Hypertension, **23**:385-390.

Koo, M.M. and Rohan, T.E. (1997). Accuracy of short-term recall of age at menarche. Annals of Human Biology, **24**(1):61-64.

Kotchen, J. M., Kotchen, T.A., Schwertman, N.C. and Kuller, L.H. (1974). Blood pressure distributions of urban adolescents. American Journal of Epidemiology, **99**:315-324.

Kotchen, J.M., McKean, H.E., Neill, M. and Kotchen, T.A. (1989). Blood pressure trends associated with changes in height and weight from early adolescence to young adulthood. Journal of Clinical Epidemiology, **42**:735-741.

Koziel, S., Kolodziej, H. and Ulijaszek, S. (2001). Body size, fat distribution, menarcheal age and blood pressure in 14-year-old girls. European Journal of Epidemiology, **17**:1111-1115.

Kozinetz, C.A. (1988). Blood pressure and self-assessment of female sexual maturation. Journal of Adolescent Health Care, **9**:457-464.

Kozinetz, C.A. (1991). Sexual maturation and blood pressure levels of a biracial sample of girls. American Journal of Diseases in Childhood, **145**:142-146.

Krieger, N., Williams, D.R. and Moss, N.E. (1997). Measuring Social Class In Us Public Health Research: Concepts, Methodologies, and Guidelines. Annual Reviews in Public Health, **18**:341-378.

Kuczmarski, R.J., Ogden, C.L. and Guo, S.S. (2002). 2000 CDC growth charts for the United States: Methods and development. National Center for Health Statistics. Vital and Health Statistics, **11**(246). http://www.cdc.gov/growthcharts/2000growthchart-us.pdf. Accessed 30th November 2011.

Kulaga, Z., Litwin, M., Pan, H., Feber, J., Wojcik, P., Grajda, A., Gurzkowska, B. and Napieralska, E. (2010). Lifestyle and Socioeconomic Determinants of Blood Pressure in School-Aged Children and Adolescents. Journal of Hypertension, **28**:e399.

Kuschnir, M.C.C. and Mendonça, G.A.S. (2007). Risk factors associated with arterial hypertension in adolescents. Jornal de Pediatria, **83**(4):335-342.

Lachat, C.K., Verstraeten, R., Khanh, L.N.B., Hagströmer, M., Khan, N.C., Van, N.D.A., Dung, N.Q. and Kolsteren, P.W. (2008). Validity of two physical activity questionnaires (IPAQ and PAQA) for Vietnamese adolescents in rural and urban areas. International Journal of Behavioral Nutrition and Physical Activity, **5**:37-45.

Lagos State Government (2011). http://www.lagosstate.gov.ng/index.php?page=subpage&spid=12&mnu=null. Accessed 5th April 2011.

Lattuada, S., Rindi, M., Antivalle, M., Salvaggio, A., Grillo, A. and Libretti, A. (1986). Blood Pressure Levels in Adolescents: The Milan Study. Journal of Cardiovascular Pharmacology, **8**(Suppl 5):S113-115.

Lauer, R.M., Anderson, A.R., Beaglehole, R. and Burns, T.L. (1984). Factors Related to Tracking of Blood Pressure in Children U.S. National Center for Health Statistics Health Examination Surveys Cycles II and III. Hypertension, **6**:307-314.

Laurie, H. and Lynn, P. (2009). The Use of Respondent Incentives on Longitudinal Surveys, in Methodology of Longitudinal Surveys (Lynn, P. ed), John Wiley and Sons, Limited, Chichester, United Kingdom.

Leary, S.D., Ness, A.R., Smith, G.D., Mattocks, C., Deere, K., Blair, S.N., Riddoch, C. (2008). Physical Activity and Blood Pressure in Childhood: Findings from a Population-Based Study. Hypertension, **51**:92-98.

Leccia, G., Marotta, T., Masella, M.R., Mottola, G., Mitrano, G., Golia, F., Capitanata, P., Guida, L., Contaldo, F. and Ferrara, L.A. (1999). Sex-related influence of body size and sexual maturation on blood pressure in adolescents. European Journal of Clinical Nutrition, **53**:333-337.

Lee, R. (2003). The demographic transition: three centuries of fundamental change. Journal of Economic Perspectives, **17**:167-190.

Lee, H.P., Ong, C.N. and Chia, C.B. (1983). An estimation of sodium chloride intake by adults in Singapore. Singapore Medical Journal, **24**(6):346-349.

Leino, M., Porkka, K.V.K., Raitakari, O.T., Laitinen, S., Taimela, S. and Viikarl, J.S.A. (1996). Influenceof Parental Occupation on Coronary Heart Disease Risk Factors in

Children. The Cardiovascular Risk in Young Finns Study. International Journal of Epidemiology, **25**(6):1189-1195.

Lenfant, C. (2008). Low birth weight and blood pressure. Metabolism, **57**(Suppl 2):S32-S35.

Leone, M. and Comtois, A.S. (2007). Validity and reliability of self-assessment of sexual maturity in elite adolescent athletes. Journal of Sports Medicine and Physical Fitness, **47**(3):361-365.

Li, C., Huang, T.K., Cruz, M.L. and Goran, M.I. (2006). Birth weight, puberty, and systolic blood pressure in children and adolescents: a longitudinal analysis. Journal of Human Hypertension, **29**(6):444-450.

Liang, Y. and Mi, J. (2011). Pubertal Hypertension is a Strong Predictor for the Risk of Adult Hypertension. Biomedical and Environmental Sciences, **24**(5):459-466.

Liebman, L.F., Chopin, E., Carter, A.J., Clark, G.W., Disney, M., Hegsted, M.A., Kenney, Z.A., Kirmani, K.L. Koonce, M.K. and Korslund, M. (1986). Factors related to blood pressure in a biracial adolescent female population. Hypertension, **8**:843-850.

Lien, N., Friestad, C. and Klepp, K. (2001). Adolescents' proxy reports of parents' socioeconomic status: How valid are they? Journal of Epidemiology and Community Health, **55**:731-737.

Lindelow, M. (2006). Sometimes more equal than others: how health inequalities depend on the choice of welfare indicator. Health Economic, **15**(3):263-279.

Liu, K., Cooper, R., Soltero, I. and Stamler, J. (1979a). Variability in 24-Hour Urine Sodium Excretion in Children. Hypertension, **1**(6):631-636.

Liu, K., Dyer, A.R., Cooper, R.S., Stamler, R. and Stamler, J. (1979b). Can overnight urine replace 24-hour urine collection to assess salt intake? Hypertension, **1**:529-536.

Lobstein, T., Baur, L. and Uauy, R. (2004). Obesity in children and young people: a crisis in public health. Obesity reviews, **5** (Suppl. 1):4-85.

Londe, S., Johanson, A., Kronemer, N.S. and Goldring, D. (1975). Blood pressure and puberty. Journal of Pediatrics, **87**(6 Part 1):896-900.

Longo-Mbenza, B., Lukoki L.E. and M'Buyamba-Kabangu, J.R. (2007). Nutritional status, socio-economic status, heart rate, and blood pressure in African school children and adolescents. International Journal of Cardiology, **121**:171-177.

Looker, E.D. (1989). Accuracy of Proxy Reports of Parental Status Characteristics. Sociology of Education, **62**(4):257-276.

Lopez, A.D., Mathers, C.D., Ezzati, M., Jamison, D.T. and Murray, C.J. (2006). Global and regional burden of disease and risk factors, 2001: systematic analysis of population health data. Lancet, **367**:1747-1757.

Luepker, R., Jacobs, D., Prineas, R. and Sinaiko, A. (1999). Secular trends of blood pressure and body size in a multi-ethnic adolescent population: 1986 to 1996. Journal of Pediatrics, **134**:668-674.

Luma, G.B. and Spiotta, R.T. (2006). Hypertension in Children and Adolescents. American Family Physician, **73**(9):1558-1566.

M'buyamba-Kabangu, J.R., Fagard, R., Lijnen, P., Mbuy Wa Mbuy, R., Staessen, J. and Amery, A. (1986). Blood Pressure and urinary cations in urban Bantu of Zaire. American Journal of Epdemiology, **124**(6):957-968.

Macintyre, S., Watt, G., West, P. and Ecob, R. (1991). Correlates of blood pressure in 15 year olds in the West of Scotland. Journal of Epidemiology and Community Health, **45**:143-147.

Macnee, C.L. and McCabe, S. (2008). Understanding nursing research: using research in evidence-based practice. Lippincott Williams and Wilkinson. Philadelphia. Second edition.

Maffeis, C., Corciulo, N., Livieri, C., Rabbone, I., Trifiro, G., Falorni, A., Guerraggio, L., Peverelli, P., Cuccarolo, G., Bergamaschi, G., Di Pietro, M. and Grezzani, A. (2003). Waist circumference as a predictor of cardiovascular and metabolic risk factors in obese girls. European Journal of Clinical Nutrition, **57**:566-572.

Maffeis, C., Pietrobelli, A., Grezzani, A., Provera, S. and Tato, L. (2001). Waist Circumference and Cardiovascular Risk Factors in Prepubertal Children. Obesity Research, **9**(3):179-187.

Marshall, W.A. and Tanner, J.M. (1969). Variations in pattern of pubertal changes in girls. Archives of Disease in Childhood, **44**:291-303.

Marshall, W.A. and Tanner, J.M. (1970). Variations in the pattern of pubertal changes in boys. Archives of Disease in Childhood, **45**:13-23.

Mathers, C.D. and Loncar, D. (2006). Projections of Global Mortality and Burden of Disease from 2002 to 2030. PLoS Medicine, **3**(11):2011-2029.

Matsudo, S.M.M. and Matsudo, V.K.R. (1994). Self-assessment and physician assessment of sexual maturation in Brazilian boys and girls: Concordance and reproducibility. American Journal Human Biology, **6**:451-455.

Matsuzuki, H., Muto, T. and Haruyama, Y. (2008). School children's salt intake is correlated with salty taste preference assessed by their mothers. The Tohoku Journal of Experimental Medicine, **21**(5):71-77.

Mazicioglu, M.M., Yalcin, B.M., Ozturk, A., Ustunbas, H.B. and Kurtoglu, S. (2010). Anthropometric risk factors for elevated blood pressure in adolescents in Turkey aged 11–17. Pediatric Nephrology, **25**:2327-2334.

McKenzie, D.J. (2004). Measuring inequality with asset indicators. Journal of Population Economics, **18**(2):229-60.

McNiece, K.L., Poffenbarger, T.S., Turner, J.L., Franco, K.D., Sorof, J.M. and Portman, R.J. (2007). Prevalence of Hypertension and Pre-Hypertension among Adolescents. Journal of Pediatrics, **150**:640-644.

Mei, Z., Grummer-Strawn, L.M., Pietrobelli, A., Goulding, A., Goran, M.I. and Dietz, W.H. (2002).Validity of body mass index compared with other body-composition screening indexes for the assessment of body fatness in children and adolescents. American Journal of Clinical Nutrition, **75**(6):978-985.

Meininger, J.C., Liehr, P., Chan, W., Smith, P. and Mueller, W.H. (2004). Developmental, Gender, and Ethnic Group Differences in Moods and Ambulatory Blood Pressure in Adolescents. Annals of Behavioural Medicine, **28**(1):10-19.

Mendez, M.A., Cooper, R., Wilks, R., Luke, A. and Forrester, T. (2003). Income, education, and blood pressure in adults in Jamaica, a middle-income developing country. International Journal of Epidemiology, **32**:400-408.

Mensah, G.A. (2008). Epidemiology of stroke and high blood pressure in Africa. Heart, **94**:697-705.

Merhi, B.A., Al-Hajj, F., Al-Tannir, M., Ziade, F. and El-Rajab, M. (2011). A survey of blood pressure in Lebanese children and adolescence. North American Journal of Medical Sciences, **3**(1):24-29.

Micheli, E. and Rosa, A.A. (2003). Estimation of sodium intake by urinary excretion and dietary records in children and adolescents from Porto Alegre, Brazil: a comparison of two methods. Nutrition Research, **23**:1477-1487.

Miech, R.A. and Hauser, R.M. (2000). Socio-economic Status (SES) and Health at Midlife; A Comparison of Educational Attainment with Occupation-Based Indicators. http://www.ssc.wisc.edu/~hauser/miech-hauser.pdf. Accessed 30th June 2011.

Mijinyawa, M.S., Iliyasu, Z. and Borodo, M.M. (2008). Prevalence of hypertension among teenage students in Kano, Nigeria. Nigerian Journal of Medicine: Journal of the National Association of Resident Doctors of Nigeria, **17**(2):173-178.

Miller, R.A. and Shekelle, R.B. (1976). Blood Pressure in Tenth-grade Students: Results from the Chicago Heart Association Pediatric Heart Screening Project. Circulation, **54**(6):993-1000.

Miranda, J. J., Kinra, S. J., Casas, P., Davey Smith, G. and Ebrahim, S. (2008). Non-communicable diseases in low- and middle-income countries: context, determinants and health policy. Tropical Medicine and International Health, **13**(10):1225-1234.

Mittelmark, M.B. and Sternberg, B. (1985). Assessment of salt use at the table: comparison of observed and reported behaviour. American Journal of Public Health, **75**:215-1216.

Mohan, B., Kumar, N., Aslam, N., Rangbulla, A., Kumbkarni, S., Sood, N.K. and Wander, G.S. (2004). Prevalence of Sustained Hypertension and Obesity in Urban and Ruarl School Going Children in Ludhiana. Indian Heart Journal, **56**:310-314.

Montgomery, M.R., Gragnaloti, M., Burke, K. and Paredes, E. (2000). Measuring living standards with proxy variables. Demography, **37**(2):155-174.

Monyeki, K.D. and Kemper, H.C.G. (2008). The risk factors for elevated blood pressure and how to address cardiovascular risk factors: a review in paediatric populations. Journal of Human Hypertension, **22**:450-459.

Monyeki, K.D., Kemper, H.C.G. and Makgae, P.J. (2008). Relationship between fat patterns, physical fitness and blood pressure of rural South African Children: Ellisras Longitudinal Growth Study. Journal of Human Hypertension, **22**:311-319.

Monyeki, K.D., Kemper, H.C.G. and Makgae, P.J. (2006). The association of fat patterning with blood pressure in rural South African Children: Ellisras Longitudinal Growth Study. International Journal of Epidemiology, **35**:114-120.

Morris, S.S., Carletto, C., Hoddinott, J. and Christiaensen, L.J.M. (2000). Validity of rapid estimates of household wealth and income for health serveys in rural Africa. Journal of Epidemiology and Community Health, **54**: 381-387.

Morris, N.M. and Udry, J.R. (1980). Validation of self-administered instrument to assess stage of adolescent development. Journal of Youth and Adolescence, **9**:271-280.

Morrow, V. (2009). The Ethics of Social Research with Children and Families in Young Lives: Practical Experiences Young Lives, Working Paper No. 53, Department of International Development, University of Oxford, Oxford. http://www.younglives.org.uk/files/working-papers/wp53-the-ethics-of-social-research-with-children-and-families-in-young-lives-practical-experiences. Accessed 20th March 2011.

Moser, C. and Felton, A. (2007). The construction of an asset index measuring asset accumulation in Ecuador. Working Paper 87 Chronic Poverty Research Center. http://cprc.abrc.co.uk/pdfs/87Moser_Felton.pdf. Accessed 10th April 2011.

Moura, A.A., Silva, M.A.M, Ferraz, M.R.M.T. and Rivera, I.R. (2004). Prevalence of high blood pressure in children and adolescents from the city of Maceió, Brazil. Journal de Pediatria, **80**(1):35-40.

Mueller, W.H., Cho, S.D., Meininger, P.L. and Chan, W. (2001). Strategies for combining and scaling sexual maturity indicators: the Heartfelt Study. Annals of Human Biology, **28**(4):422-430.

Muñoz, S., Muñoz, H. and Zambrano, F. (1980). Blood pressure in a school-age population. Distribution, correlations, and prevalence of elevated values. Mayo Clinic Proceedings, **55**(10):623-632.

Muntner, P., He, J., Cutler, J.A., Wildman, R.P. and Whelton, P.K.. (2004). Trends in blood pressure among children and adolescents. Journal of the American Medical Association, **291**(17):2107-2113.

Muraguri, P.W., McLigeyo, S.O. and Kayima, J.K. (1997). Proteinuria, other elected urinary abnormalities and hypertension among teenage secondary school students in Nairobi Kenya. East Africa Medical Journal, **74**(8):467-473.

Must, A. and Anderson, S.E. (2006). Body mass index in children and adolescents: considerations for population-based applications. International Journal of Obesity, **30**:590-594.

Must, A., Jacques, P.F., Dallal, G.E., Bajema, C.J. and Dietz, W.H. (1992). Long-term morbidity and mortality of overweight adolescents. A follow-up of the Harvard Growth Study of 1922 to 1935. New England Journal of Medicine, **327**(19):1350-1355.

National Child Measurement Programme (NCMP) (2012). http://www.ic.nhs.uk/ncmp. Accessed 20th June 2012.

National Heart, Lung, and Blood Institute. Report of the Task Force on Blood Pressure Control in Children (1977). Pediatrics, **59**:797-820.

National Heart, Lung, and Blood Institute. Report of the Second Task Force on Blood Pressure Control in Children-1987 (1987). Pediatrics, **79**:1-25.

National High Blood Pressure Education Program (NHBPEP) Working Group on High Blood Pressure in Children and Adolescents (1996). Update on the 1987 Task Force Report on High Blood Pressure in Children and Adolescents: a working group report from the National High Blood Pressure Education Program. Pediatrics, **98**(4):649-658.

National High Blood Pressure Education Program (NHBPEP) Working Group on High Blood Pressure in Children and Adolescents (2004). The Fourth Report on the Diagnosis, Evaluation, and Treatment of High Blood Pressure in Children and Adolescents. Pediatrics, **114**(2):555-576.

Neinstein, L.S. (1982). Adolescent self-assessment of sexual maturation: reassessment and evaluation in a mixed ethnic urban population. Clinical Pediatrics, **21**:482-484.

Neovius, M., Linné, Y. and Rossner, S. (2005). BMI, waist-circumference and waist-hip-ratio as diagnostic tests for fatness in adolescents. International Journal of Obesity, **29**(2):163-169.

Ng'amdu, N.H. (1992). Blood Pressure Levels of Zambian Rural Adolescents and their Relationship to Age, Sex, Weight, Height and Three Weight-For-Height Indices. International Journal of Epidemiology, **21**(2):246-252.

Nichols, S. and Cadogan, F. (2006). Blood Pressure and its Correlates in Tobagonian Adolescents. West Indian Medical Journal, **55**(5):1-8.

Niemi, R. (1974). How Family Members Perceive Each Other: Political and Social Attitudes in Two Generations. New Haven, CT: Yale University Press.

Nigeria: Country Profile. http://www.who.int/gho/countries/nga.pdf. Accessed 20th March 2012.

Nigeria National Population Commission (2006). Population and Housing Census of the Federal Republic of Nigeria Priority Tables Volume 1. http://www.population.gov.ng/files/Priority%20Tables%20Volume%20I-update_2.pdf. Accessed 30th March 2011.

Norero, C., Vargas, N.A., Mayne, D., Monti, A., Kutz, M. and Saito, R. (1981). Blood Pressure Levels in Urban School-Age Population in Chile. Hypertension, **3**(suppl II):II-238-II-241.

Norris, S.A. and Richter, L.M. (2005). Usefulness and Reliability of Tanner Pubertal Self-Rating to Urban Black Adolescents in South Africa. Journal of Research on Adolescence, **15**(4):609-624.

Norris, S.A. and Richter, L.M. (2008). Are there short cuts to pubertal assessments? Self-reported and assessed group differences in pubertal development in African adolescents. Journal of Adolescent Health, **42**(3):259-265.

Nur, N., Çetinkaya, S., Yilmaz, A., Ayvaz, A., Bulut, M.O. and Sümer, H. (2008). Prevalence of Hypertension among High School Students in a Middle Anatolian Province of Turkey. Journal of Health, Population and Nutrition, **26**(1):88-94.

O'Brien, E., Asmar, R., Beilin, L., Imai, Y., Mallion, J.M., Mancia, G., Mengden, T., Myers, M. Padfield, P., Palatini, P., Parati, G., Pickering, T., Redon, J., Staessen, J., Stergiou, G. and Verdecchia, P. (2003). European Society of Hypertension recommendations for conventional, ambulatory and home blood pressure measurement. Journal of Hypertension, **21**:821-848.

O'Quin, M., Sharma, B.B., Miller, K.A., Tomsovic, JP. (1992). Adolescent blood pressure survey: Tulsa, Oklahoma, 1987 to 1989. Southern Medical Journal, **85**(5):487-90.

Obika, L.F.O., Adedoyin, M.A. and Olowoyeye, J.O. (1995). Pattern of Paediatric Blood Pressure in Rural, Semi-urban and Urban Communities in Ilorin Nigeria. African Journal of Medicine and Medical Sciences, **24**:371-377.

Ogunlesi, T.A., Dedeke, I.O.F. and Kuponiyi, O.T. (2008). Socio-Economic Classification of Children attending Specialist Paediatric Centres in Ogun State, Nigeria. Nigerian Medical Practitioner, **54**(1):21-25.

Ogunlesi, A., Osotimehin, B., Abbiyessuku, F., Kadiri, S., Akinkugbe, O., Liao, Y.L. and Cooper, R. (1991). Blood pressure and educational level among factory workers in Ibadan, Nigeria. Journal of Human Hypertension, **5**(5):375-380.

Oke, O., Victor-Ahuchogu, V., Adetoro, B., Odumosu, O., Nelson-Twakor, N. and Okesola, O. (2000). Family Health International – Lagos State, Nigeria: Report of Rapid Assessment In Selected LGAs. pp 8-9.
http://www.fhi.org/NR/rdonlyres/edamzquh5f6vwhyytihhmkszht3socidgdcvyuqkiawfuainggz6v6x2p6grmk42eb4rn7z4l46aqn/LagosRapidAssessmentNigeria1enhv.pdf.
Accessed 20th February 2011.

Oladipo, F.O. and Adekunle, O.A. (2010). Empirical Determination of Socio-economic Status and its Relationship with Selected Characteristics of Rural Male Farmers in Kwara State, Nigeria. Research Journal of Agriculture and Biological Sciences, **6**(1):64-76.

Olatunde, Y.P. (2010). Socio-Economic Background and Mathematics Achievement of Students in Some Selected Senior Secondary Schools in Southwestern Nigeria. Pakistan Journal of Social Sciences, **7**(1):23-27.

Olubodun, J.O.B., Akingbade, O.A. and Abiola, O.O. (1997). Salt intake and blood pressure in Nigerian hypertensive patients. International Journal of Cardiology, **59**(2):185-188.

Olshansky, S.J. and Ault, B. (1986). The fourth stage of the epidemiologic transition: the age of delayed degenerative diseases. The Milbank Quarterly, **64**(3):355-391.

Omigbodun, O.O., Adediran, K.I., Akinyemi, J.O., Omigbodun, A.O., Adedokun, B.O. and Esan, O. (2010). Gender and rural–urban differences in the nutritional status of in-school adolescents in South-western Nigeria. Journal of Biosocial Science, **42**:653-676.

Omran, A.R. (1971). The epidemiologic transition: a theory of the epidemiology of population change. Milbank Memorial Fund Quarterly, **49**(4):509-538.

Onwujekwe, O., Hanson, K. and Fox-Rushby, J. (2006). Some indicators of socioeconomic status may not be reliable and use of indices with these data could worsen equity. Health Economics, **15**(6):639-644.

Opara, D.C., Ikpeme, E.E. and Ekanem, U.S. (2010). Prevalence of Stunting, Underweight and Obesity in School Aged Children in Uyo, Nigeria. Pakistan Journal of Nutrition, **9**(5):459-466.

Orchard, T.J., Rodgers, M., Hedley, A.J. and Mitchell, J.R. (1980). Changes in blood lipids and blood pressure during adolescence. British Medical Journal, **280**:1563-1567.

Oyewole, O.O. and Oritogun, K.S. (2009). Relationship between Anthropometric Parameters and Blood Pressure in Sagamu Adolescents, Ogun State, South-West Nigeria. International Journal of Biomedical and Health Sciences, **5**(4):191-198.

Paradis, G., Lambert, M., O'Loughlin, J., Lavallée, C., Aubin, J., Delvin, E., Lévy, E. and Hanley, J.A. (2004). Blood Pressure and Adiposity in Children and Adolescents. Circulation, **110**:1832-1838.

Pearson, T.A. (1999). Cardiovascular Disease in Developing Countries: Myths, Realities, and Opportunities. Cardiovascular Drugs and Therapy, **13**:95-104.

Peterson, A., Crockett, L., Richards, M. and Boxer, A. (1988). A self-report measure of pubertal status: reliability, validity, and initial norms. Journal of Youth Adolescence, **17**:117-133.

Phillips, K., Holm, K. and Wu, A.C. (1985). Contemporary table salt practices and blood pressure. American Journal of Public Health, **75**(4):405-406.

Pickering, T.G., Hall, J.E., Appel, L.J., Falkner, B.E., Graves, J., Hill, M.N, Jones, D.W., Kurtz, T., Sheps, S.G. and Roccella, E.J. (2005). Recommendations for Blood Pressure Measurement in Humans and Experimental Animals. Part 1: Blood Pressure Measurement in Humans: A Statement for Professionals From the Subcommittee of Professional and Public Education of the American Heart Association Council on High Blood Pressure Research. Hypertension, **45**:142-157.

Pierin, A.M.G., Ignez, E.C., Filho, W.J., Barbato, A.J.G. and Mion, D. (2008). Blood pressure measurements taken by patients are similar to home and Ambulatory blood pressure measurements. Clinics, **63**(1):43-50.

Pietinen, P., Tanskanen, A. and Tuomilehto, J. (1982). Assessment of sodium intake by a short dietary questionnaire. Scandinavian Journal of Social Medicine, **10**:105-112.

Pileggi, C., Carbone, V., Nobile, C.G.A. and Pavia, M. (2005). Blood pressure and related cardiovascular disease risk factors in 6–18 year-old students in Italy. Journal of Paediatrics and Child Health, **41**:347-352.

Popkin, B.M. and Gordon-Larsen, P. (2004). The nutrition transition: worldwide obesity dynamics and their determinants. International Journal of Obesity, **28**:S2-S9.

Poulton, R., Capsi, A., Milne, B.J., Thomson, W.M., Taylor, A., Sears, M.R. and Moffitt, T.E. (2002). Association between children's experience of socio-economic disadvantage and adult health: a life-course study. Lancet, **360**:1619-1620.

Pu, C., Huang, N. and Chou, Y. (2011). Do agreements between adolescent and parent reports on family socioeconomic status vary with household financial stress? BMC Medical Research Methodology, **11**:50-57.

Pueyo, M.J., Serra-Sutton, V., Alonso, J., Starfield, B. and Rajmil, L. (2007). Self-reported social class in adolescents: validity and relationship with gradients in selfreported health. BMC Health Service Research, **7**:151.

Raj, M. and Kumar, K. (2010). Obesity in children and adolescents. Indian Journal of Medical Research, **132**:598-607.

Ramzan, M., Ali, I. and Khan, A. (2008). Body mass status of school children of Dera Ismail Khan, Pakistan. Journal of Ayub Medical College Abbottabad, **20**(4):119-121.

Rao, S. and Apte, P. (2009). Social class-related gradient in the association of skeletal growth with blood pressure among adolescent boys in India. Public Health Nutrition, **12**(12):2256-2262.

Reinehr, T. and Toschke, A.M. (2009). Onset of Puberty and Cardiovascular Risk Factors in Untreated Obese Children and Adolescents: A 1-Year Follow-up Study. Archives of Pediatrics and Adolescent Medicine, **163**(8):709-715.

Remsberg, K.E., Demerath, E.W., Schubert, C.M., Chumlea, C., Sun, S.S. and Siervogel, R.M. (2005). Early Menarche and the Development of Cardiovascular Disease Risk Factors in Adolescent Girls: The Fels Longitudinal Study. The Journal of Clinical Endocrinology and Metabolism, **90**(5):2718-2724.

Renzaho, A.M.N. (2004). Fat, rich and beautiful: changing socio-cultural paradigms associated with obesity risk, nutritional status and refugee children from sub-Saharan Africa. Health and Place, **10**:105-113.

Ribeiro, J., Guerra, S., Pinto, A., Oliveira, J., Duarte, J. and Mota, J. (2003). Overweight and obesity in students and adolescents: relationship with blood pressure, and physical activity. Annals of Human Biology, **30**:203-213.

Rice, M. and Broome, M.E. (2004). Incentives for Children in Research. Journal of Nursing Scholarship, **36**(2):167-172.

Rona, R.J., Qureshi, S. and Chinn, S. (1996). Factors related to total cholesterol and blood pressure in British 9 year olds. Journal of Epidemiology and Community Health, **50**:512-518.

Rothman, K.J., Greenland, S. and Lash, T.L. (2008). Modern Epidemiology. Lippincott Williams and Wilkinson. Philadelphia. Third edition.

Rose, G. (2008). Rose's strategy of preventive medicine. Commentary by Khaw, K.T. and Marmot, M. Oxford: Oxford University Press.

Rutstein, S.O. and Johnson, K. (2004). DHS Comparative Reports 6: The DHS Wealth Index. ORC Macro MEASURE DHS, Calverton, Maryland, USA. http://www.measuredhs.com/pubs/pdf/cr6/cr6.pdf. Accessed 20th July 2011.

Sahn, D.E. and Stifel, D (2003). Exploring alternative measures of welfare in the absence of expenditure data. Review of Income and Wealth, **49**(4):463-489.

Savva, S.C., Tornaritis, M., Savva, M.E., Kourides, Y., Panagi, A., Silikiotou, N., Georgiou, C. and Kafatos, A. (2000). Waist circumference and waist-to-height ratio are better predictors of cardiovascular disease risk factors in children than body mass index. International Journal of Obesity, **24**:1453-1458.

Schall, J.I., Semeao, E.J., Stallings, V.A. and Zemel, B.S. (2002). Self-assessment of sexual maturity status in children with Crohn's disease. Journal of Pediatrics, **141**:223-229.

Schellenberg, J.A., Victora, C.G., Mushi, A., de Savigny, D., Schellenberg, D., Mshinda, H., Bryce, J. (2003). Inequities among the very poor: health care for children in southern Tanzania. The Lancet, **361**:561-566.

Schlossberger, N.M., Turner, R.A. and Irwin, C.E. (1992). Validity of self-report of pubertal maturation in early adolescents. Journal of Adolescent Health, **13**:109-113.

Schmitz, K.E., Hovell, M.F., Nichols, J.F., Irvin, V.L., Keating, K. and Simon, G.M. (2004). A Validation Study of Early Adolescents' Pubertal Self-Assessments. The Journal of Early Adolescence, **24**:357-383.

Schulze, M.B., Kroke, A., Bergmann, M.M. and Boeing, H. (2000). Differences of blood pressure estimates between consecutive measurements on one occasion: Implications for inter-study comparability of epidemiologic studies. European Journal of Epidemiology, **16**:891-898.

Scott, C. and Amenuvegbe, B. (1990). Effect of recall duration on reporting household expenditures: An experimental study in Ghana, Social Dimensions of Adjustment in Africa Working Paper 6, The World Bank. http://www-wds.worldbank.org/external/default/WDSContentServer/WDSP/IB/2000/01/15/000178830_9810190142324/Rendered/PDF/multi_page.pdf. Accessed 15th July 2011.

Senbanjo, I.O., Njokanma, O.F. and Oshikoya, K.A. (2009). Waist Circumference values of Nigerian Children and Adolescents. Annals of Nutrition and Metabolism, **54**:145-150.

Senbanjo, I.O. and Oshikoya, K.A. (2010). Physical activity and body mass index of school children and adolescents in Abeokuta, Southwest Nigeria. World Journal of Pediatrics, **6**(3):217-222.

Shankar, R.R., Eckert, G.J., Saha, C., Tu, W. and Pratt, J.H. (2005). The Change in Blood Pressure during Pubertal Growth. The Journal of Clinical Endocrinology and Metabolism, **90**(1):163-167.

Sharma, A., Grover, N., Kaushik, S., Bhardwaj, R. and Sankhyan, N. (2010). Prevalence of Hypertension among Schoolchildren in Shimla. Indian Pediatrics, **47**:873-876.

Shavers, V.L. (2007). Measurement of Socioeconomic Status in Health Disparities Research. Journal of the National Medical Association, **99**(9):1013-1023.

Shepherd, R. and Farleigh, C.A. (1987). Salt intake assessment by questionnaire and urinary sodium excretion. Nutrition Research, **7**:557-568.

Shepherd, R., Farleigh, C.A. and Land, D.G. (1985). Estimation of salt intake by questionnaire. Appetite, **6**:219-233.

Sheppard, Z.A., Norris, S.A., Pettifor, J.M., Cameron, N. and Griffiths, P.L. (2009). Approaches for assessing the role of household socioeconomic status on child anthropometric measures in urban South Africa. American Journal of Human Biology, **21**(1):48-54.

Shuler, C.L., Allison, N., Holcomb, S., Harlan, M., McNeill, J., Robinett, G. and Bagby, S.P. (1998). Accuracy of an Automated Blood Pressure Device in Stable Inpatients: Optimum vs Routine Use. Archives of Internal Medicine, **158**:714-721.

Silverberg, D.S., Van Nostrand, C., Juchli, B., Smith, S.O. and Van Dorsser, E. (1975). Screening for hypertension in a high school population. Canadian Medical Association Journal, **113**:103-108.

Sinaiko, A.R., Gomez-Marin, O. and Prineas, R.J. (1989). Prevalence of “significant” hypertension in junior high school-aged children: The Children and Adolescent Blood Pressure Program. Journal of Pediatrics, **114**(4):664-669.

Sinaiko, A.R., Donahue, R.P., Jacobs, D.R. and Prineas, R.J. (1999). Relation of weight and rate of increase in weight during childhood and adolescence to body size, blood pressure, fasting insulin, and lipids in young adults. The Minneapolis Children's Blood Pressure Study. Circulation, **99**(11):1471-1476.

Singer, E. and Couper, M.P. (2008). Do Incentives Exert Undue Influence on Survey Participation? Experimental Evidence. Journal of Empirical Research on Human Research Ethics, **3**(3):49-56.

Sirin, S.R. (2005). Socio-economic Status and Academic Achievement: A Meta-Analytic Review of Research. Review of Educational Research, **75**(3):417-453.

Smith, S.M. and Mensah, G.A. (2003). Population aging and implications for epidemic cardiovascular disease in Sub-Saharan Africa. Ethnicity and Disease, **13**(2):S77-80.

Sorof, J. and Daniels, S. (2002). Obesity Hypertension in Children: A Problem of Epidemic Proportions. Hypertension, **40**:441-447.

Sorof, J.M, Poffenbarger, T., Franco, K., Bernard, L. and Portman, R.J. (2002). Isolated systolic hypertension, obesity, and hyperkinetic hemodynamic states in children. Journal of Pediatrics, **140**:660-666.

Sorof, J.M., Lai, D., Turner, J., Poffenbarger, T. and Portman, R.J. (2004). Overweight, Ethnicity, and the Prevalence of Hypertension in School-Aged Children. Pediatrics, **113**(3):475-484.

Soylu, A., Kavukçu, S., Türkmen, M., Cabuk, N. and Duman, M. (2000). Effect of socioeconomic status on the blood pressure in children living in a developing country. Pediatrics International, **42**:37-42.

St. John, N. (1970). The Validity of Children's Reports of Their Parents' Educational Level: A Methodological Note. Sociology of Education, **43**(3):255-269.

Stranges, S. and Cappuccio, F.P. (2007). Children under pressure: an underestimated burden. Archives of Disease in Childhood, **92**:288-290.

Subramanian, S.V., Kawachi, I. and Smith, G.D. (2007). Income inequality and the double burden of under- and overnutrition in India. Journal of Epidemiology and Community Health, **61**:802-809.

Suchday, S., Chhabra, R., Wylie-Rosett, J. and Almeida, M. (2008). Subjective and Objective Measures of Socioeconomic Status: Predictors Of Cardiovascular Risk In College Students In Mumbai, India. Ethnicity and Disease, **18**(Suppl 2):S2-235-S2-237.

Taksande, A., Chaturvedi, P., Vilhekar, K. and Jain, M. (2008). Distribution of blood pressure in school going children in rural area of Wardha district, Maharashatra, India. Annals of Pediatric Cardiology, **1**(2):101-106.

Tang, H.K., Dibley, M.J., Sibbritt, D. and Tran, H.M.T. (2007). Gender and socio-economic differences in BMI of secondary high school students in Ho Chi Minh City. Asia Pacific Journal of Clinical Nutrition, **16**(1):74-83.

Tanner, J.M. (1962). Growth and adolescence, Second edition. Oxford: Blackwell.

Taylor, S.J., Whincup, P.H., Hindmarsh, P.C., Lampe, F., Odoki, K., Cook, D.G. (2001). Performance of a new pubertal self-assessment questionnaire: a preliminary study. Paediatric and Perinatal Epidemiology, **15**:88-94.

Tell, G.S. (1985). Cardiovascular Disease Risk Factors related to Sexual maturation: The Oslo Youth study. Journal of Chronic Diseases, **38**(8):633-642.

Terra, S.G., Blum, R.A., Wei, G.C., Lew, R.A., Digenio, A.G., Rajman, I. and Kazierad, D.J. (2004). Evaluation of Methods for Improving Precision of Blood Pressure Measurements in Phase I Clinical Trials. Journal of Clinical Pharmacology, **44**:457-463.

Tesfaye, F., Byass, P. and Wall, S. (2009). Population based prevalence of high blood pressure among adults in Addis Ababa: uncovering a silent epidemic. BMC Cardiovascular Disorders, **9**:39.

Thakor, H.G., Kumar, P. and Desai, V.K. (1998). An Epidemiological Study of Hypertension amongst Children From Various Primary Schools Of Surat City. Indian Journal of Community Medicine, **23**(3):110-115.

Tharkar, S. and Viswanathan, V. (2009). Impact of Socioeconomic Status on Prevalence of Overweight and Obesity among Children and Adolescents in Urban India. The Open Obesity Journal, **1**:9-14.

Thompson, D.R., Obarzanek, E., Franko, D.L., Barton, B.A., Morrison, J., Biro, F.M., Daniels, S.R. and Striegel-Moore, R.H. (2007). Childhood Overweight and Cardiovascular Disease Risk Factors: The National Heart, Lung, and Blood Institute Growth and Health Study. Journal of Pediatrics, **150**:18-25.

Timmreck, T.C. (2002). An Introduction to Epidemiology. Jones and Bartlett Publishers Inc. Third edition.

Treuth, M.S., Hou, N., Young, D.R. and Maynard, L.M. (2005). Validity and reliability of the Fels physical activity questionnaire for children. Medicine and Science in Sports and Exercise, **37**(3):488-495.

Tuinstra, J., Groothoff, J.W., van den Heuvel, W.J. and Post, D. (1998). Socio-economic differences in health risk behavior in adolescence: do they exist? Social Science and Medicine, **47**(1):67-74.

UN-HABITAT (2006). World Urban Forum III. An International UN-HABITAT Event on Urban sustainability. Vancouver, Canada. http://www.unhabitat.org/cdrom/docs/WUF5.pdf. Accessed 15th July 2011.

UNICEF: State of the World's Children (2011). http://www.unicef.org/sowc2011/fullreport.php. Accessed 20th June 2011.

United Nations (2000). Millennium Development Goals (MDGs). http://www.un.org/millenniumgoals/bkgd.shtml. Accessed 20th March 2012.

United Nations (2010). Millennium Development Goals Review Summit. http://www.un.org/en/mdg/summit2010/pdf/mdg%20outcome%20document.pdf. Accessed 18th February 2012.

United Nations (2011). UN High-Level Meeting on Prevention and Control of Chronic non-communicable diseases. http://www.un.org/en/ga/ncdmeeting2011/index.shtml. Accessed 18th February 2012.

United Nations (2007). Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat. World Urbanisation Prospects: The 2007 Revision. http://www.un.org/esa/population/publications/wup2007/2007WUP_Highlights_web.pdf. Accessed 20th June 2011.

United States Department of State (2011). http://geography.about.com/gi/dynamic/offsite.htm?site=http://www.state.gov/r/pa/ei/bgn/2836.htm. Accessed 20th June 2011.

Urrutia-Rojas, X., Egbuchunam, C.U., Bae, S., Menchaca, J., Bayona, M, Rivers, P.A. and Singh, K.P. (2006). High blood pressure in school children: prevalence and risk factors. BMC Pediatrics, **6**:32-38.

Uwaifo, V. O. and Uddin, P.S.O. (2009). Transition from the 6-3-3-4 to the 9-3-4 System of Education in Nigeria: An Assessment of Its Implementation on Technology Subjects. Studies on Home and Community Science, **3**(2):81-86.

van der Horst, K., Oenema, A., van de Looij-Jansen, P. and Brug, J. (2008). The ENDORSE study: Research into environmental determinants of obesity related behaviors in Rotterdam schoolchildren. BMC Public Health, **8**:142.

Van Lenthe, F.J., Boreham, C.A., Twisk, J.W.R., Strain, J.J., Savage, J.M. and Smith, G.D. (2001). Socio-economic position and coronary heart disease risk factors in youth: Findings from the Young Hearts Project in Northern Ireland. European Journal of Public Health, **11**(1):43-50.

Vartiainen, E., Tuomilehto, J. and Nissinen, A. (1986). Blood pressure in puberty. Acta Paediatrica Scandinavica, **75**:626-631.

Veldre, G. and Jürimäe, T. (2004). Anthropometric parameters and sexual maturation in 12- to 15-year-old Estonian boys. Anthropologischer Anzeiger, **62**(2):203-215.

Vogt, B.A. (2001). Hypertension in Children and Adolescents: Definition, Pathophysiology, Risk Factors, and Long-Term Sequelae. Current Therapeutic Research Clinical Experience, **62**(4):283-297.

Voors, A.W., Webber, L.S. and Berenson, G.S. (1979). Time Course Studies of Blood Pressure in Children-The Bogalusa Heart Study. American Journal of Epidemiology, **109**:320-334.

Vyas, S. and Kumaranayake, L. (2006). Constructing socio-economic status indices: how to use principal components analysis. Health Policy Plan, **21**(6):459-468.

Wacharasindhu, S., Pri-Ngam, P. and Kongchonrak, T. (2002). Self-assessment of sexual maturation in Thai children by Tanner photograph. Journal of the Medical Association of Thailand, **85**:308-319.

Walter, H.J. and Hofman, A. (1987). Socioeconomic status, ethnic origin, and risk factors for coronary heart disease in children. American Heart Journal, **113**(3):812-818.

Wang, Y. (2004). Epidemiology of childhood obesity - methodological aspects and guidelines: what is new? International Journal of Obesity, **28**:S21-S28.

Wang, Y. and Lobstein, T. (2006). Worldwide trends in childhood overweight and obesity. International Journal of Pediatric Obesity, **1**:11-25.

Wannamethee, S.G., Whincup, P.H., Shaper, G. and Walker, M. (1996). Influence of fathers' social class on cardiovascular disease in middle-aged men. The Lancet, **348**(9037):1259-1263.

Wardle, J., Robb, K. and Johnson, F. (2002). Assessing socioeconomic status in adolescents: the validity of a home affluence scale. Journal of Epidemiology and Community Health, **56**:595-599.

Weir, M.R., Strattford, E.M., Gregory, G., Lawson, M.A. and Pearl, W. (1988). The relationship between sexual maturity rating, age, and increased blood pressure in adolescents. Journal of Adolescent Health Care, **9**(6):465-469.

West, P., Sweeting, H., and Speed, E. (2001). We Really Do Know What You Do: A Comparison of Reports from 11 Year Olds and their Parents in Respect of Parental Economic Activity and Occupation. Sociology, **35**:539-559.

Whitaker, R.C., Wright, J.A., Pepe, M.S., Seidel, K.D. and Dietz, W.H. (1997). Predicting Obesity in Young Adulthood from Childhood and Parental Obesity. New England Journal of Medicine, **337**:869-873.

White, W.B. and Anwar, Y.A. (2001). Evaluation of the overall efficacy of the Omron office digital blood pressure HEM-907 monitor in adults. Blood Pressure Monitoring, **6**:107-110.

Wiles, R., Heath, S., Crow, G., and Charles, V. (2005). Informed Consent in Social Research: A Literature Review. NCRM Methods Review Papers NCRM/001. http://eprints.ncrm.ac.uk/85/1/MethodsReviewPaperNCRM-001.pdf. Accessed 12th March 2011.

Williams, R. L., Cheyne, K. L., Houtkooper, L. K. and Lohman, T.G. (1988). Adolescent self assessment of sexual maturation: Effects of fatness classification and actual sexual maturational stage. Journal of Adolescent Health Care, **9**:480-482.

Wingfield, D., Freeman, G.K. and Bulpitt, C.J. (2002). Selective recording in blood pressure readings may increase subsequent mortality. Quarterly Journal of Medicine (Association of Physicians), **95**:571-577.

Winkleby, M.A., Jatulis, D.E., Frank, E. and Fortmann, S.P. (1992). Socioeconomic Status and Health: How Education, Income, and Occupation Contribute to Risk Factors for Cardiovascular Disease. American Joumal of Public Health, **82**(6):816-820.

World Bank (2011). Nigeria: Country Brief. http://web.worldbank.org/WBSITE/EXTERNAL/COUNTRIES/AFRICAEXT/NIGERIAEXTN/0,,menuPK:368906~pagePK:141132~piPK:141107~theSitePK:368896,00.html. Accessed 20th June 2011.

World Health Organisation (1994). WHO Expert Committee on Hypertension Control. Geneva, Switzerland: World Health Organisation. www.who.int/acd/cvd/trs862.html#tableg. Accessed 30th November 2009.

World Health Organisation (1995). Physical status: the use and interpretation of anthropometry: a report of a WHO expert committee series No 854. Geneva: WHO. http://www.who.int/childgrowth/publications/physical_status/en/index.html. Accessed 18th January 2010.

World Health Organisation (2000). The World Health Report 2000 – Health systems: improving performance. http://www.who.int/whr/2000/en/index.html. Accessed 30th April 2011.

World Health Organisation (2005). Preventing chronic diseases: a vital investment: WHO global report. Geneva: World Health Organisation, 2005. http://whqlibdoc.who.int/publications/2005/9241563001_eng.pdf. Accessed 10th August 2009.

World Health Organisation (2006). Obesity and Overweight. http://www.who.int/mediacentre/factsheets/fs311/en/index.html. Accessed 30th April 2010.

World Health Organisation (2007). Growth reference data for 5-19 years. http://www.who.int/growthref/en/. Accessed 3rd February 2011.

World Health Organisation (2009). World Health Statistics (2009). http://www.who.int/whosis/whostat/2009/en/index.html. Accessed 30th September 2009.

World Health Organisation (2010). Cardiovascular disease (CVD) Fact sheet. http://www.who.int/mediacentre/factsheets/fs317/en/index.html. Accessed January 10th January 2012.

World Health Organisation (2011a). Global status report on non-communicable diseases 2010. http://www.who.int/nmh/publications/ncd_report_full_en.pdf. Accessed January 10th January 2012.

World Health Organisation (2011b). World Health Statistics (2011). http://www.who.int/whosis/whostat/2011/en/index.html. Accessed 3rd February 2012.

World Health Organisation (2011c). Non-communicable Diseases Country Profiles – Nigeria. http://www.who.int/nmh/countries/nga_en.pdf. Accessed 3rd February 2012.

World Health Organisation (2012). World Health Statistics (2012). http://www.who.int/healthinfo/EN_WHS2012_Full.pdf. Accessed 23rd May 2012.

Wu, Y., Schreiber, G.B., Klementowicz, V., Biro, F. and Wright, D. (2001). Racial differences in accuracy of self-assessment of sexual maturation among young black and white girls. Journal of Adolescent Health, **28**:197-203.

Yach, D., Hawkes, C., Gould, C. and Hofman, K. (2004). The global burden of chronic diseases: overcoming impediments to prevention and control. Journal of the American Medical Association, **291**(21):2616-2622.

Youngblood, R. L. (1977). Student-Parent Agreement on Socioeconomic Indicators: A Research Note from Manila. Public Opinion Quarterly, **41**:396-399.

Yusuf, S., Reddy, K.S., Ounpu, S. and Anand, S. (2001). Global burden of cardiovascular diseases: Part I: General considerations, the epidemiological transition, risk factors, and impact of urbanization. Circulation, **104**:2746-2753.

Zhao, M., Shu, X.O., Jin, F., Yang, G., Li, H., Liu, D., Wen, W., Gao, Y. and Zheng, W. (2002). Birthweight, childhood growth and hypertension in adulthood. International Journal of Epidemiology, **31**:1043-1051.

Zurayk H., Halabi, S. and Deeb, M. (1987). Measures of social class based on education for use in health studies in developing countries. Journal of Epidemiology and Community Health, **41**(2):173-179.

APPENDICES

APPENDIX 1: BP LEVELS FOR BOYS BY AGE AND HEIGHT PERCENTILE

Age, y	BP Percentile	SBP, mm Hg							DBP, mm Hg						
		Percentile of Height							Percentile of Height						
		5th	10th	25th	50th	75th	90th	95th	5th	10th	25th	50th	75th	90th	95th
1	50th	80	81	83	85	87	88	89	34	35	36	37	38	39	39
	90th	94	95	97	99	100	102	103	49	50	51	52	53	53	54
	95th	98	99	101	103	104	106	106	54	54	55	56	57	58	58
	99th	105	106	108	110	112	113	114	61	62	63	64	65	66	66
2	50th	84	85	87	88	90	92	92	39	40	41	42	43	44	44
	90th	97	99	100	102	104	105	106	54	55	56	57	58	58	59
	95th	101	102	104	106	108	109	110	59	59	60	61	62	63	63
	99th	109	110	111	113	115	117	117	66	67	68	69	70	71	71
3	50th	86	87	89	91	93	94	95	44	44	45	46	47	48	48
	90th	100	101	103	105	107	108	109	59	59	60	61	62	63	63
	95th	104	105	107	109	110	112	113	63	63	64	65	66	67	67
	99th	111	112	114	116	118	119	120	71	71	72	73	74	75	75
4	50th	88	89	91	93	95	96	97	47	48	49	50	51	51	52
	90th	102	103	105	107	109	110	111	62	63	64	65	66	66	67
	95th	106	107	109	111	112	114	115	66	67	68	69	70	71	71
	99th	113	114	116	118	120	121	122	74	75	76	77	78	78	79
5	50th	90	91	93	95	96	98	98	50	51	52	53	54	55	55
	90th	104	105	106	108	110	111	112	65	66	67	68	69	69	70
	95th	108	109	110	112	114	115	116	69	70	71	72	73	74	74
	99th	115	116	118	120	121	123	123	77	78	79	80	81	81	82
6	50th	91	92	94	96	98	99	100	53	53	54	55	56	57	57
	90th	105	106	108	110	111	113	113	68	68	69	70	71	72	72
	95th	109	110	112	114	115	117	117	72	72	73	74	75	76	76
	99th	116	117	119	121	123	124	125	80	80	81	82	83	84	84
7	50th	92	94	95	97	99	100	101	55	55	56	57	58	59	59
	90th	106	107	109	111	113	114	115	70	70	71	72	73	74	74
	95th	110	111	113	115	117	118	119	74	74	75	76	77	78	78
	99th	117	118	120	122	124	125	126	82	82	83	84	85	86	86
8	50th	94	95	97	99	100	102	102	56	57	58	59	60	60	61
	90th	107	109	110	112	114	115	116	71	72	72	73	74	75	76
	95th	111	112	114	116	118	119	120	75	76	77	78	79	79	80
	99th	119	120	122	123	125	127	127	83	84	85	86	87	87	88
9	50th	95	96	98	100	102	103	104	57	58	59	60	61	61	62
	90th	109	110	112	114	115	117	118	72	73	74	75	76	76	77
	95th	113	114	116	118	119	121	121	76	77	78	79	80	81	81
	99th	120	121	123	125	127	128	129	84	85	86	87	88	88	89
10	50th	97	98	100	102	103	105	106	58	59	60	61	61	62	63
	90th	111	112	114	115	117	119	119	73	73	74	75	76	77	78
	95th	115	116	117	119	121	122	123	77	78	79	80	81	81	82
	99th	122	123	125	127	128	130	130	85	86	86	88	88	89	90
11	50th	99	100	102	104	105	107	107	59	59	60	61	62	63	63
	90th	113	114	115	117	119	120	121	74	74	75	76	77	78	78
	95th	117	118	119	121	123	124	125	78	78	79	80	81	82	82
	99th	124	125	127	129	130	132	132	86	86	87	88	89	90	90
12	50th	101	102	104	106	108	109	110	59	60	61	62	63	63	64
	90th	115	116	118	120	121	123	123	74	75	75	76	77	78	79
	95th	119	120	122	123	125	127	127	78	79	80	81	82	82	83
	99th	126	127	129	131	133	134	135	86	87	88	89	90	90	91
13	50th	104	105	106	108	110	111	112	60	60	61	62	63	64	64
	90th	117	118	120	122	124	125	126	75	75	76	77	78	79	79
	95th	121	122	124	126	128	129	130	79	79	80	81	82	83	83
	99th	128	130	131	133	135	136	137	87	87	88	89	90	91	91
14	50th	106	107	109	111	113	114	115	60	61	62	63	64	65	65
	90th	120	121	123	125	126	128	128	75	76	77	78	79	79	80
	95th	124	125	127	128	130	132	132	80	80	81	82	83	84	84
	99th	131	132	134	136	138	139	140	87	88	89	90	91	92	92
15	50th	109	110	112	113	115	117	117	61	62	63	64	65	66	66
	90th	122	124	125	127	129	130	131	76	77	78	79	80	80	81
	95th	126	127	129	131	133	134	135	81	81	82	83	84	85	85
	99th	134	135	136	138	140	142	142	88	89	90	91	92	93	93
16	50th	111	112	114	116	118	119	120	63	63	64	65	66	67	67
	90th	125	126	128	130	131	133	134	78	78	79	80	81	82	82
	95th	129	130	132	134	135	137	137	82	83	83	84	85	86	87
	99th	136	137	139	141	143	144	145	90	90	91	92	93	94	94
17	50th	114	115	116	118	120	121	122	65	66	66	67	68	69	70
	90th	127	128	130	132	134	135	136	80	80	81	82	83	84	84
	95th	131	132	134	136	138	139	140	84	85	86	87	87	88	89
	99th	139	140	141	143	145	146	147	92	93	93	94	95	96	97

Source: The National High Blood Pressure Education Program (NHBPEP) Working Group on Children and Adolescents (2004).

APPENDIX 2: BP LEVELS FOR GIRLS BY AGE AND HEIGHT PERCENTILE

Age, y	BP Percentile	SBP, mm Hg							DBP, mm Hg						
		Percentile of Height							Percentile of Height						
		5th	10th	25th	50th	75th	90th	95th	5th	10th	25th	50th	75th	90th	95th
1	50th	83	84	85	86	88	89	90	38	39	39	40	41	41	42
	90th	97	97	98	100	101	102	103	52	53	53	54	55	55	56
	95th	100	101	102	104	105	106	107	56	57	57	58	59	59	60
	99th	108	108	109	111	112	113	114	64	64	65	65	66	67	67
2	50th	85	85	87	88	89	91	91	43	44	44	45	46	46	47
	90th	98	99	100	101	103	104	105	57	58	58	59	60	61	61
	95th	102	103	104	105	107	108	109	61	62	62	63	64	65	65
	99th	109	110	111	112	114	115	116	69	69	70	70	71	72	72
3	50th	86	87	88	89	91	92	93	47	48	48	49	50	50	51
	90th	100	100	102	103	104	106	106	61	62	62	63	64	64	65
	95th	104	104	105	107	108	109	110	65	66	66	67	68	68	69
	99th	111	111	113	114	115	116	117	73	73	74	74	75	76	76
4	50th	88	88	90	91	92	94	94	50	50	51	52	52	53	54
	90th	101	102	103	104	106	107	108	64	64	65	66	67	67	68
	95th	105	106	107	108	110	111	112	68	68	69	70	71	71	72
	99th	112	113	114	115	117	118	119	76	76	76	77	78	79	79
5	50th	89	90	91	93	94	95	96	52	53	53	54	55	55	56
	90th	103	103	105	106	107	109	109	66	67	67	68	69	69	70
	95th	107	107	108	110	111	112	113	70	71	71	72	73	73	74
	99th	114	114	116	117	118	120	120	78	78	79	79	80	81	81
6	50th	91	92	93	94	96	97	98	54	54	55	56	56	57	58
	90th	104	105	106	108	109	110	111	68	68	69	70	70	71	72
	95th	108	109	110	111	113	114	115	72	72	73	74	74	75	76
	99th	115	116	117	119	120	121	122	80	80	80	81	82	83	83
7	50th	93	93	95	96	97	99	99	55	56	56	57	58	58	59
	90th	106	107	108	109	111	112	113	69	70	70	71	72	72	73
	95th	110	111	112	113	115	116	116	73	74	74	75	76	76	77
	99th	117	118	119	120	122	123	124	81	81	82	82	83	84	84
8	50th	95	95	96	98	99	100	101	57	57	57	58	59	60	60
	90th	108	109	110	111	113	114	114	71	71	71	72	73	74	74
	95th	112	112	114	115	116	118	118	75	75	75	76	77	78	78
	99th	119	120	121	122	123	125	125	82	82	83	83	84	85	86
9	50th	96	97	98	100	101	102	103	58	58	58	59	60	61	61
	90th	110	110	112	113	114	116	116	72	72	72	73	74	75	75
	95th	114	114	115	117	118	119	120	76	76	76	77	78	79	79
	99th	121	121	123	124	125	127	127	83	83	84	84	85	86	87
10	50th	98	99	100	102	103	104	105	59	59	59	60	61	62	62
	90th	112	112	114	115	116	118	118	73	73	73	74	75	76	76
	95th	116	116	117	119	120	121	122	77	77	77	78	79	80	80
	99th	123	123	125	126	127	129	129	84	84	85	86	86	87	88
11	50th	100	101	102	103	105	106	107	60	60	60	61	62	63	63
	90th	114	114	116	117	118	119	120	74	74	74	75	76	77	77
	95th	118	118	119	121	122	123	124	78	78	78	79	80	81	81
	99th	125	125	126	128	129	130	131	85	85	86	87	87	88	89
12	50th	102	103	104	105	107	108	109	61	61	61	62	63	64	64
	90th	116	116	117	119	120	121	122	75	75	75	76	77	78	78
	95th	119	120	121	123	124	125	126	79	79	79	80	81	82	82
	99th	127	127	128	130	131	132	133	86	86	87	88	88	89	90
13	50th	104	105	106	107	109	110	110	62	62	62	63	64	65	65
	90th	117	118	119	121	122	123	124	76	76	76	77	78	79	79
	95th	121	122	123	124	126	127	128	80	80	80	81	82	83	83
	99th	128	129	130	132	133	134	135	87	87	88	89	89	90	91
14	50th	106	106	107	109	110	111	112	63	63	63	64	65	66	66
	90th	119	120	121	122	124	125	125	77	77	77	78	79	80	80
	95th	123	123	125	126	127	129	129	81	81	81	82	83	84	84
	99th	130	131	132	133	135	136	136	88	88	89	90	90	91	92
15	50th	107	108	109	110	111	113	113	64	64	64	65	66	67	67
	90th	120	121	122	123	125	126	127	78	78	78	79	80	81	81
	95th	124	125	126	127	129	130	131	82	82	82	83	84	85	85
	99th	131	132	133	134	136	137	138	89	89	90	91	91	92	93
16	50th	108	108	110	111	112	114	114	64	64	65	66	66	67	68
	90th	121	122	123	124	126	127	128	78	78	79	80	81	81	82
	95th	125	126	127	128	130	131	132	82	82	83	84	85	85	86
	99th	132	133	134	135	137	138	139	90	90	90	91	92	93	93
17	50th	108	109	110	111	113	114	115	64	65	65	66	67	67	68
	90th	122	122	123	125	126	127	128	78	79	79	80	81	81	82
	95th	125	126	127	129	130	131	132	82	83	83	84	85	85	86
	99th	133	133	134	136	137	138	139	90	90	91	91	92	93	93

Source: The National High Blood Pressure Education Program (NHBPEP) Working Group on Children and Adolescents (2004).

APPENDIX 3: WHO BMI REFERENCE DATA FOR BOYS AND GIRLS

BMI-for-age BOYS

5 to 19 years (z-scores)

					Z-scores (BMI in kg/m²)						
Year: Month	Month	L	M	S	-3 SD	-2 SD	-1 SD	Median	1 SD	2 SD	3 SD
9: 4	112	-1.6753	16.1692	0.10214	12.6	13.6	14.7	16.2	18.1	20.8	24.9
9: 5	113	-1.6851	16.2009	0.10259	12.6	13.6	14.7	16.2	18.1	20.8	25.0
9: 6	114	-1.6944	16.2333	0.10303	12.7	13.6	14.8	16.2	18.2	20.9	25.1
9: 7	115	-1.7032	16.2665	0.10347	12.7	13.6	14.8	16.3	18.2	21.0	25.3
9: 8	116	-1.7116	16.3004	0.10391	12.7	13.6	14.8	16.3	18.3	21.1	25.5
9: 9	117	-1.7196	16.3351	0.10435	12.7	13.7	14.8	16.3	18.3	21.2	25.6
9:10	118	-1.7271	16.3704	0.10478	12.7	13.7	14.9	16.4	18.4	21.2	25.8
9:11	119	-1.7341	16.4065	0.10522	12.8	13.7	14.9	16.4	18.4	21.3	25.9
10: 0	120	-1.7407	16.4433	0.10566	12.8	13.7	14.9	16.4	18.5	21.4	26.1
10: 1	121	-1.7468	16.4807	0.10609	12.8	13.8	15.0	16.5	18.5	21.5	26.2
10: 2	122	-1.7525	16.5189	0.10652	12.8	13.8	15.0	16.5	18.6	21.6	26.4
10: 3	123	-1.7578	16.5578	0.10695	12.8	13.8	15.0	16.6	18.6	21.7	26.6
10: 4	124	-1.7626	16.5974	0.10738	12.9	13.8	15.0	16.6	18.7	21.7	26.7
10: 5	125	-1.7670	16.6376	0.10780	12.9	13.9	15.1	16.6	18.8	21.8	26.9
10: 6	126	-1.7710	16.6786	0.10823	12.9	13.9	15.1	16.7	18.8	21.9	27.0
10: 7	127	-1.7745	16.7203	0.10865	12.9	13.9	15.1	16.7	18.9	22.0	27.2
10: 8	128	-1.7777	16.7628	0.10906	13.0	13.9	15.2	16.8	18.9	22.1	27.4
10: 9	129	-1.7804	16.8059	0.10948	13.0	14.0	15.2	16.8	19.0	22.2	27.5
10:10	130	-1.7828	16.8497	0.10989	13.0	14.0	15.2	16.9	19.0	22.3	27.7
10:11	131	-1.7847	16.8941	0.11030	13.0	14.0	15.3	16.9	19.1	22.4	27.9
11: 0	132	-1.7862	16.9392	0.11070	13.1	14.1	15.3	16.9	19.2	22.5	28.0
11: 1	133	-1.7873	16.9850	0.11110	13.1	14.1	15.3	17.0	19.2	22.5	28.2
11: 2	134	-1.7881	17.0314	0.11150	13.1	14.1	15.4	17.0	19.3	22.6	28.4
11: 3	135	-1.7884	17.0784	0.11189	13.1	14.1	15.4	17.1	19.3	22.7	28.5

2007 WHO Reference

BMI-for-age BOYS

5 to 19 years (z-scores)

					Z-scores (BMI in kg/m²)						
Year: Month	Month	L	M	S	-3 SD	-2 SD	-1 SD	Median	1 SD	2 SD	3 SD
11: 4	136	-1.7884	17.1262	0.11228	13.2	14.2	15.5	17.1	19.4	22.8	28.7
11: 5	137	-1.7880	17.1746	0.11266	13.2	14.2	15.5	17.2	19.5	22.9	28.8
11: 6	138	-1.7873	17.2236	0.11304	13.2	14.2	15.5	17.2	19.5	23.0	29.0
11: 7	139	-1.7861	17.2734	0.11342	13.2	14.3	15.6	17.3	19.6	23.1	29.2
11: 8	140	-1.7846	17.3240	0.11379	13.3	14.3	15.6	17.3	19.7	23.2	29.3
11: 9	141	-1.7828	17.3752	0.11415	13.3	14.3	15.7	17.4	19.7	23.3	29.5
11:10	142	-1.7806	17.4272	0.11451	13.3	14.4	15.7	17.4	19.8	23.4	29.6
11:11	143	-1.7780	17.4799	0.11487	13.4	14.4	15.7	17.5	19.9	23.5	29.8
12: 0	144	-1.7751	17.5334	0.11522	13.4	14.5	15.8	17.5	19.9	23.6	30.0
12: 1	145	-1.7719	17.5877	0.11556	13.4	14.5	15.8	17.6	20.0	23.7	30.1
12: 2	146	-1.7684	17.6427	0.11590	13.5	14.5	15.9	17.6	20.1	23.8	30.3
12: 3	147	-1.7645	17.6985	0.11623	13.5	14.6	15.9	17.7	20.2	23.9	30.4
12: 4	148	-1.7604	17.7551	0.11656	13.5	14.6	16.0	17.8	20.2	24.0	30.6
12: 5	149	-1.7559	17.8124	0.11688	13.6	14.6	16.0	17.8	20.3	24.1	30.7
12: 6	150	-1.7511	17.8704	0.11720	13.6	14.7	16.1	17.9	20.4	24.2	30.9
12: 7	151	-1.7461	17.9292	0.11751	13.6	14.7	16.1	17.9	20.4	24.3	31.0
12: 8	152	-1.7408	17.9887	0.11781	13.7	14.8	16.2	18.0	20.5	24.4	31.1
12: 9	153	-1.7352	18.0488	0.11811	13.7	14.8	16.2	18.0	20.6	24.5	31.3
12:10	154	-1.7293	18.1096	0.11841	13.7	14.8	16.3	18.1	20.7	24.6	31.4
12:11	155	-1.7232	18.1710	0.11869	13.8	14.9	16.3	18.2	20.8	24.7	31.6
13: 0	156	-1.7168	18.2330	0.11898	13.8	14.9	16.4	18.2	20.8	24.8	31.7
13: 1	157	-1.7102	18.2955	0.11925	13.8	15.0	16.4	18.3	20.9	24.9	31.8
13: 2	158	-1.7033	18.3586	0.11952	13.9	15.0	16.5	18.4	21.0	25.0	31.9
13: 3	159	-1.6962	18.4221	0.11979	13.9	15.1	16.5	18.4	21.1	25.1	32.1

2007 WHO Reference

BMI-for-age BOYS

5 to 19 years (z-scores)

					Z-scores (BMI in kg/m²)						
Year: Month	Month	L	M	S	-3 SD	-2 SD	-1 SD	Median	1 SD	2 SD	3 SD
13: 4	160	-1.6888	18.4860	0.12005	14.0	15.1	16.6	18.5	21.1	25.2	32.2
13: 5	161	-1.6811	18.5502	0.12030	14.0	15.2	16.6	18.6	21.2	25.2	32.3
13: 6	162	-1.6732	18.6148	0.12055	14.0	15.2	16.7	18.6	21.3	25.3	32.4
13: 7	163	-1.6651	18.6795	0.12079	14.1	15.2	16.7	18.7	21.4	25.4	32.6
13: 8	164	-1.6568	18.7445	0.12102	14.1	15.3	16.8	18.7	21.5	25.5	32.7
13: 9	165	-1.6482	18.8095	0.12125	14.1	15.3	16.8	18.8	21.5	25.6	32.8
13:10	166	-1.6394	18.8746	0.12148	14.2	15.4	16.9	18.9	21.6	25.7	32.9
13:11	167	-1.6304	18.9398	0.12170	14.2	15.4	17.0	18.9	21.7	25.8	33.0
14: 0	168	-1.6211	19.0050	0.12191	14.3	15.5	17.0	19.0	21.8	25.9	33.1
14: 1	169	-1.6116	19.0701	0.12212	14.3	15.5	17.1	19.1	21.8	26.0	33.2
14: 2	170	-1.6020	19.1351	0.12233	14.3	15.6	17.1	19.1	21.9	26.1	33.3
14: 3	171	-1.5921	19.2000	0.12253	14.4	15.6	17.2	19.2	22.0	26.2	33.4
14: 4	172	-1.5821	19.2648	0.12272	14.4	15.7	17.2	19.3	22.1	26.3	33.5
14: 5	173	-1.5719	19.3294	0.12291	14.5	15.7	17.3	19.3	22.2	26.4	33.5
14: 6	174	-1.5615	19.3937	0.12310	14.5	15.7	17.3	19.4	22.2	26.5	33.6
14: 7	175	-1.5510	19.4578	0.12328	14.5	15.8	17.4	19.5	22.3	26.5	33.7
14: 8	176	-1.5403	19.5217	0.12346	14.6	15.8	17.4	19.5	22.4	26.6	33.8
14: 9	177	-1.5294	19.5853	0.12363	14.6	15.9	17.5	19.6	22.5	26.7	33.9
14:10	178	-1.5185	19.6486	0.12380	14.6	15.9	17.5	19.6	22.5	26.8	33.9
14:11	179	-1.5074	19.7117	0.12396	14.7	16.0	17.6	19.7	22.6	26.9	34.0
15: 0	180	-1.4961	19.7744	0.12412	14.7	16.0	17.6	19.8	22.7	27.0	34.1
15: 1	181	-1.4848	19.8367	0.12428	14.7	16.1	17.7	19.8	22.8	27.1	34.1
15: 2	182	-1.4733	19.8987	0.12443	14.8	16.1	17.8	19.9	22.8	27.1	34.2
15: 3	183	-1.4617	19.9603	0.12458	14.8	16.1	17.8	20.0	22.9	27.2	34.3

2007 WHO Reference

BMI-for-age BOYS

5 to 19 years (z-scores)

					Z-scores (BMI in kg/m²)						
Year: Month	Month	L	M	S	-3 SD	-2 SD	-1 SD	Median	1 SD	2 SD	3 SD
15: 4	184	-1.4500	20.0215	0.12473	14.8	16.2	17.9	20.0	23.0	27.3	34.3
15: 5	185	-1.4382	20.0823	0.12487	14.9	16.2	17.9	20.1	23.0	27.4	34.4
15: 6	186	-1.4263	20.1427	0.12501	14.9	16.3	18.0	20.1	23.1	27.4	34.5
15: 7	187	-1.4143	20.2026	0.12514	15.0	16.3	18.0	20.2	23.2	27.5	34.5
15: 8	188	-1.4022	20.2621	0.12528	15.0	16.3	18.1	20.3	23.3	27.6	34.6
15: 9	189	-1.3900	20.3211	0.12541	15.0	16.4	18.1	20.3	23.3	27.7	34.6
15:10	190	-1.3777	20.3796	0.12554	15.0	16.4	18.2	20.4	23.4	27.7	34.7
15:11	191	-1.3653	20.4376	0.12567	15.1	16.5	18.2	20.4	23.5	27.8	34.7
16: 0	192	-1.3529	20.4951	0.12579	15.1	16.5	18.2	20.5	23.5	27.9	34.8
16: 1	193	-1.3403	20.5521	0.12591	15.1	16.5	18.3	20.6	23.6	27.9	34.8
16: 2	194	-1.3277	20.6085	0.12603	15.2	16.6	18.3	20.6	23.7	28.0	34.8
16: 3	195	-1.3149	20.6644	0.12615	15.2	16.6	18.4	20.7	23.7	28.1	34.9
16: 4	196	-1.3021	20.7197	0.12627	15.2	16.7	18.4	20.7	23.8	28.1	34.9
16: 5	197	-1.2892	20.7745	0.12638	15.3	16.7	18.5	20.8	23.8	28.2	35.0
16: 6	198	-1.2762	20.8287	0.12650	15.3	16.7	18.5	20.8	23.9	28.3	35.0
16: 7	199	-1.2631	20.8824	0.12661	15.3	16.8	18.6	20.9	24.0	28.3	35.0
16: 8	200	-1.2499	20.9355	0.12672	15.3	16.8	18.6	20.9	24.0	28.4	35.1
16: 9	201	-1.2366	20.9881	0.12683	15.4	16.8	18.7	21.0	24.1	28.5	35.1
16:10	202	-1.2233	21.0400	0.12694	15.4	16.9	18.7	21.0	24.2	28.5	35.1
16:11	203	-1.2098	21.0914	0.12704	15.4	16.9	18.7	21.1	24.2	28.6	35.2
17: 0	204	-1.1962	21.1423	0.12715	15.4	16.9	18.8	21.1	24.3	28.6	35.2
17: 1	205	-1.1826	21.1925	0.12726	15.5	17.0	18.8	21.2	24.3	28.7	35.2
17: 2	206	-1.1688	21.2423	0.12736	15.5	17.0	18.9	21.2	24.4	28.7	35.2
17: 3	207	-1.1550	21.2914	0.12746	15.5	17.0	18.9	21.3	24.4	28.8	35.3

2007 WHO Reference

BMI-for-age BOYS

5 to 19 years (z-scores)

					Z-scores (BMI in kg/m²)						
Year: Month	Month	L	M	S	-3 SD	-2 SD	-1 SD	Median	1 SD	2 SD	3 SD
17: 4	208	-1.1410	21.3400	0.12756	15.5	17.1	18.9	21.3	24.5	28.9	35.3
17: 5	209	-1.1270	21.3880	0.12767	15.6	17.1	19.0	21.4	24.5	28.9	35.3
17: 6	210	-1.1129	21.4354	0.12777	15.6	17.1	19.0	21.4	24.6	29.0	35.3
17: 7	211	-1.0986	21.4822	0.12787	15.6	17.1	19.1	21.5	24.7	29.0	35.4
17: 8	212	-1.0843	21.5285	0.12797	15.6	17.2	19.1	21.5	24.7	29.1	35.4
17: 9	213	-1.0699	21.5742	0.12807	15.6	17.2	19.1	21.6	24.8	29.1	35.4
17:10	214	-1.0553	21.6193	0.12816	15.7	17.2	19.2	21.6	24.8	29.2	35.4
17:11	215	-1.0407	21.6638	0.12826	15.7	17.3	19.2	21.7	24.9	29.2	35.4
18: 0	216	-1.0260	21.7077	0.12836	15.7	17.3	19.2	21.7	24.9	29.2	35.4
18: 1	217	-1.0112	21.7510	0.12845	15.7	17.3	19.3	21.8	25.0	29.3	35.4
18: 2	218	-0.9962	21.7937	0.12855	15.7	17.3	19.3	21.8	25.0	29.3	35.5
18: 3	219	-0.9812	21.8358	0.12864	15.7	17.4	19.3	21.8	25.1	29.4	35.5
18: 4	220	-0.9661	21.8773	0.12874	15.8	17.4	19.4	21.9	25.1	29.4	35.5
18: 5	221	-0.9509	21.9182	0.12883	15.8	17.4	19.4	21.9	25.1	29.5	35.5
18: 6	222	-0.9356	21.9585	0.12893	15.8	17.4	19.4	22.0	25.2	29.5	35.5
18: 7	223	-0.9202	21.9982	0.12902	15.8	17.5	19.5	22.0	25.2	29.5	35.5
18: 8	224	-0.9048	22.0374	0.12911	15.8	17.5	19.5	22.0	25.3	29.6	35.5
18: 9	225	-0.8892	22.0760	0.12920	15.8	17.5	19.5	22.1	25.3	29.6	35.5
18:10	226	-0.8735	22.1140	0.12930	15.8	17.5	19.6	22.1	25.4	29.6	35.5
18:11	227	-0.8578	22.1514	0.12939	15.8	17.5	19.6	22.2	25.4	29.7	35.5
19: 0	228	-0.8419	22.1883	0.12948	15.9	17.6	19.6	22.2	25.4	29.7	35.5

2007 WHO Reference

BMI-for-age GIRLS

5 to 19 years (z-scores)

					Z-scores (BMI in kg/m²)						
Year: Month	Month	L	M	S	-3 SD	-2 SD	-1 SD	Median	1 SD	2 SD	3 SD
11: 4	136	-1.4436	17.4847	0.12882	12.9	14.0	15.5	17.5	20.2	24.1	30.8
11: 5	137	-1.4389	17.5464	0.12914	12.9	14.1	15.6	17.5	20.2	24.2	30.9
11: 6	138	-1.4339	17.6088	0.12946	12.9	14.1	15.6	17.6	20.3	24.3	31.1
11: 7	139	-1.4288	17.6719	0.12978	13.0	14.2	15.7	17.7	20.4	24.4	31.2
11: 8	140	-1.4235	17.7357	0.13009	13.0	14.2	15.7	17.7	20.5	24.5	31.4
11: 9	141	-1.4180	17.8001	0.13040	13.0	14.3	15.8	17.8	20.6	24.7	31.5
11:10	142	-1.4123	17.8651	0.13070	13.1	14.3	15.8	17.9	20.6	24.8	31.6
11:11	143	-1.4065	17.9306	0.13099	13.1	14.3	15.9	17.9	20.7	24.9	31.8
12: 0	144	-1.4006	17.9966	0.13129	13.2	14.4	16.0	18.0	20.8	25.0	31.9
12: 1	145	-1.3945	18.0630	0.13158	13.2	14.4	16.0	18.1	20.9	25.1	32.0
12: 2	146	-1.3883	18.1297	0.13186	13.2	14.5	16.1	18.1	21.0	25.2	32.2
12: 3	147	-1.3819	18.1967	0.13214	13.3	14.5	16.1	18.2	21.1	25.3	32.3
12: 4	148	-1.3755	18.2639	0.13241	13.3	14.6	16.2	18.3	21.1	25.4	32.4
12: 5	149	-1.3689	18.3312	0.13268	13.3	14.6	16.2	18.3	21.2	25.5	32.6
12: 6	150	-1.3621	18.3986	0.13295	13.4	14.7	16.3	18.4	21.3	25.6	32.7
12: 7	151	-1.3553	18.4660	0.13321	13.4	14.7	16.3	18.5	21.4	25.7	32.8
12: 8	152	-1.3483	18.5333	0.13347	13.5	14.8	16.4	18.5	21.5	25.8	33.0
12: 9	153	-1.3413	18.6006	0.13372	13.5	14.8	16.4	18.6	21.6	25.9	33.1
12:10	154	-1.3341	18.6677	0.13397	13.5	14.8	16.5	18.7	21.6	26.0	33.2
12:11	155	-1.3269	18.7346	0.13421	13.6	14.9	16.6	18.7	21.7	26.1	33.3
13: 0	156	-1.3195	18.8012	0.13445	13.6	14.9	16.6	18.8	21.8	26.2	33.4
13: 1	157	-1.3121	18.8675	0.13469	13.6	15.0	16.7	18.9	21.9	26.3	33.6
13: 2	158	-1.3046	18.9335	0.13492	13.7	15.0	16.7	18.9	22.0	26.4	33.7
13: 3	159	-1.2970	18.9991	0.13514	13.7	15.1	16.8	19.0	22.0	26.5	33.8

2007 WHO Reference

BMI-for-age GIRLS

5 to 19 years (z-scores)

					Z-scores (BMI in kg/m^2)						
Year: Month	**Month**	**L**	**M**	**S**	**-3 SD**	**-2 SD**	**-1 SD**	**Median**	**1 SD**	**2 SD**	**3 SD**
13: 4	160	-1.2894	19.0642	0.13537	13.8	15.1	16.8	19.1	22.1	26.6	33.9
13: 5	161	-1.2816	19.1289	0.13559	13.8	15.2	16.9	19.1	22.2	26.7	34.0
13: 6	162	-1.2739	19.1931	0.13580	13.8	15.2	16.9	19.2	22.3	26.8	34.1
13: 7	163	-1.2661	19.2567	0.13601	13.9	15.2	17.0	19.3	22.4	26.9	34.2
13: 8	164	-1.2583	19.3197	0.13622	13.9	15.3	17.0	19.3	22.4	27.0	34.3
13: 9	165	-1.2504	19.3820	0.13642	13.9	15.3	17.1	19.4	22.5	27.1	34.4
13:10	166	-1.2425	19.4437	0.13662	14.0	15.4	17.1	19.4	22.6	27.1	34.5
13:11	167	-1.2345	19.5045	0.13681	14.0	15.4	17.2	19.5	22.7	27.2	34.6
14: 0	168	-1.2266	19.5647	0.13700	14.0	15.4	17.2	19.6	22.7	27.3	34.7
14: 1	169	-1.2186	19.6240	0.13719	14.1	15.5	17.3	19.6	22.8	27.4	34.7
14: 2	170	-1.2107	19.6824	0.13738	14.1	15.5	17.3	19.7	22.9	27.5	34.8
14: 3	171	-1.2027	19.7400	0.13756	14.1	15.6	17.4	19.7	22.9	27.6	34.9
14: 4	172	-1.1947	19.7966	0.13774	14.1	15.6	17.4	19.8	23.0	27.7	35.0
14: 5	173	-1.1867	19.8523	0.13791	14.2	15.6	17.5	19.9	23.1	27.7	35.1
14: 6	174	-1.1788	19.9070	0.13808	14.2	15.7	17.5	19.9	23.1	27.8	35.1
14: 7	175	-1.1708	19.9607	0.13825	14.2	15.7	17.6	20.0	23.2	27.9	35.2
14: 8	176	-1.1629	20.0133	0.13841	14.3	15.7	17.6	20.0	23.3	28.0	35.3
14: 9	177	-1.1549	20.0648	0.13858	14.3	15.8	17.6	20.1	23.3	28.0	35.4
14:10	178	-1.1470	20.1152	0.13873	14.3	15.8	17.7	20.1	23.4	28.1	35.4
14:11	179	-1.1390	20.1644	0.13889	14.3	15.8	17.7	20.2	23.5	28.2	35.5
15: 0	180	-1.1311	20.2125	0.13904	14.4	15.9	17.8	20.2	23.5	28.2	35.5
15: 1	181	-1.1232	20.2595	0.13920	14.4	15.9	17.8	20.3	23.6	28.3	35.6
15: 2	182	-1.1153	20.3053	0.13934	14.4	15.9	17.8	20.3	23.6	28.4	35.7
15: 3	183	-1.1074	20.3499	0.13949	14.4	16.0	17.9	20.4	23.7	28.4	35.7

2007 WHO Reference

BMI-for-age GIRLS

5 to 19 years (z-scores)

					Z-scores (BMI in kg/m^2)						
Year: Month	**Month**	**L**	**M**	**S**	**-3 SD**	**-2 SD**	**-1 SD**	**Median**	**1 SD**	**2 SD**	**3 SD**
15: 4	184	-1.0996	20.3934	0.13963	14.5	16.0	17.9	20.4	23.7	28.5	35.8
15: 5	185	-1.0917	20.4357	0.13977	14.5	16.0	17.9	20.4	23.8	28.5	35.8
15: 6	186	-1.0838	20.4769	0.13991	14.5	16.0	18.0	20.5	23.8	28.6	35.8
15: 7	187	-1.0760	20.5170	0.14005	14.5	16.1	18.0	20.5	23.9	28.6	35.9
15: 8	188	-1.0681	20.5560	0.14018	14.5	16.1	18.0	20.6	23.9	28.7	35.9
15: 9	189	-1.0603	20.5938	0.14031	14.5	16.1	18.1	20.6	24.0	28.7	36.0
15:10	190	-1.0525	20.6306	0.14044	14.6	16.1	18.1	20.6	24.0	28.8	36.0
15:11	191	-1.0447	20.6663	0.14057	14.6	16.2	18.1	20.7	24.1	28.8	36.0
16: 0	192	-1.0368	20.7008	0.14070	14.6	16.2	18.2	20.7	24.1	28.9	36.1
16: 1	193	-1.0290	20.7344	0.14082	14.6	16.2	18.2	20.7	24.1	28.9	36.1
16: 2	194	-1.0212	20.7668	0.14094	14.6	16.2	18.2	20.8	24.2	29.0	36.1
16: 3	195	-1.0134	20.7982	0.14106	14.6	16.2	18.2	20.8	24.2	29.0	36.1
16: 4	196	-1.0055	20.8286	0.14118	14.6	16.2	18.3	20.8	24.3	29.0	36.2
16: 5	197	-0.9977	20.8580	0.14130	14.6	16.3	18.3	20.9	24.3	29.1	36.2
16: 6	198	-0.9898	20.8863	0.14142	14.7	16.3	18.3	20.9	24.3	29.1	36.2
16: 7	199	-0.9819	20.9137	0.14153	14.7	16.3	18.3	20.9	24.4	29.1	36.2
16: 8	200	-0.9740	20.9401	0.14164	14.7	16.3	18.3	20.9	24.4	29.2	36.2
16: 9	201	-0.9661	20.9656	0.14176	14.7	16.3	18.4	21.0	24.4	29.2	36.3
16:10	202	-0.9582	20.9901	0.14187	14.7	16.3	18.4	21.0	24.4	29.2	36.3
16:11	203	-0.9503	21.0138	0.14198	14.7	16.3	18.4	21.0	24.5	29.3	36.3
17: 0	204	-0.9423	21.0367	0.14208	14.7	16.4	18.4	21.0	24.5	29.3	36.3
17: 1	205	-0.9344	21.0587	0.14219	14.7	16.4	18.4	21.1	24.5	29.3	36.3
17: 2	206	-0.9264	21.0801	0.14230	14.7	16.4	18.4	21.1	24.6	29.3	36.3
17: 3	207	-0.9184	21.1007	0.14240	14.7	16.4	18.5	21.1	24.6	29.4	36.3

2007 WHO Reference

BMI-for-age GIRLS

5 to 19 years (z-scores)

					Z-scores (BMI in kg/m^2)						
Year: Month	**Month**	**L**	**M**	**S**	**-3 SD**	**-2 SD**	**-1 SD**	**Median**	**1 SD**	**2 SD**	**3 SD**
17: 4	208	-0.9104	21.1206	0.14250	14.7	16.4	18.5	21.1	24.6	29.4	36.3
17: 5	209	-0.9024	21.1399	0.14261	14.7	16.4	18.5	21.1	24.6	29.4	36.3
17: 6	210	-0.8944	21.1586	0.14271	14.7	16.4	18.5	21.2	24.6	29.4	36.3
17: 7	211	-0.8863	21.1768	0.14281	14.7	16.4	18.5	21.2	24.7	29.4	36.3
17: 8	212	-0.8783	21.1944	0.14291	14.7	16.4	18.5	21.2	24.7	29.5	36.3
17: 9	213	-0.8703	21.2116	0.14301	14.7	16.4	18.5	21.2	24.7	29.5	36.3
17:10	214	-0.8623	21.2282	0.14311	14.7	16.4	18.5	21.2	24.7	29.5	36.3
17:11	215	-0.8542	21.2444	0.14320	14.7	16.4	18.6	21.2	24.8	29.5	36.3
18: 0	216	-0.8462	21.2603	0.14330	14.7	16.4	18.6	21.3	24.8	29.5	36.3
18: 1	217	-0.8382	21.2757	0.14340	14.7	16.5	18.6	21.3	24.8	29.5	36.3
18: 2	218	-0.8301	21.2908	0.14349	14.7	16.5	18.6	21.3	24.8	29.6	36.3
18: 3	219	-0.8221	21.3055	0.14359	14.7	16.5	18.6	21.3	24.8	29.6	36.3
18: 4	220	-0.8140	21.3200	0.14368	14.7	16.5	18.6	21.3	24.8	29.6	36.3
18: 5	221	-0.8060	21.3341	0.14377	14.7	16.5	18.6	21.3	24.9	29.6	36.2
18: 6	222	-0.7980	21.3480	0.14386	14.7	16.5	18.6	21.3	24.9	29.6	36.2
18: 7	223	-0.7899	21.3617	0.14396	14.7	16.5	18.6	21.4	24.9	29.6	36.2
18: 8	224	-0.7819	21.3752	0.14405	14.7	16.5	18.6	21.4	24.9	29.6	36.2
18: 9	225	-0.7738	21.3884	0.14414	14.7	16.5	18.7	21.4	24.9	29.6	36.2
18:10	226	-0.7658	21.4014	0.14423	14.7	16.5	18.7	21.4	24.9	29.6	36.2
18:11	227	-0.7577	21.4143	0.14432	14.7	16.5	18.7	21.4	25.0	29.7	36.2
19: 0	228	-0.7496	21.4269	0.14441	14.7	16.5	18.7	21.4	25.0	29.7	36.2

2007 WHO Reference

Source: Growth reference data for 5-19 years, WHO (2007).
http://www.who.int/growthref/en/

APPENDIX 4: WAIST CIRCUMFERENCE ESTIMATED VALUE FOR PERCENTILE REGRESSION FOR AFRICAN AMERICAN CHILDREN AND ADOLESCENTS BY GENDER

	Percentile for boys					Percentile for girls				
	10th	25th	50th	75th	90th	10th	25th	50th	75th	90th
Intercept	40.1	41.2	42.7	44.1	43.6	39.9	41.2	41.7	42.1	42.8
Slope	1.6	1.7	1.9	2.2	3.2	1.6	1.7	2.1	2.8	3.7
Age (y)										
2	43.2	44.6	46.4	48.5	50.0	43.0	44.6	46.0	47.7	50.1
3	44.8	46.3	48.3	50.7	53.2	44.6	46.3	48.1	50.6	53.8
4	46.3	48.0	50.1	52.9	56.4	46.1	48.0	50.2	53.4	57.5
5	47.9	49.7	52.0	55.1	59.6	47.7	49.7	52.3	56.2	61.1
6	49.4	51.4	53.9	57.3	62.8	49.2	51.4	54.5	59.0	64.8
7	51.0	53.1	55.7	59.5	66.1	50.8	53.2	56.6	61.8	68.5
8	52.5	54.8	57.6	61.7	69.3	52.4	54.9	58.7	64.7	72.2
9	54.1	56.4	59.4	63.9	72.5	53.9	56.6	60.9	67.5	75.8
10	55.6	58.1	61.3	66.1	75.7	55.5	58.3	63.0	70.3	79.5
11	57.2	59.8	63.2	68.3	78.9	57.0	60.0	65.1	73.1	83.2
12	58.7	61.5	65.0	70.5	82.1	58.6	61.7	67.3	75.9	86.9
13	60.3	63.2	66.9	72.7	85.3	60.2	63.4	69.4	78.8	90.5
14	61.8	64.9	68.7	74.9	88.5	61.7	65.1	71.5	81.6	94.2
15	63.4	66.6	70.6	77.1	91.7	63.3	66.8	73.6	84.4	97.9
16	64.9	68.3	72.5	79.3	94.9	64.8	68.5	75.8	87.2	101.6
17	66.5	70.0	74.3	81.5	98.2	66.4	70.3	77.9	90.0	105.2
18	68.0	71.7	76.2	83.7	101.4	68.0	72.0	80.0	92.9	108.9

Source: Fernández *et al* (2004)

APPENDIX 5: MINISTRY OF EDUCATION APPROVAL LETTER

LAGOS STATE GOVERNMENT
MINISTRY OF EDUCATION

The Secretariat,
Block No.:5
Alausa-Ikeja.
PMB No.:2104311
Ikeja.

E-mail: edunet.lagosstate.gov.ng
Website: www.lagosstate.gov.ng

Ref. No: LED/ADM.6/S.1/60

Date: 9th March, 2010

Oluwatoyin Ogboye (Miss),
Health Sciences Research Institute,
University of Warwick,
Conventry,
CV474L.

RE: REQUEST TO HAVE ACCESS TO SECONDARY SCHOOLS

I am directed to convey approval of the Ministry to you to carry out research in Public Secondary Schools in Lagos State that would make a significant contribution to the knowledge of high blood pressure or hypertension which has been reported among children and adolescent worldwide.

2. However, the approval is given on the following conditions:-
   - i) The research should be conducted at no cost to Government or the students.
   - ii) No student should be forced to participate in the research.
   - iii) A signed parental consent form must be obtained on any student that participates in the research.
   - iv) All results from the test must be confidential and related to the parents.
   - v) If at any time, adverse reports on the conduct of the research are received by the Ministry, the approval will be withdrawn.
   - vi) The researcher should please ensure strict compliance with the rules and regulations of the host schools.
   - vii) Officers of BES Department and the Education Districts should monitor the exercise.

3. Grateful for your cooperation.

A.O.Olaogun (Mrs.)
For: Permanent Secretary

PROVIDING THE CITIZENS WITH GOOD QUALITY EDUCATION IN PARTNERSHIP WITH COMPETENT TEACHERS IN A CONDUCIVE TEACHING AND LEARNING ENVIRONMENT.

APPENDIX 6: CMUL, RESEARCH GRANTS AND EXPERIMENTATION ETHICS COMMITTEE APPROVAL LETTER

COLLEGE OF MEDICINE
UNIVERSITY OF LAGOS
P.M.B. 12003, LAGOS, NIGERIA

Provost: O. A. ATOYEBI, *MB, BS, (Hons), Lagos, FMCS, FWACS, FICS*

Deputy Provost: A. F. FAGBENRO-BEYIOKU, *B.Sc. (George Town), M.Sc. (Chicago), Ph.D. (Lagos)*

College Secretary: O.O.AMODU (MRS.), *B.A. (Hons.) PGDPA (Ife), MNIM.*

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234- 1- 5835629 (Direct Line)
E-mail: collegeofmedicine@unilag.edu.ng

CM/COM/8/VOL.XXI

May 17, 2010

Miss Oluwatoyin Ogboye
c/o Dr. P.C. Campbell
Department of Community Health & Primary Care
College of Medicine
Idi-Araba

Dear Dr. Campbell,

RE: ETHICAL APPROVAL

The Research Grants and Experimentation Ethics Committee met on **Wednesday, May 12, 2010** and considered your application for **Ethical Clearance** for a research proposal titled **"Blood Pressure of Children and Adolescent in Nigeria".**

On behalf of the Committee, I am pleased to inform you that **Ethical Approval** has been given to you to conduct the research titled **"Blood Pressure of Children and Adolescent in Nigeria".**

We wish you success in you research efforts. Please send us a copy of the report when completed.

Thank you.

Yours sincerely,

Beyioku 17/5/10

Prof. A.F. Fagbenro-Beyioku
Chairman, Research Grants & Experimentation Ethics Committee, CMUL

APPENDIX 7: BIOMEDICAL RESEARCH ETHICS COMMITTEE APPROVAL LETTER

Warwick
Medical School

2 June 2010

Oluwatoyin Ogboye
LS725
Lakeside
University of Warwick
Coventry
CV4 7AL

Dear Toyin

Blood Pressure of Children and Adolescents in Nigeria

Thank you for submitting your revisions for the above-named project to the University of Warwick Biomedical Research Ethics Sub-Committee for Chair's Approval.

As you know BREC approved your revisions some time ago but has been waiting for clarification from the University that adequate indemnity and sponsorship arrangements for your study are in place. I am pleased to confirm that the University has now secured the necessary insurance cover in Nigeria which in turn means the University is able to sponsor your study.

It is with pleasure that I confirm that the revised documentation now meets the required standard which means that full approval is granted and your study may commence. I take this opportunity to wish you every success with your research and to remind you that any substantial amendments require approval from the Committee.

Yours sincerely

Professor Jill Thistlethwaite
Deputy Chair
Biomedical Research
Ethics Sub-Committee

Copy:
Academic Supervisors: Margaret Thorogood, Aileen Clarke and Kandala Ngianga-Bakwin

APPENDIX 8: LETTER TO PRINCIPAL/HEAD TEACHER

Invitation to Principal/Head Teacher

Health Sciences Research Institute
Warwick Medical School
University of Warwick
Coventry
CV4 7AL

Dear Principal/Head Teacher,

Invitation to participate
I would like to invite you and your school to participate in this interesting research study on blood pressure of children and adolescents in Nigeria. My name is Oluwatoyin Ogboye. I am currently undergoing a PhD in Health Sciences programme at the University of Warwick, United Kingdom. In fulfilment of my doctoral degree I am required to carry out an original research.

My proposed research would require the participation of secondary school pupils aged 11 to 18 years in Lagos State. My study will involve measuring blood pressure, body weight, height and waist, and also asking all pupils to complete a questionnaire about them (for example: age), their living environment and stage of body development during school time. It will potentially identify individuals at an early age with possibility of having high blood pressure so as to get the most out of their health in future.

With your approval I will provide an information sheet for the selected pupils as well as send out a letter to their parents/carers to read 2 weeks beforehand. The letter will include information about the project and include a consent form (to be returned to the school) for those who want their child/ward to participate. Consent will be obtained directly from pupils on the day of the measurements and questionnaire.

Before you decide whether you want your school to participate, it is important that you understand why the research is being done and what it will involve. Please take time to read the information sheet below carefully and discuss it with others, if you wish.

If you would like your school to participate then please complete the consent form attached to this letter. I will contact you soon to discuss the feasibility of the research in your school.

Enclosed with this letter is:
Principal or Head Teacher's information and consent form
information and consent for pupils
information and consent for parents/carers
the questionnaire to be used.

I look forward to meeting you. Please do not hesitate to contact me if you would like any further information or further details.

Yours sincerely,

Oluwatoyin Ogboye
Telephone: +44(0)7899684918 or +234(0)7028366209.
Email: Oluwatoyin.Ogboye@warwick.ac.uk

Principal or Head Teacher Information sheet

Why is the study being carried out?

Sometimes young people may have high blood pressure or hypertension. After a while, high blood pressure in young people if not identified and treated appropriately can cause health problems when they become adults. I am carrying out this study to identify young people who are likely to have high blood pressure so that they may have the most out of their health in future. It will give information for promoting health across schools.

What does the research involve?

With your approval I will provide an information sheet for the selected pupils as well as send out a letter to their parents/carers to read 2 weeks beforehand. The letter will include information about the study and include a consent form (to be returned to the school before the study day) for those who want their child/ward to participate. If the pupils are happy to take part, they will be asked to sign a consent form on the day of the measurements and questionnaire. Then pupils will be given a questionnaire which contain questions about them (e.g. age), their living environment and stage of body development to complete and blood pressure, body weight, height and waist will be measured.

Does a school have to take part?

Taking part in the research is entirely voluntary.

What happens if my school does not want to take part?

There is no pressure to take part. If you do not want your school to take part, it should just indicate that to me.

Does the research have ethics committee approval?

Ethical approval has been obtained from the Warwick Biomedical Research Ethics Committee.

Will we pay you or your pupils for taking part?

The ethics committee does not allow us to offer the pupils incentives to take part. But, with your permission we would like to recognise the time that pupils and the school have devoted to our study by giving a small chocolate bar/biscuit or equivalent to all pupils in classes completing measurements and questionnaire. In addition a number of books will be donated to the school library.

Can I see my pupils' answers?

No, but you will be able to have a blank copy of the questionnaire attached with this sheet.

Can I know my pupils' blood pressure measurement?

No, all information obtained from your pupils will be kept confidential and blood pressure measurement information of all your pupils will be communicated to their parents/carers in writing. Further action would be advised to parents/carers if necessary.

What will happen if my pupil's blood pressure measurement is found to be higher than his or her peers?

If your pupil's blood pressure measurement is found to be higher than his or her peers, a letter will be sent to their parents/carers informing and advising them as a precaution to have your pupil's blood pressure checked next time they have a visit with a doctor. If necessary, in addition to a letter, the parents/carers will be contacted directly (e.g. via mobile) to inform and advise them to consult a doctor for further medical examination.

What will happen to the results of the research study?

The finding of the study will be written up in fulfilment of a doctoral degree in Health Sciences from the University of Warwick. The report will be used to identify high risk individuals for hypertension at an early age so as to maximise their health in future; and also to better understand the factors associated with high blood pressure in young people in Nigeria. The anonymised results will also be published in journals and presented at conferences.

When I have finished the study, I will send a summary of the results to the schools. Everything will be fully anonymised: no individual person measurements or their responses to the questionnaire will be shown to anyone.

Could taking part in this study do my pupils any harm?

Taking blood pressure, body weight, height and waist measurements and filling a questionnaire on your pupil's living environment and stage of body development will not cause pain to your pupil or harm your pupil in any way. However, identifying their stage of body development may make your pupil feel uncomfortable. If your pupil is affected he or she could talk to their teacher, parents/carers or researcher or contact the school counsellor.

What do I do if I have any major complaints about the research?

You can address your major complaints to the Deputy Registrar, who has overall responsibility for governance throughout the University of Warwick. Please find details below:

Ken Sloan
Deputy Registrar
Deputy Registrar's Office
University of Warwick
Coventry
CV4 8UW
Telephone: 024 7652 2713
E-mail: Ken.Sloan@warwick.ac.uk

Can my pupils change their mind after they agree taking part?

Pupils can change their mind at any time about taking part in the study. They can let the school know.

Thank you for taking the time to read this information

Principal/Head Teacher Consent Form

Project Title: Blood Pressure of Children and Adolescents in Nigeria

Please tick □ the boxes

1. I confirm that I have read and understood the attached information sheet relating to my pupils participating as part of the above named study and I have had the opportunity to ask questions about the project.

2. I understand that the information from this project will be kept completely anonymous at all times.

3. I understand that the anonymised findings will be:

□ available to me in summary.

□ disseminated at conferences and meetings, specifically at national and international conferences.

□ written up for peer-reviewed journal publications. No publications from this project will reveal the identity of any participant individual or school.

4. I understand that the participation of my school is voluntary and that we are free to withdraw at any time without giving any reason and without being penalised or disadvantaged in any way.

5. I understand that the names of participating pupils will not be revealed. The information they provide will be treated in the STRICTEST CONFIDENCE. The completed forms will not be seen by me or any of the school staff or parents.

6. I agree that my school can take part in the above study and I am willing to:

1. Facilitate the researchers of this project to administer individual questionnaires to pupils.
2. Facilitate the researchers of this project to perform measurements on the pupils.

Name of Principal/ Head Teacher______________	Date ______________	Signature _______________

Name of person taking consent ______________	Date ___________	Signature _______________

APPENDIX 9: LETTER TO STUDENT

Student Invite and Information Sheet

Hello!

You are being invited to take part in a research study on blood pressure in young people which would involve measurement of your blood pressure, height, weight and waist, and filling a questionnaire.

Sometimes young people may have high blood pressure or hypertension. After a while, high blood pressure in young people if not identified and treated appropriately can cause health problems when they become adults. I am carrying out this study to identify young people who are likely to have high blood pressure so that they may have the most out of their health in future. It will give information for promoting health across schools.

This information sheet explains what will happen in the study. All information will NOT be shown to anyone (e.g. friends, parents/carers, principal, teachers e.t.c.) and no individual student taking part in the study will be identified.

Please take time to read this information carefully to decide whether or not you would like to take part. You might want to discuss it with others (teacher, friends, parents/carers, researcher).

Why have I been chosen for this study?

I am conducting this study in Lagos State secondary schools and your school has agreed to take part. I am inviting you because you are the right age to take part in this research.

What does the research involve?

I will attend your school in two weeks time. If you decide to take part, you will be asked to sign a consent form.

What do the measurements involve?

The measurements will include your blood pressure, body weight, height and waist. Your measurements will be confidential that means it will NOT me shown to anyone. None of the other pupils, staff, principals or head teachers will know your measurements are.

What does the questionnaire involve?

The questionnaire contain questions about you (e.g. your age) and questions about your living environment and stage of body development. Once you have completed the consent form, you will be given the questionnaire to complete and return in a sealed envelope. There are no right or wrong answers. I just want to find out what you think. None of the other pupils, staff, principals or head teachers or your parents will know what your answers to the questionnaire are.

Do I have to take part?

No. It is completely your choice whether you take part or not.

What happens if I don't want to take part?

If you do not want to take part you can let the school know or let the researcher know on the day of the study. There is no pressure to take part in this study.

Will my answers and measurements be shown to anyone?

No, your answers and measurements will not be shown to anyone (e.g. friends, parents/carers, principal, teachers e.t.c), but, your blood pressure measurement information will be sent to your parents/carers in writing.

What will happen if my blood pressure measurement is found to be higher than my peers?

If your blood pressure measurement is found to be higher than your peers, a letter will be sent to your parents/carers informing and advising them as a precaution to have your blood pressure checked next time you have a visit with a doctor. If necessary, your parents/carers will be contacted directly (e.g. through mobile) to inform and advise them to check with a doctor for additional medical examination.

What will happen to the results of the research study?

The overall results (with out any names of students) of the study will be written in research report in fulfilment of a doctoral degree. The results will also be published in journals and presented at conferences.

I will send a summary of the results to your school when I have finished my study. No individual person measurements or responses to the questionnaire will be shown to anyone.

Will my measurements and answers to the questionnaire affect how I am treated at school?

No. Your Principal or Head Teacher has agreed to you and your school being involved in the study. The measurements and answers to the questionnaire will be kept completely confidential – so neither your teachers nor anyone at your school can find out what your measurements and answers you give are.

Will we pay you for taking part?

No, but we would like to recognise your time by giving some chocolates (or equivalent) to classes with pupils having their measurements taken and completing a questionnaire. In addition a number of books will be donated to the school library.

Could taking part in this study upset me?

Taking blood pressure, body weight and height measurements and filling a questionnaire on your living environment and stage of body development will not cause you pain or harm you in any way. However, identifying your stage of body development may make you feel uncomfortable. If you are affected you could talk to your teacher, parents/carers, the researcher or contact the school counsellor.

What do I do if I have any major complaints about the research?

You can address your major complaints to the Deputy Registrar, who has overall responsibility for governance throughout the University of Warwick. Please find details below:

Ken Sloan
Deputy Registrar
Deputy Registrar's Office
University of Warwick
Coventry
CV4 8UW
Telephone: 024 7652 2713
E-mail: Ken.Sloan@warwick.ac.uk

Can I change my mind if I volunteer now but have second thoughts?

You can change your mind about taking part in the study at any time. You can let the school know.

What do I do next?

You can keep this information sheet. If you decide to take part, in about two weeks time you will be asked to sign a consent form and then your blood pressure, body weight, height measurements will be taken, and you will be given a questionnaire to complete.

Where can I get more information from?

If you would like to know more about this study or you have any other questions, you can ask your Principal or Head Teacher.

Thank you for taking the time to read this information

APPENDIX 10: LETTER TO PARENT/CARER

Health Sciences Research Institute
Warwick Medical School
University of Warwick
Coventry, CV4 7AL

Dear Parent/Carer,

I am inviting pupils aged 11 to 18 years old from your child's/ward's school to take part in a research study which would involve measurement of your blood pressure, height, weight and waist, and filling a questionnaire.

Sometimes young people may have high blood pressure or hypertension. After a while, high blood pressure in young people if not identified and treated appropriately can cause health problems when they become adults. I am carrying out this study to identify young people who are likely to have high blood pressure so that they may have the most out of their health in future. It will give information for promoting health across schools.

This information sheet explains what will happen in the study. All information will be treated in the strictest confidence and no individual child/ward taking part in the study will be identified.

Before you decide whether your child/ward should take part, it is important that you understand why the research is being done and what it will involve. Please take time to read the information below carefully and discuss it with others, if you wish.

If you would like your child/ward to take part in this research, kindly complete the attached form and return it to the school within 14 days of receiving this letter. Please do not hesitate to contact the school if you would like any further information or further details.

Yours sincerely,

Oluwatoyin Ogboye
Telephone: +44(0)7899684918 or +234(0)7028366209.
Email: Oluwatoyin.Ogboye@warwick.ac.uk

Parent/Carer Information sheet

Why has my child/ward been chosen to take part?

I am conducting this study in Lagos State secondary schools and your child's/ward's school has agreed to take part.

What does the research involve?

I will visit your child's/ward's school in about 2 weeks. Your child/ward will have been given information about the study and if your child/ward is happy to take part, he or she will be asked to sign a consent form. Then students will be given a questionnaire which contains questions about them (e.g. age), their living environment and stage of body development to complete and blood pressure, body weight, height and waist will be measured.

Does your child/ward have to take part?

Taking part in the research is entirely up to you and your child/ward. You or your child/ward is free to opt out at any time.

What happens if I do not want my child/ward to take part?

If you do not want your child/ward to take part, you do not need to do anything. Please do not fill in or return the form at the end of this letter to the school. There is no pressure to take part in this study.

Can I see my child's/ward's answers?

No, but you will be able to request a blank copy of the questionnaire if you wish.

Can I know my child's/ward's blood pressure measurement?

Yes. All information obtained from your child/ward will be kept confidential, but, blood pressure measurement information of your child/ward will be sent to you in writing. Further action would be advised if necessary.

What will happen if my child's/ward's blood pressure measurement is found to be higher than his or her peers?

If your child's/ward's blood pressure measurement is found to be higher than his or her peers, a letter will be sent to you informing and advising you as a precaution to have your child's/ward's blood pressure checked next time they have a visit with a doctor. If necessary, in addition to a letter, you will be contacted directly (e.g. via mobile) to inform and advise you to consult a doctor for further medical examination.

What will happen to the results of the study?
All the results of this research will be kept completely anonymously at all times. None of the other pupils, staff, principals, head teachers or researcher will know what your child's/ward's measurements or answers to the questionnaire are.

The overall findings of the study will be written in research report in fulfilment of a doctoral degree. The anonymised results will also be published in journals and presented at conferences. I will send a summary of the results to the school.

Will your child's/ward's measurements or answers in the questionnaire affect how he or she is treated at school?
The Principal or Head teacher has agreed to your child's/ward's school being involved in the study. Whatever your child's/ward's measurements or answers will not be reported back to any of their teachers or to anyone at the school. Your child/ward will not be treated any differently at school if you or they decide that they do not want to participate.

Does the research have ethics committee approval?
Ethical approval has been obtained from the Warwick Biomedical Research Ethics Committee.

Will the pupils be paid for taking part?
No, but we would like to recognise the time that pupils have devoted to our study by giving some chocolates (or equivalent) to classes with pupils being measured and completing questionnaires. In addition a number of books will be donated to the school library.

Could taking part in this study do my child/ward any harm?
Taking blood pressure, body weight, height and waist measurements and filling a questionnaire on your child's/ward's living environment and stage of body development will not cause pain to your child/ward or harm your child/ward in any way. However, identifying their stage of body development may make your child/ward feel uncomfortable. If your

child/ward is affected he or she could talk to their teacher, parents/carers, the researcher or contact the school counsellor.

What do I do if I have any major complaints about the research?

You can address your major complaints to the Deputy Registrar, who has overall responsibility for governance throughout the University of Warwick. Please find details below:

Ken Sloan
Deputy Registrar
Deputy Registrar's Office
University of Warwick
Coventry
CV4 8UW
Telephone: 024 7652 2713
E-mail: Ken.Sloan@warwick.ac.uk

Does my child/ward know about the study?

Yes, they have been given an information sheet like this one at school.

Can I change my mind about my child/ward taking part?

You can change your mind about your child/ward taking part in the study at any time by letting the school know.

What do I do next?

If you decide that you are happy for your child/ward to take part in this research, please complete the form attached to this sheet and return it to the school within 14 days of receiving this letter.

Where can I get more information from?

If you would like to know more about this study or you have any other questions, you can ask the school Principal or Head Teacher.

Thank you for taking the time to read this information

Parent/Carer Consent Form

Project Title: Blood Pressure of Children and Adolescents in Nigeria

Please tick ✓ the boxes

1. I confirm that I have read and understood the attached information sheet relating to my child/ward filling in a questionnaire and taking measurements as part of the above named study and I have had the opportunity to ask questions about the project. ☐

2. I understand that the information from this project will be kept completely confidential at all times and that any reports from this study will NOT reveal the identity of my child/ward. ☐

3. I understand that taking part in this study is a choice and that I and my child/ward can withdraw at any time without giving a reason and without being treated differently at school or disadvantaged in any way. ☐

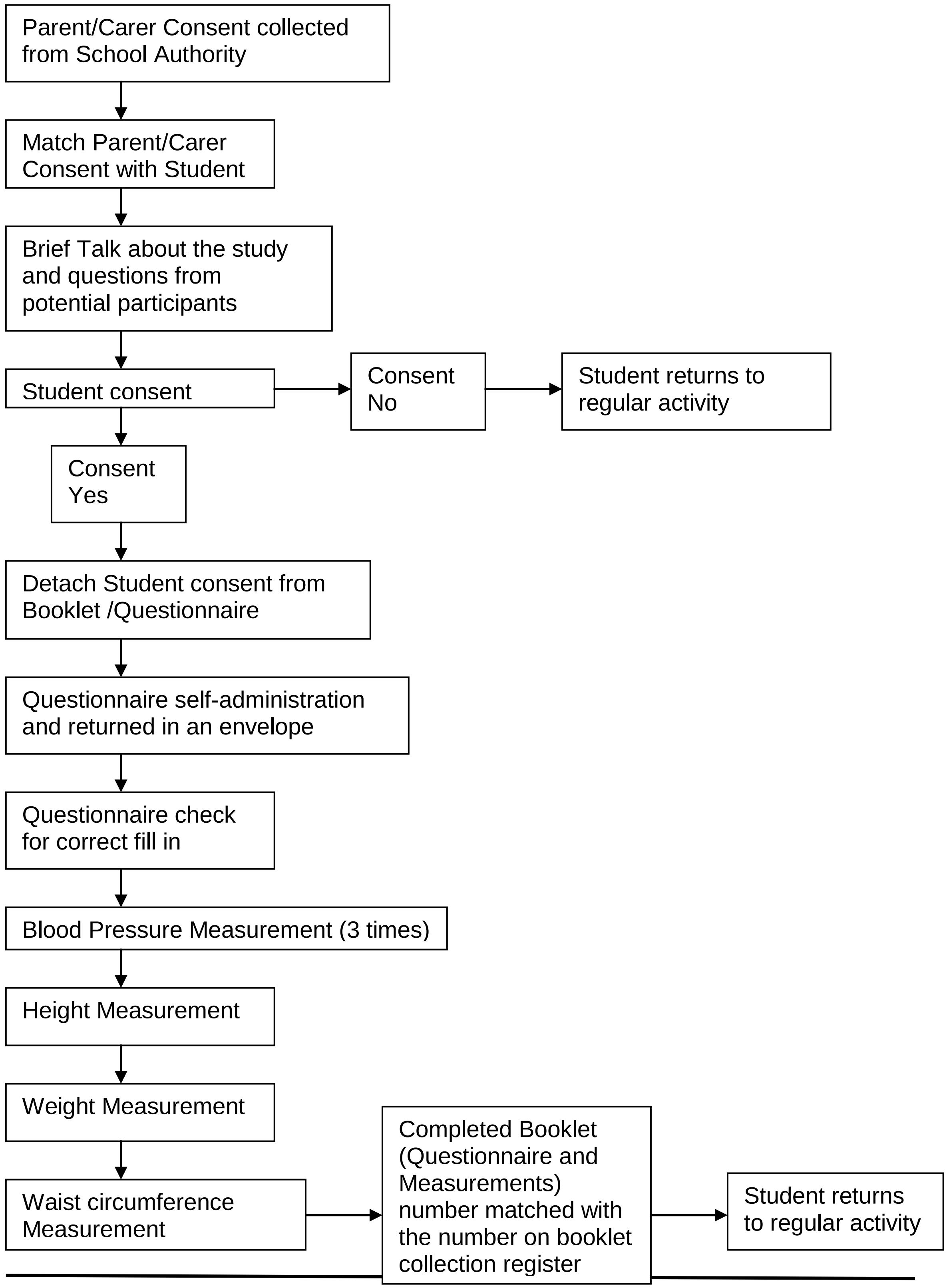
4. I understand that if my child's/ward's blood pressure is higher than his or her peers I will be sent a letter informing and advising me to consult a doctor; and if necessary I would be contacted directly (e.g. via mobile) in addition to the letter. ☐

5. I agree that my child/ward can take part in the above named study. ☐

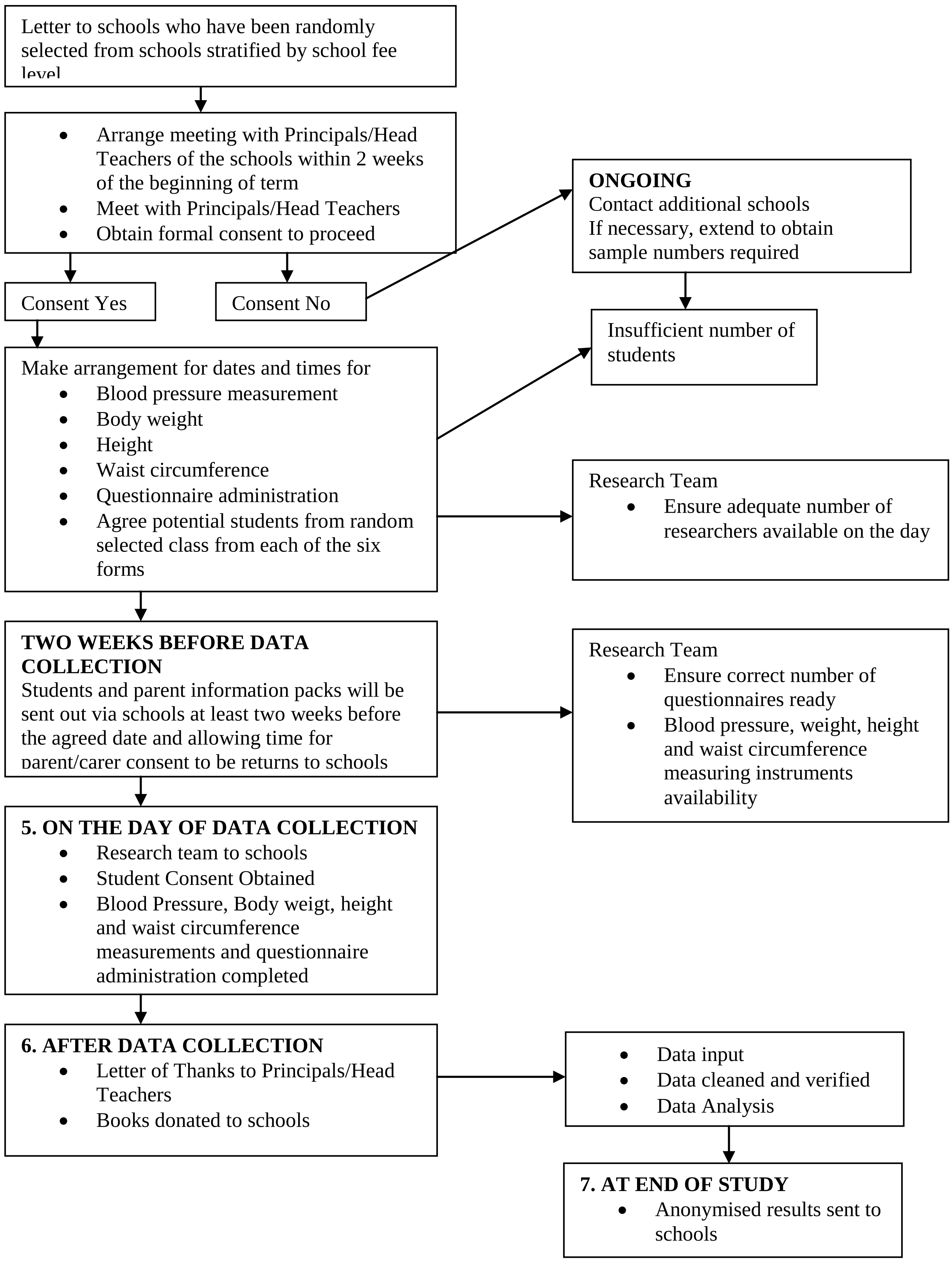
____________________	____________________	____________________
Name of Parent/ Carer	**Date**	**Signature**

____________________	____________________
Name of child/ward	**Form/Class**

APPENDIX 11: STANDARD OPERATING PROCEDURE (SOP) FOR THE STUDY IN THE SCHOOLS



APPENDIX 12: FLOW CHART FOR THE STUDY IN SCHOOLS



APPENDIX 13: SURVEY QUESTIONNAIRE FOR BOYS

Student Consent Form

Project Title: Blood Pressure of Children and Adolescents in Nigeria

Please tick ✓ the boxes

1. I confirm that I have read and understood the attached information sheet relating to me participating as part of the above named study and I have had the opportunity to ask questions about the project. ☐

2. I understand that anonymous information will be used in reports the researcher but it will not be possible to identify me from the reports. ☐

3. I understand that my participation is voluntary and that I am free to withdraw at any time without giving any reason and without being penalised or disadvantaged in any way. ☐

4. I understand that my name will not be revealed. I understand that my measurements and answers will be made confidential so that no-one – including my fellow students, teachers and parents/carers - will know what my measurements and answers to these questions are. ☐

5. I understand that if my blood pressure is higher than my peers my parents/carers will be sent a letter informing and advising them to check with a doctor; and if necessary my parents/carers would be contacted directly (e.g. via mobile) in addition to the letter. ☐

6. I agree that to take part in the above study and I am willing to:
1. fill in a questionnaire.
2. undergo blood pressure, body weight, height and waist measurements. ☐

Name of Principal/ Head Teacher________________ Date ________________ Signature __________________

Name of person taking consent ________________ Date _____________ Signature __________________

Dear Survey Participant,

We are asking you to take part in a research study on blood pressure in young people. The information you provide will help us to better identify young people who are likely to have high blood pressure so that they can make the most of their health in future.

I would like to ask you to answer a few questions that should take a short time to complete. Although some of the questions are quite personal, we assure you that your answers will be kept entirely confidential, that is they will not be shared with anyone including your fellow students, teachers and parents/guardians. Your name will be separated from all your answers and will not be used in any reports about this information. For each question below, please write in the answer or place a check mark (✓) in the box.

I want to thank you for your contribution.

How to answer the questions

- Please read each question carefully.
- There are no right and wrong answers — this is **not** a test.
- Please answer all the questions as honestly and accurately as you can — this is very important.
- Most of the questions can be answered by putting a tick ✓ in the box that applies to you, for example: ☑
- If it is difficult to choose put a tick in the box that is most true for you at the time, using your best guess.
- Sometimes you should write an answer.
- Please write clearly and in big letters on the line (for example see below).

In the last year, what sports or physically active games did you play outside of school? (***Please write on the dotted lines and tick (✓) only one box for each line***).

I played (Please specify/write)	Regularly	Often	Sometimes
Dancing............................	☐	☑	☐

- If you want to change an answer just cross it out and put in the new answer as clearly as you can.

Section 1

This section is to be completed by all participants. I assure you that your answers will be completely confidential.

Below are some questions about you and your health.

Please Tick (✓) ONE box only

1). How old are you? ....

2). Are you a: A. Boy ☐ B. Girl ☐

3). Are you: A. Hausa ☐ B. Igbo ☐ . Yoruba ☐ Other ☐

4). Are you: A. Christian ☐ B. Muslim ☐ C. Other ☐

5). Who do you currently live with most of the time?

A. Parents ☐ B. Grandparents ☐ C. Other relatives ☐ D. Non-Relatives ☐

6). In the last year, what sports did you play in school? (***Please write on the dotted lines and tick (✔) only one box for each line***).

No sport ☐

I played (Please specify/write)	Regularly	Often	Sometimes
....	☐	☐	☐
I played (Please specify/write)	Regularly	Often	Sometimes
....	☐	☐	☐
I played (Please specify/write)	Regularly	Often	Sometimes
....	☐	☐	☐
I played (Please specify/write)	Regularly	Often	Sometimes
....	☐	☐	☐

7). In the last year, what sports or physically active games did you play outside of school? (***Please write on the dotted lines and tick (✔) only one box for each line***).

No sport or physically active game ☐

I played (Please specify/write)	Regularly	Often	Sometimes
....	☐	☐	☐
I played (Please specify/write)	Regularly	Often	Sometimes
....	☐	☐	☐
I played (Please specify/write)	Regularly	Often	Sometimes
....	☐	☐	☐
I played (Please specify/write)	Regularly	Often	Sometimes
....	☐	☐	☐

8). When I play sports or games I sweat: (***Please tick (✔) only one box***).

Very often ☐ Often ☐ Sometimes ☐ Seldom ☐ Never ☐

9). During leisure time I play sports: (***Please tick (✔) only one box***).

Very often ☐ Often ☐ Sometimes ☐ Seldom ☐ Never ☐

10). During leisure time do you watch television or read: (***Please tick (✔) only one box***).

Never ☐ Seldom ☐ Sometimes ☐ Often ☐ Very often ☐

11). How often do you walk and/or bicycle to and from school? (***Please tick (✔) only one box***).

Very often ☐ Often ☐ Sometimes ☐ Seldom ☐ Never ☐

12). What house work/chores do you do at home that are physically active and how often do you do them? ***Please write on the dotted lines and tick (✔) only one box for each line***).

No chore ☐

House work/Chore (Please specify/write)	Regularly	Often	Sometimes
....	☐	☐	☐
....	☐	☐	☐
....	☐	☐	☐
....	☐	☐	☐

13). When I do chores/house work I sweat: (***Please tick (✔) only one box***).

Never ☐ Seldom ☐ Sometimes ☐ Often ☐ Very often ☐

14). Do you have any long standing illness or disease such as sickle cell, diabetes, asthma, kidney disease or heart problem? 1. Yes ☐ 2. No ☐

15). If **yes**, write the name of the illness or disease; if **no** write "None".

....

16). Are you currently taking any medicine? 1. Yes ☐ . No ☐

17). If **yes**, write the name of the medicine and what the medicine is for?

....

18). ***Please tick (✔) only one box***.

A). Do you usually add salt to prepared food on your plate before tasting it? ☐

B). Do you usually add salt to prepared food on your plate after tasting it? ☐

C). Do you usually eat food on your plate as it was prepared, without adding salt? ☐

Section 2

This section is to be completed by all participants. Again I assure you that your responses will be completely confidential and will not be used for any other purpose.

Below are some questions about your parents/guardians, members of your household and your living environment.

Please Tick (✓) ONE box only

19). What is the highest education of your father/male guardian?

A). Did not attend school ☐ B). Primary school ☐ C). Secondary school ☐

D). Polytechnic ☐ E). University ☐ F). I do not know ☐

20). What is the highest education of your mother/female guardian?

A). Did not attend school ☐ B). Primary school ☐ C). Secondary school ☐

D). Polytechnic ☐ E). University ☐ F). I do not know ☐

21). What is the main source of drinking water for members of your household? (***Please tick (✓) only one box***).

A). Piped Tap water (Indoor) ☐

B). Piped Tap water (Outside in the compound) ☐

C). Public Tap water/Standpipe water (Outside the compound) ☐

D). Borehole ☐

E). Dug Well ☐

F). Rainwater ☐

G). Tanker Truck ☐

H). Cart with Small Tank ☐

I). Surface water (for example - river/lake/pond/stream/canal/irrigation channel) ☐

J). Bottled water ☐

K). Sachet water ☐

L). Other (specify/write) ....

22). Where is the water source located?

A). Indoor ☐

B). Outside in the compound ☐

C). Elsewhere ☐

23). If the water source located **elsewhere**, how long does it take to go there, get water and come back?

Minutes ....

Don't Know ☐

24). Do you do anything to make the water safer to drink?

1. Yes ☐ 2. No ☐ 3. Don't Know ☐

25). If **yes**, what do you usually do to make the water safer to drink? (***Please tick (✓) only one box***).

A). Boil ☐

B). Add Bleach/Chlorine/Chemical ☐

C). Strain through a Cloth ☐

D). Use Water Filter (Ceramic/Sand/Composite/e.t.c.) ☐

E). Solar Disinfection ☐

F). Let It Stand and Settle ☐

G). Other (specify/write) ....

H). Don't Know ☐

26). What kind of toilet facility do members of your household usually use? (***Please tick (✔) only one box***).

A). Flush or pour flush toilet inside house ☐

B). Flush or pour flush toilet outside house ☐

C). Pit latrine ☐

D). Composite toilet ☐

E). Bucket toilet ☐

F). Hanging Toilet/Hanging Latrine ☐

G). No toilet facility/bush/field ☐

H). Other (specify/write) ....

27). Do you share this toilet facility with other households? 1. Yes ☐ No ☐

28). How many households use this toilet facility?

A). Number of Household if less than 10 | 0 | |

B). 10 or more Households ☐

C). Don't Know ☐

29). ***Please answer all questions***. Does your household have:

A). A bed? 1. Yes ☐ 2. No ☐

B). A sofa/couch/settee? 1. Yes ☐ 2. No ☐

C). A chair? 1. Yes ☐ 2. No ☐

D). A table? 1. Yes ☐ 2. No ☐

E). A cupboard/cabinet? 1. Yes ☐ 2. No ☐

F). Electricity? 1. Yes ☐ 2. No ☐

G). A radio? 1. Yes ☐ 2. No ☐

H). A television? 1. Yes ☐ 2. No ☐

I). A mobile telephone? 1. Yes ☐ 2. No ☐

J. A non-mobile telephone/land line? 1. Yes ☐ 2. No ☐

K). A Fridge or Freezer? 1. Yes ☐ 2. No ☐

L). An ipod/mp3 player? 1. Yes ☐ 2. No ☐

M). An electric fan? 1. Yes ☐ 2. No ☐

N). Microwave? 1. Yes ☐ 2. No ☐

O). Desk top computer /Laptop? 1. Yes ☐ 2. No ☐

P). Generator? 1. Yes ☐ 2. No ☐

Q). Internet access: 1. Yes ☐ 2. No ☐

R). Air conditioner: 1. Yes ☐ 2. No ☐

S). Camera? 1. Yes ☐ 2. No ☐

T). VCR or DVD player? 1. Yes ☐ 2. No ☐

U). Cable/Satelite TV? 1. Yes ☐ 2. No ☐

30). What type of fuel does your household mainly use for cooking? (***Please tick (✓) only one box***).

A). Electricity ☐ B). Gas ☐ C). Kerosene ☐ D). Charcoal ☐

E). Wood ☐ F). Straw/shrubs/grass ☐ G). Agricultural crop ☐

H). Animal dung ☐ I). No food cooked in household ☐

J). Other (specify/write) ....

31). Is the cooking usually done in the house, in a separate building, or outdoors?

A). In the house ☐ B). In a separate building ☐ C). Outdoors ☐

D). Other (specify/write) ....

32). If cooking is done **inside** the house, do you have a separate room which is used as a kitchen? 1. Yes ☐ 2. No ☐

33). What is the main material of the floor in your house? (***Please tick (✔) only one box***).

A). Earth/Sand ☐

B). Dung ☐

C). Wood Planks ☐

D). Palm/Bamboo ☐

E). Parquet or Polished Wood ☐

F). Vinyl (plastic material) or Asphalt (tar) Strips ☐

G). Ceramic Tiles ☐

H). Cement ☐

I). Carpet ☐

J). Other (specify/write) ....

34). What is the main material of the roof of your house? (***Please tick (✔) only one box***).

A). No Roof ☐

B). Thatch/Palm Leaf ☐

C). Sod (grass) ☐

D). Rustic Mat ☐

E). Palm/Bamboo ☐

F). Wood Planks ☐

G). Cardboard ☐

H). Metal (iron, zinc, aluminium), "*Panu*" ☐

I). Wood ☐

J). Asbestos ☐

K). Ceramic Tiles ☐

L). Cement ☐

M). Other (specify/write) ……………………………………………………………

35). What is the main material of the exterior wall of your house? (***Please tick (✔) only one box***).

A). No Walls ☐

B). Cane/Palm/Trunks ☐

C). Dirt ☐

D). Bamboo with Mud ☐

E). Stone with Mud ☐

F). Plywood ☐

G). Cardboard ☐

H). Reused Wood ☐

I). Cement ☐

J). Stone with Lime/Cement ☐

K). Bricks ☐

L). Cement Blocks ☐

M). Wood Planks/Shingles ☐

N). Other (specify/write) ....

36). How many rooms in your household are used for sleeping? ....

37). What is the number of adults and children living in your household?

Adults (age 18 years and over) .... Children (under age 18 years) ....

38). ***Please answer all questions***. Does any member of your household own:

A). A watch? 1. Yes ☐ 2. No ☐

B). A bicycle? 1. Yes ☐ 2. No ☐

C). A motorcycle or motor scooter? 1. Yes ☐ 2. No ☐

D). An animal-drawn cart? 1. Yes ☐ 2. No ☐

E). A car or truck? 1. Yes ☐ 2. No ☐

F). A boat with an engine/motor? 1. Yes ☐ 2. No ☐

39). Does any member of your household own any farm/agricultural land?

1. Yes ☐ 2. No ☐

40). How many hectares of farm/agricultural land do members of your household own?

A). Hectares ☐☐ . ☐

B). 95 or more Hectares ☐

C). Don’t Know ☐

41). Does your household own any livestock, herds, other farm animals, or poultry?

1. Yes ☐ 2. No ☐

42). If yes, how many of the following animals does your household own?

If None write "0"

If you don't know write "Don't know"

Cattle	
Cows/Bulls	
Horse/Donkey/Mules	
Goats	
Sheep	
Chickens	

43). Does any member of your household have a bank account?

1. Yes ☐ 2. No ☐

Section 3

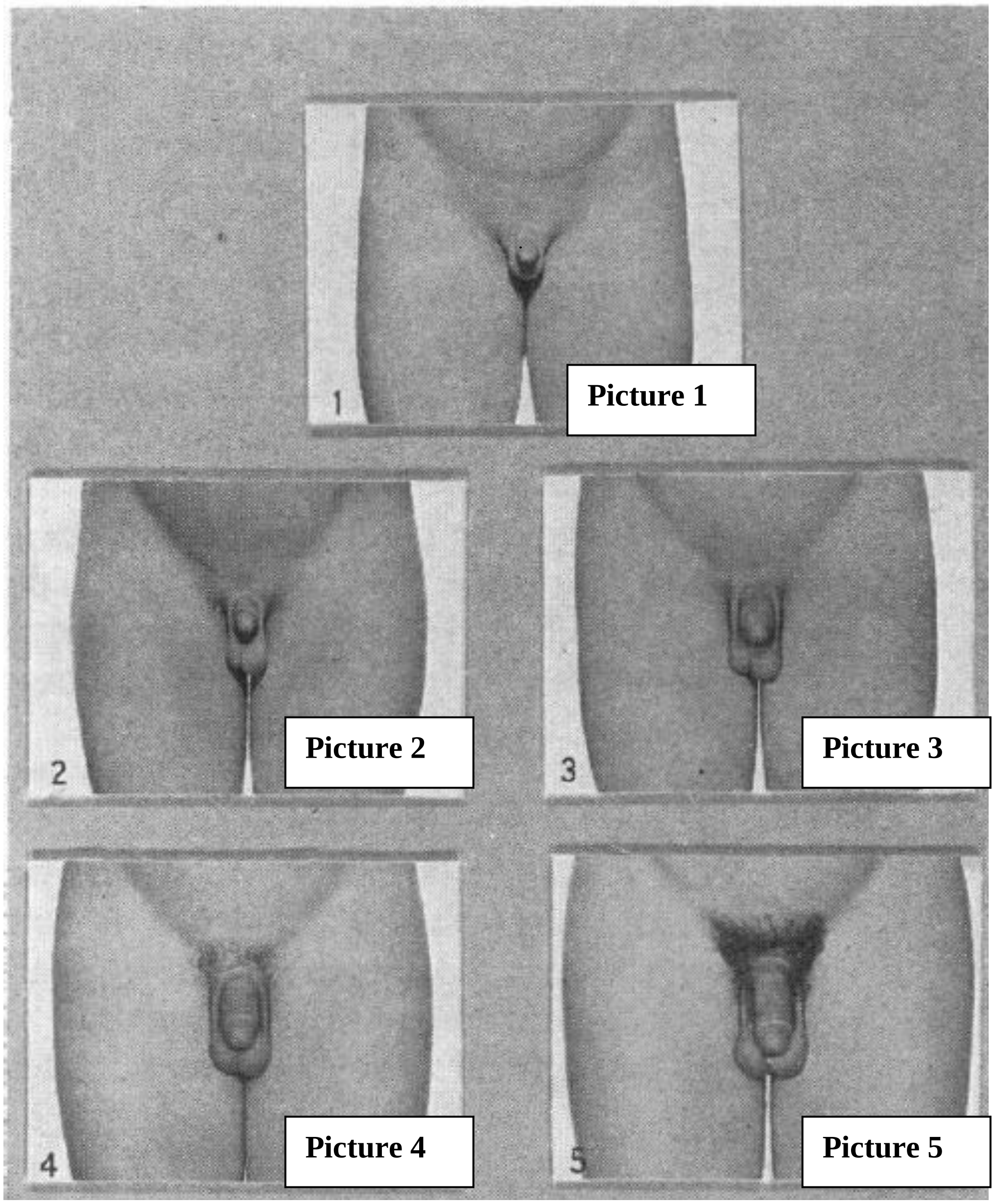
This section is to be completed by all participants. Again I assure you that your answers will be completely confidential.

Below is a question about your body development stage.

44). Please tick the picture number that best describes you from the number shown on each picture below (PLEASE TAKE NOTICE OF THE SIZE OF THE PENIS AND SCROTUM):

Please Tick (✔) ONE box only

Picture 1 ☐ Picture 2 ☐ Picture 3 ☐ Picture 4 ☐ Picture 5 ☐


1
Picture 1
2
Picture 2
3
Picture 3
4
Picture 4
5
Picture 5

Definitions of some words

Where is it	What's the word	What it means
Information section, Section 1, Section 2, Section 3	**Confidential**	Kept carefully. Confidential information is only released to specified individuals.
Section 1.	**Leisure time**	Free time before or after compulsory activities such as eating, sleeping, going to school, doing homework, house work/chores.
Section 1.	**Very Often**	**Very frequent**, e.g. within every week.
Section 1.	**Often**	**Frequent**, e.g. within every 1 month.
Section 1.	**Sometimes**	**From time to time**, e.g. within every 2-6 months.
Section 1.	**Seldom**	**Rarely**, e.g. within every 6-12 months.
Section 1.	**Regularly**	**Usually**, e.g. within every week.
Section 2.	**Guardian**	Someone who you live with all of the time, who is like a parent; and without any payment or fee is responsible for you and takes care of you.
Section 2.	**Household**	Your house, flat, room in multi-tenanted building (for example: "face me I face you"), family or people you live with.
Section 2.	**Hectares**	1 hectare = 10,000 square meters (m^2).

That's it!!!

Thank you for taking part!

Section 4

You don't need to fill in this section. This section is to be completed by the researcher. Once again I assure you of complete confidentiality of the results.

Weight (kg) ☐

Height (cm) ☐

	1st	2nd	3rd	Average
Systolic blood pressure (mmHg)				
Diastolic blood pressure (mmHg)				

Waist circumference (cm) ☐

APPENDIX 14: SURVEY QUESTIONNAIRE FOR GIRLS

Student Consent Form

Project Title: Blood Pressure of Children and Adolescents in Nigeria

Please tick ✓ the boxes

1. I confirm that I have read and understood the attached information sheet relating to me participating as part of the above named study and I have had the opportunity to ask questions about the project. ☐

2. I understand that anonymous information will be used in reports the researcher but it will not be possible to identify me from the reports. ☐

3. I understand that my participation is voluntary and that I am free to withdraw at any time without giving any reason and without being penalised or disadvantaged in any way. ☐

4. I understand that my name will not be revealed. I understand that my measurements and answers will be made confidential so that no-one – including my fellow students, teachers and parents/carers - will know what my measurements and answers to these questions are. ☐

5. I understand that if my blood pressure is higher than my peers my parents/carers will be sent a letter informing and advising them to check with a doctor; and if necessary my parents/carers would be contacted directly (e.g. via mobile) in addition to the letter. ☐

6. I agree that to take part in the above study and I am willing to:
1. fill in a questionnaire.
2. undergo blood pressure, body weight, height and waist measurements. ☐

Name of Principal/ Head Teacher______________ Date ______________ Signature ________________

Name of person taking consent ______________ Date ____________ Signature ________________

Dear Survey Participant,

We are asking you to take part in a research study on blood pressure in young people. The information you provide will help us to better identify young people who are likely to have high blood pressure so that they can make the most of their health in future.

I would like to ask you to answer a few questions that should take a short time to complete. Although some of the questions are quite personal, we assure you that your answers will be kept entirely confidential, that is they will not be shared with anyone including your fellow students, teachers and parents/guardians. Your name will be separated from all your answers and will not be used in any reports about this information. For each question below, please write in the answer or place a check mark (✓) in the box.

I want to thank you for your contribution.

How to answer the questions

- Please read each question carefully.
- There are no right and wrong answers — this is **not** a test.
- Please answer all the questions as honestly and accurately as you can — this is very important.
- Most of the questions can be answered by putting a tick ✓ in the box that applies to you, for example: ☑
- If it is difficult to choose put a tick in the box that is most true for you at the time, using your best guess.
- Sometimes you should write an answer.
- Please write clearly and in big letters on the line (for example see below).

In the last year, what sports or physically active games did you play outside of school? (***Please write on the dotted lines and tick (✓) only one box for each line***).

I played (Please specify/write)	Regularly	Often	Sometimes
Dancing............	☐	☑	☐

- If you want to change an answer just cross it out and put in the new answer as clearly as you can.

Section 1

This section is to be completed by all participants. I assure you that your answers will be completely confidential.

Below are some questions about you and your health.

Please Tick (✓) ONE box only

1). How old are you? ....

2). Are you a: A. Boy ☐ B. Girl ☐

3). Are you: A. Hausa ☐ B. Igbo ☐ C. Yoruba ☐ Other ☐

4). Are you: A. Christian ☐ B. Muslim ☐ C. Other ☐

5). Who do you currently live with most of the time?

A. Parents ☐ B. Grandparents ☐ C. Other relatives ☐ D. Non-Relatives ☐

6). In the last year, what sports did you play in school? (***Please write on the dotted lines and tick (✔) only one box for each line***).

No sport ☐

I played (Please specify/write)	Regularly	Often	Sometimes
....	☐	☐	☐
....	☐	☐	☐
....	☐	☐	☐
....	☐	☐	☐

7). In the last year, what sports or physically active games did you play outside of school? (***Please write on the dotted lines and tick (✔) only one box for each line***).

No sport or physically active game ☐

I played (Please specify/write)	Regularly	Often	Sometimes
....	☐	☐	☐
....	☐	☐	☐
....	☐	☐	☐
....	☐	☐	☐

8). When I play sports or games I sweat: (***Please tick (✓) only one box***).

Very often ☐ Often ☐ Sometimes ☐ Seldom ☐ Never ☐

9). During leisure time I play sports: (***Please tick (✓) only one box***).

Very often ☐ Often ☐ Sometimes ☐ Seldom ☐ Never ☐

10). During leisure time do you watch television or read: (***Please tick (✓) only one box***).

Never ☐ Seldom ☐ Sometimes ☐ Often ☐ Very often ☐

11). How often do you walk and/or bicycle to and from school? (***Please tick (✓) only one box***).

Very often ☐ Often ☐ Sometimes ☐ Seldom ☐ Never ☐

12). What house work/chores do you do at home that are physically active and how often do you do them? ***Please write on the dotted lines and tick (✓) only one box for each line***).

No chore ☐

House work/Chore (Please specify/write)	Regularly	Often	Sometimes
....	☐	☐	☐

House work/Chore (Please specify/write)	Regularly	Often	Sometimes
....	☐	☐	☐

House work/Chore (Please specify/write)	Regularly	Often	Sometimes
....	☐	☐	☐

House work/Chore (Please specify/write)	Regularly	Often	Sometimes
....	☐	☐	☐

13). When I do chores/house work I sweat: (***Please tick (✔) only one box***).

Never ☐ Seldom ☐ Sometimes ☐ Often ☐ Very often ☐

14). Do you have any long standing illness or disease such as sickle cell, diabetes, asthma, kidney disease or heart problem? 1. Yes ☐ 2. No ☐

15). If **yes**, write the name of the illness or disease; if **no** write "None".

....

16). Are you currently taking any medicine? 1. Yes ☐ . No ☐

17). If **yes**, write the name of the medicine and what the medicine is for?

....

18). ***Please tick (✔) only one box***.

A). Do you usually add salt to prepared food on your plate before tasting it? ☐

B). Do you usually add salt to prepared food on your plate after tasting it? ☐

C). Do you usually eat food on your plate as it was prepared, without adding salt? ☐

Section 2

This section is to be completed by all participants. Again I assure you that your responses will be completely confidential and will not be used for any other purpose.

Below are some questions about your parents/guardians, members of your household and your living environment.

Please Tick (✔) ONE box only

19). What is the highest education of your father/male guardian?

A). Did not attend school ☐ B). Primary school ☐ C). Secondary school ☐

D). Polytechnic ☐ E). University ☐ F). I do not know ☐

20). What is the highest education of your mother/female guardian?

A). Did not attend school ☐ B). Primary school ☐ C). Secondary school ☐

D). Polytechnic ☐ E). University ☐ F). I do not know ☐

21). What is the main source of drinking water for members of your household? (***Please tick (✔) only one box***).

A). Piped Tap water (Indoor) ☐

B). Piped Tap water (Outside in the compound) ☐

C). Public Tap water/Standpipe water (Outside the compound) ☐

D). Borehole ☐

E). Dug Well ☐

F). Rainwater ☐

G). Tanker Truck ☐

H). Cart with Small Tank ☐

I). Surface water (for example - river/lake/pond/stream/canal/irrigation channel) ☐

J). Bottled water ☐

K). Sachet water ☐

L). Other (specify/write) ....

22). Where is the water source located?

A). Indoor ☐

B). Outside in the compound ☐

C). Elsewhere ☐

23). If the water source located **elsewhere**, how long does it take to go there, get water and come back?

Minutes ....

Don't Know ☐

24). Do you do anything to make the water safer to drink?

1. Yes ☐ 2. No ☐ 3. Don't Know ☐

25). If **yes**, what do you usually do to make the water safer to drink? (***Please tick (✓) only one box***).

A). Boil ☐

B). Add Bleach/Chlorine/Chemical ☐

C). Strain through a Cloth ☐

D). Use Water Filter (Ceramic/Sand/Composite/e.t.c.) ☐

E). Solar Disinfection ☐

F). Let It Stand and Settle ☐

G). Other (specify/write) ....

H). Don't Know ☐

26). What kind of toilet facility do members of your household usually use? (***Please tick (✓) only one box***).

A). Flush or pour flush toilet inside house ☐

B). Flush or pour flush toilet outside house ☐

C). Pit latrine ☐

D). Composite toilet ☐

E). Bucket toilet ☐

F). Hanging Toilet/Hanging Latrine ☐

G). No toilet facility/bush/field ☐

H). Other (specify/write) ....

27). Do you share this toilet facility with other households? 1. Yes ☐ No ☐

28). How many households use this toilet facility?

A). Number of Household if less than 10 [0][ ]

B). 10 or more Households ☐

C). Don't Know ☐

29). ***Please answer all questions***. Does your household have:

A). A bed? 1. Yes ☐ 2. No ☐

B). A sofa/couch/settee? 1. Yes ☐ 2. No ☐

C). A chair? 1. Yes ☐ 2. No ☐

D). A table? 1. Yes ☐ 2. No ☐

E). A cupboard/cabinet? 1. Yes ☐ 2. No ☐

F). Electricity? 1. Yes ☐ 2. No ☐

G). A radio? 1. Yes ☐ 2. No ☐

H). A television? 1. Yes ☐ 2. No ☐

I). A mobile telephone? 1. Yes ☐ 2. No ☐

J. A non-mobile telephone/land line? 1. Yes ☐ 2. No ☐

K). A Fridge or Freezer? 1. Yes ☐ 2. No ☐

L). An ipod/mp3 player? 1. Yes ☐ 2. No ☐

M). An electric fan? 1. Yes ☐ 2. No ☐

N). Microwave? 1. Yes ☐ 2. No ☐

O). Desk top computer /Laptop? 1. Yes ☐ 2. No ☐

P). Generator? 1. Yes ☐ 2. No ☐

Q). Internet access: 1. Yes ☐ 2. No ☐

R). Air conditioner: 1. Yes ☐ 2. No ☐

S). Camera? 1. Yes ☐ 2. No ☐

T). VCR or DVD player? 1. Yes ☐ 2. No ☐

U). Cable/Satelite TV? 1. Yes ☐ 2. No ☐

30). What type of fuel does your household mainly use for cooking? (***Please tick (✓) only one box***).

A). Electricity ☐ B). Gas ☐ C). Kerosene ☐ D). Charcoal ☐

E). Wood ☐ F). Straw/shrubs/grass ☐ G). Agricultural crop ☐

H). Animal dung ☐ I). No food cooked in household ☐

J). Other (specify/write) ....

31). Is the cooking usually done in the house, in a separate building, or outdoors?

A). In the house ☐ B). In a separate building ☐ C). Outdoors ☐

D). Other (specify/write) ....

32). If cooking is done **inside** the house, do you have a separate room which is used as a kitchen? 1. Yes ☐ 2. No ☐

33). What is the main material of the floor in your house? (***Please tick (✔) only one box***).

A). Earth/Sand ☐

B). Dung ☐

C). Wood Planks ☐

D). Palm/Bamboo ☐

E). Parquet or Polished Wood ☐

F). Vinyl (plastic material) or Asphalt (tar) Strips ☐

G). Ceramic Tiles ☐

H). Cement ☐

I). Carpet ☐

J). Other (specify/write) ....

34). What is the main material of the roof of your house? (***Please tick (✔) only one box***).

A). No Roof ☐

B). Thatch/Palm Leaf ☐

C). Sod (grass) ☐

D). Rustic Mat ☐

E). Palm/Bamboo ☐

F). Wood Planks ☐

G). Cardboard ☐

H). Metal (iron, zinc, aluminium), “*Panu*” ☐

I). Wood ☐

J). Asbestos ☐

K). Ceramic Tiles ☐

L). Cement ☐

M). Other (specify/write) ....

35). What is the main material of the exterior wall of your house? (***Please tick (✓) only one box***).

A). No Walls ☐

B). Cane/Palm/Trunks ☐

C). Dirt ☐

D). Bamboo with Mud ☐

E). Stone with Mud ☐

F). Plywood ☐

G). Cardboard ☐

H). Reused Wood ☐

I). Cement ☐

J). Stone with Lime/Cement ☐

K). Bricks ☐

L). Cement Blocks ☐

M). Wood Planks/Shingles ☐

N). Other (specify/write) ....

36). How many rooms in your household are used for sleeping? ....

37). What is the number of adults and children living in your household?

Adults (age 18 years and over) .... Children (under age 18 years) ....

38). ***Please answer all questions***. Does any member of your household own:

A). A watch? 1. Yes ☐ 2. No ☐

B). A bicycle? 1. Yes ☐ 2. No ☐

C). A motorcycle or motor scooter? 1. Yes ☐ 2. No ☐

D). An animal-drawn cart? 1. Yes ☐ 2. No ☐

E). A car or truck? 1. Yes ☐ 2. No ☐

F). A boat with an engine/motor? 1. Yes ☐ 2. No ☐

39). Does any member of your household own any farm/agricultural land?

1. Yes ☐ 2. No ☐

40). How many hectares of farm/agricultural land do members of your household own?

A). Hectares ☐☐ . ☐

B). 95 or more Hectares ☐

C). Don’t Know ☐

41). Does your h[box]d own any livestock, herds, other farm animals, or poultry?

1. Yes ☐ 2. No ☐

42). If yes, how many of the following animals does your household own?

If None write "0"

If you don't know write "Don't know"

Cattle	
Cows/Bulls	
Horse/Donkey/Mules	
Goats	
Sheep	
Chickens	

43). Does any member of your household have a bank account?

1. Yes ☐ 2. No ☐

Section 3

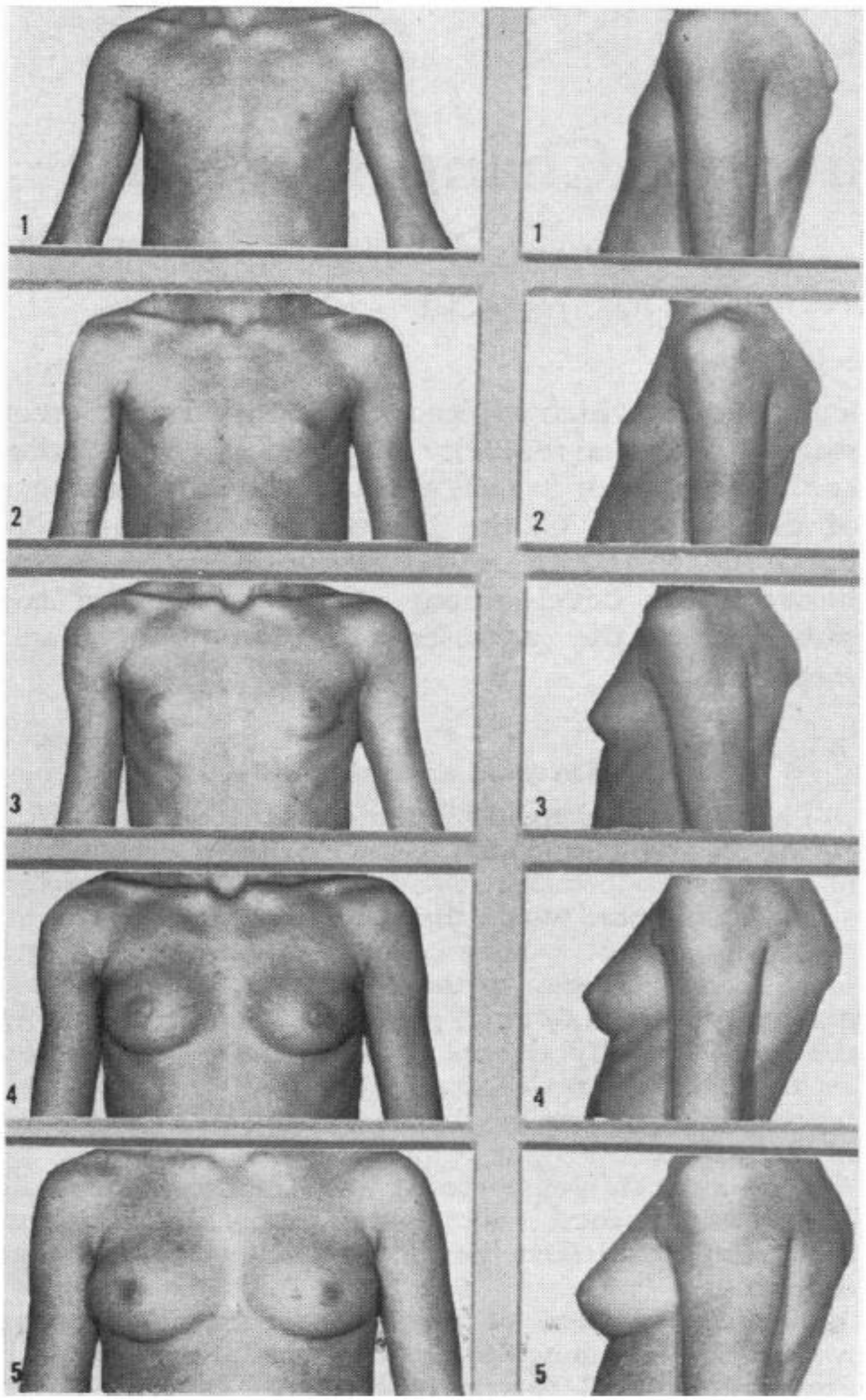
This section is to be completed by all participants. Again I assure you that your answers will be completely confidential.

Below is a question about your body development stage.

44). Please tick the picture number that best describes you from the number shown on each picture below (PLEASE TAKE NOTICE OF BREAST SIZE AND SHAPE OF NIPPLE):

Please Tick (✔) ONE box only

Picture 1 ☐ Picture 2 ☐ Picture 3 ☐ Picture 4 ☐ Picture 5 ☐



Picture 1

Picture 2

Picture 3

Picture 4

Picture 5

Definitions of some words

Where is it	What's the word	What it means
Information section, Section 1, Section 2, Section 3	**Confidential**	Kept carefully. Confidential information is only released to specified individuals.
Section 1.	**Leisure time**	Free time before or after compulsory activities such as eating, sleeping, going to school, doing homework, house work/chores.
Section 1.	**Very Often**	**Very frequent**, e.g. within every week.
Section 1.	**Often**	**Frequent**, e.g. within every 1 month.
Section 1.	**Sometimes**	**From time to time**, e.g. within every 2-6 months.
Section 1.	**Seldom**	**Rarely**, e.g. within every 6-12 months.
Section 1.	**Regularly**	**Usually**, e.g. within every week.
Section 2.	**Guardian**	Someone who you live with all of the time, who is like a parent; and without any payment or fee is responsible for you and takes care of you.
Section 2.	**Household**	Your house, flat, room in multi-tenanted building (for example: "face me I face you"), family or people you live with.
Section 2.	**Hectares**	1 hectare = 10,000 square meters (m^2).

That's it!!!

Thank you for taking part!

Section 4

You don't need to fill in this section. This section is to be completed by the researcher. Once again I assure you of complete confidentiality of the results.

Weight (kg) [ ]

Height (cm) [ ]

	1st	2nd	3rd	Average
Systolic blood pressure (mmHg)				
Diastolic blood pressure (mmHg)				

Waist circumference (cm) [ ]

APPENDIX 15: LETTER TO PARENT/CARER FOR A CHILD WITH NORMAL BLOOD PRESSURE

Health Sciences Research Institute
Warwick Medical School
University of Warwick
Coventry
CV4 7AL
United Kingdom

Dear Parents/Carers,

Your child/ward recently took part in a research involving blood pressure measurements in school. Your child's/ward's blood pressure at the time was normal.

You do not need to do anything.

Please do not hesitate to contact me if you would like any further information or further details.

Yours sincerely,

Oluwatoyin Ogboye
Telephone: +44(0)7899684918 or +234(0)7028366209.
Email: Oluwatoyin.Ogboye@warwick.ac.uk

APPENDIX 16: LETTER TO PARENT/CARER FOR A CHILD WITH HIGH NORMAL BLOOD PRESSURE

Health Sciences Research Institute
Warwick Medical School
University of Warwick
Coventry
CV4 7AL
United Kingdom

Dear Parents/Carers,

Your child/ward recently took part in a research involving blood pressure measurements in school. Your child's/ward's blood pressure at that time was a little high. There is no need to worry. However, as a precaution, you should ask your doctor to check your child's/ward's blood pressure next time you visit your doctor.

If you are worried or would like more information, please call me on this telephone number: +234(0)7028366209.

Yours sincerely,

Oluwatoyin Ogboye
Telephone: +44(0)7899684918 or +234(0)7028366209.
Email: Oluwatoyin.Ogboye@warwick.ac.uk

APPENDIX 17: LETTER TO PARENT/CARER FOR A CHILD WITH HIGH BLOOD PRESSURE

Health Sciences Research Institute
Warwick Medical School
University of Warwick
Coventry
CV4 7AL
United Kingdom

Dear Parents/Carers,

Your child/ward recently took part in a research involving blood pressure measurements in school. Your child's/ward's blood pressure at that time was high. I would like to recommend that you consult a doctor for further medical examination, as early detection and proper treatment of high blood pressure is always advisable.

If you are worried or would like more information, please do not hesitate to contact me on this telephone number: +234(0)7028366209.

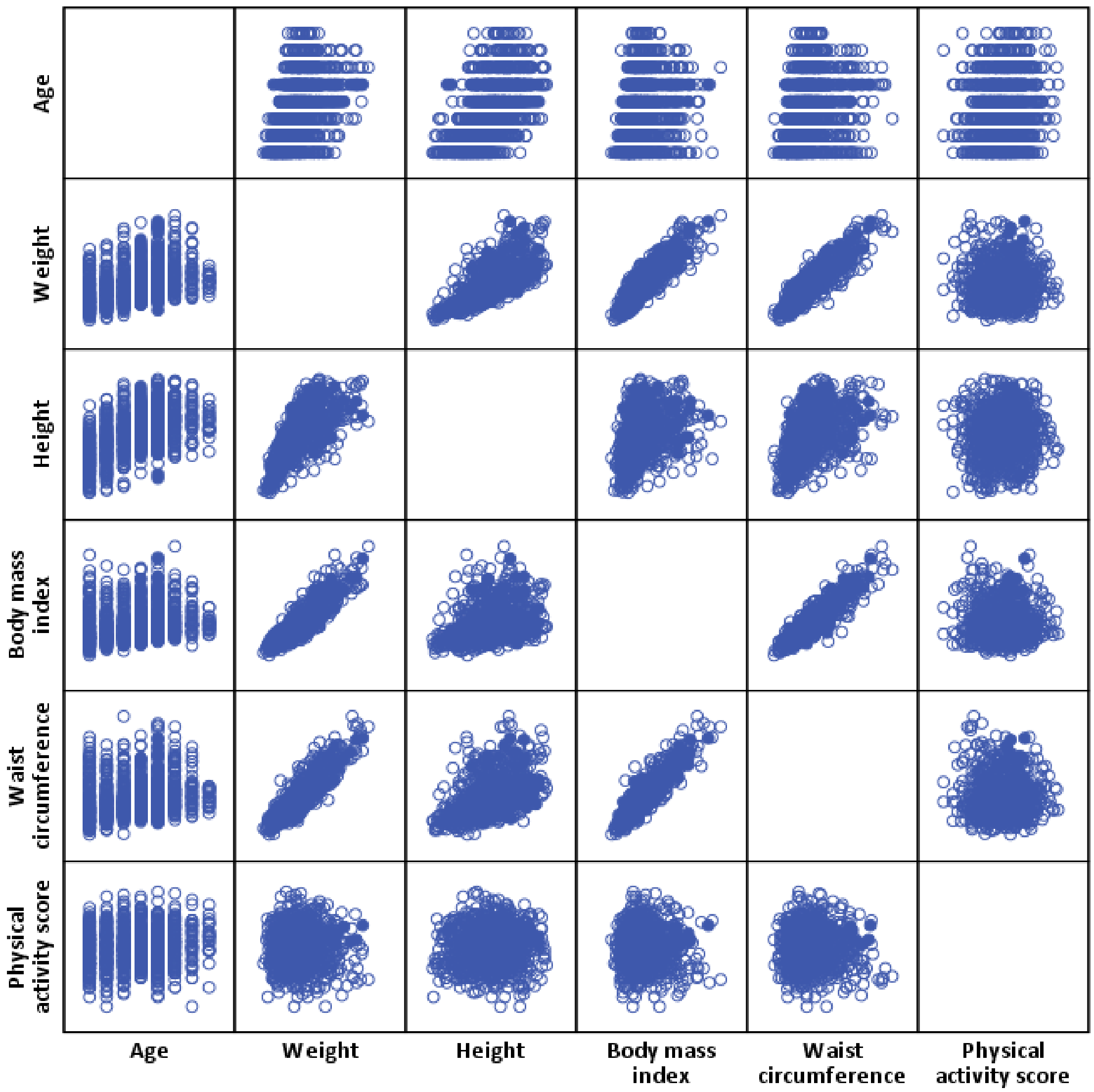
Yours sincerely,

Oluwatoyin Ogboye
Telephone: +44(0)7899684918 or +234(0)7028366209.
Email: Oluwatoyin.Ogboye@warwick.ac.uk

APPENDIX 18: EXPLORATORY ANALYSIS

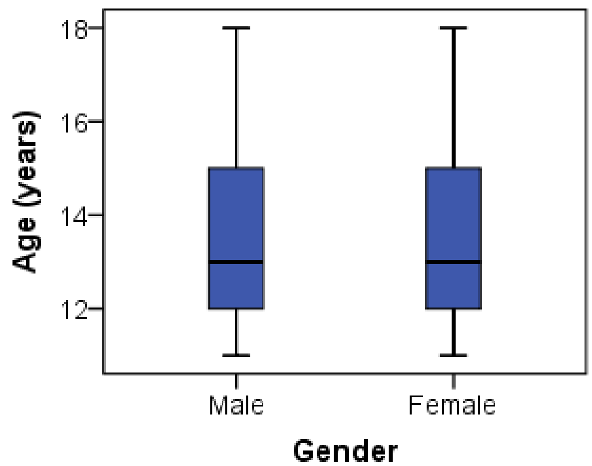
ASSESSMENT OF CORRELATIONS BETWEEN INDEPENDENT CONTINUOUS VARIABLES

Scatter plot matrix for age, weight, height, BMI, waist circumference and physical activity score

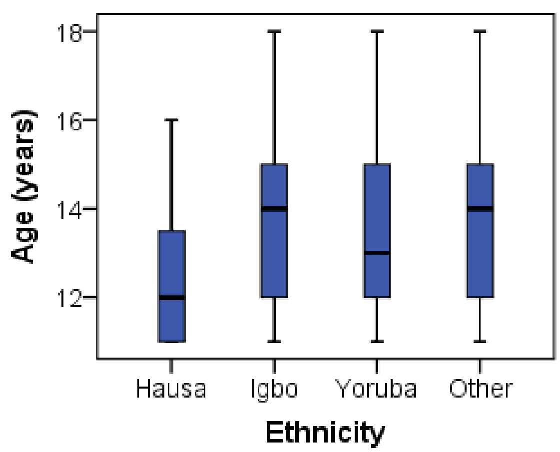


DISTRIBUTION OF AGE WITHIN INDEPENDENT CATEGORICAL VARIABLES

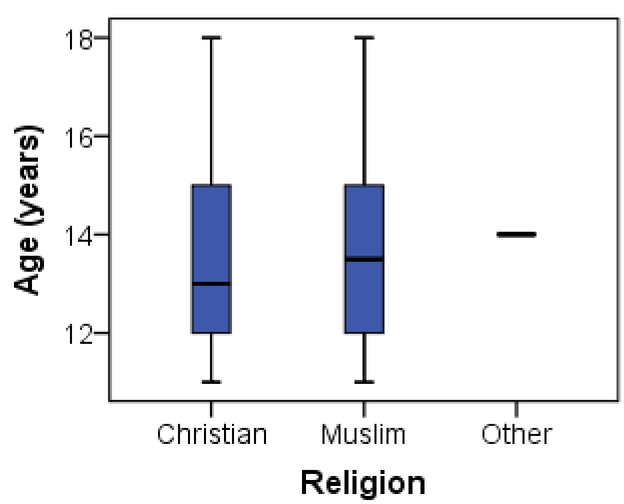
Box plot of Age vs. Gender



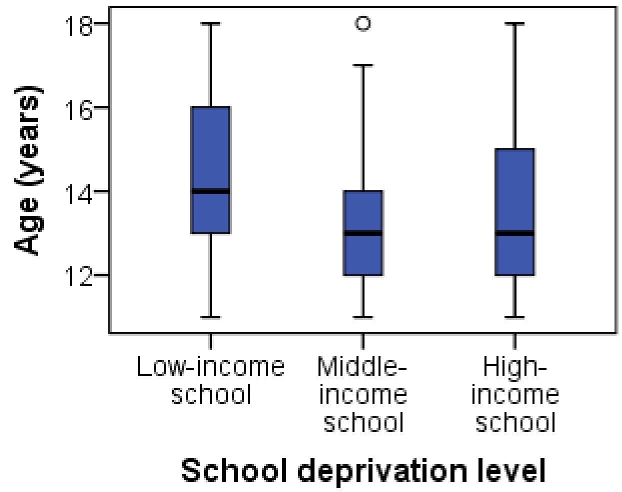
Box plot of Age vs. Ethnicity



Box plot of Age vs. Religion

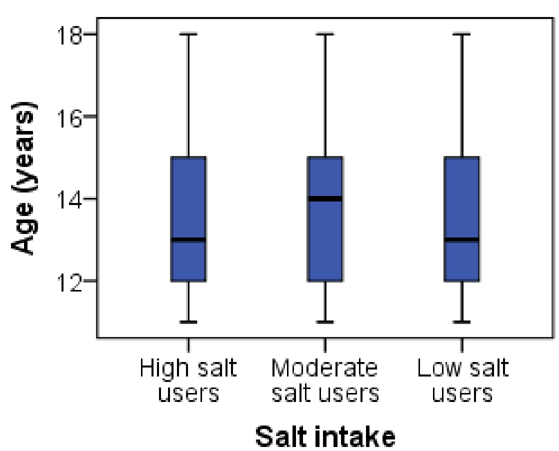


Box plot of Age vs. School deprivation level

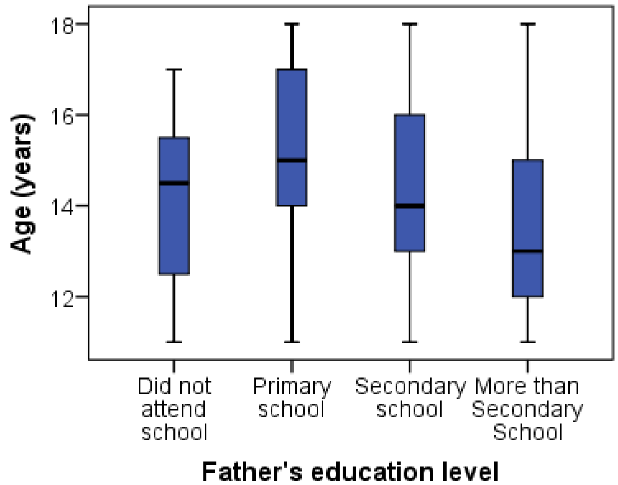


Box plot of Age vs. Wealth Index

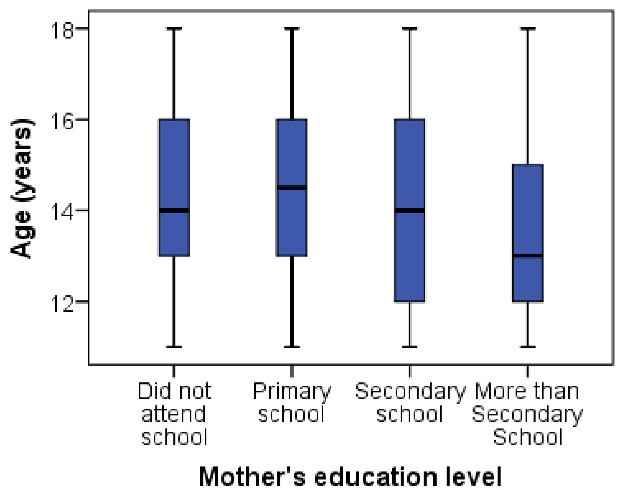
Box plot of Age vs. Salt Intake



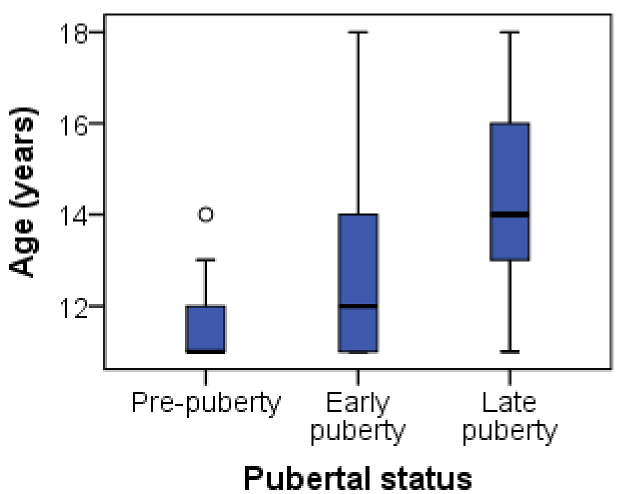
Box plot of Age vs. Father's education level



Box plot of Age vs. Mother's education level

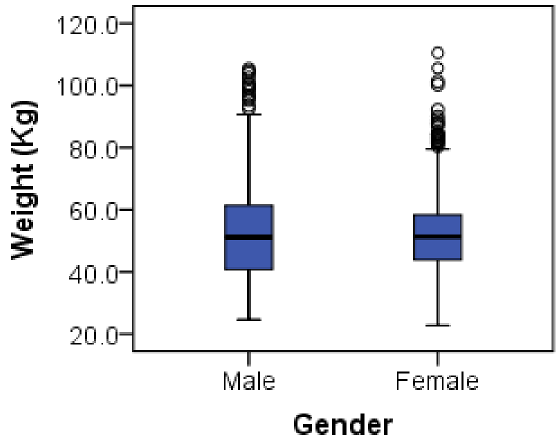


Box plot of Age vs. Pubertal status

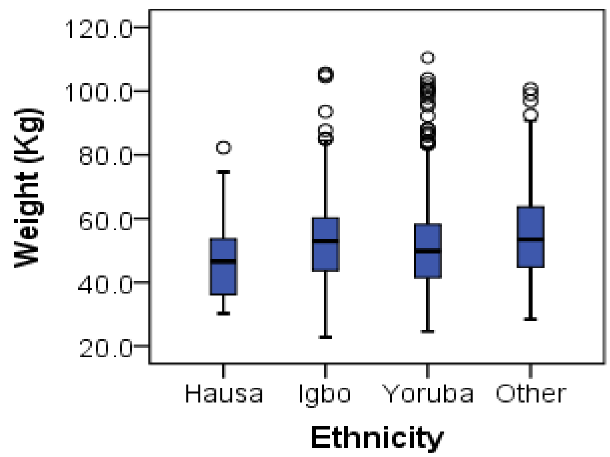


DISTRIBUTION OF WEIGHT WITHIN INDEPENDENT CATEGORICAL VARIABLES

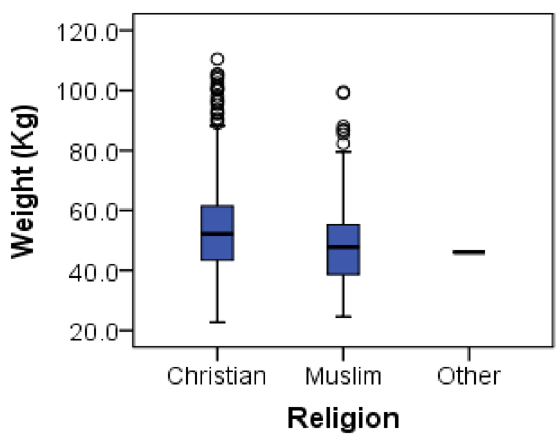
Box plot of Weight vs. Gender



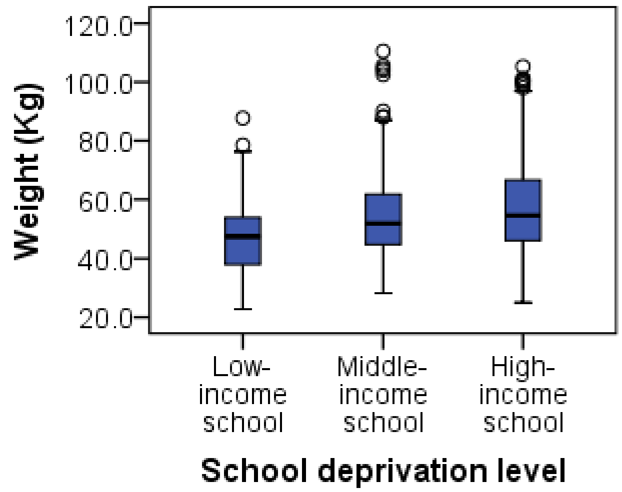
Box plot of Weight vs. Ethnicity



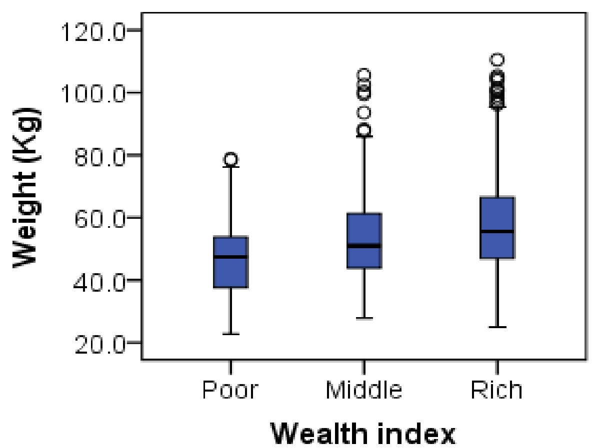
Box plot of Weight vs. Religion



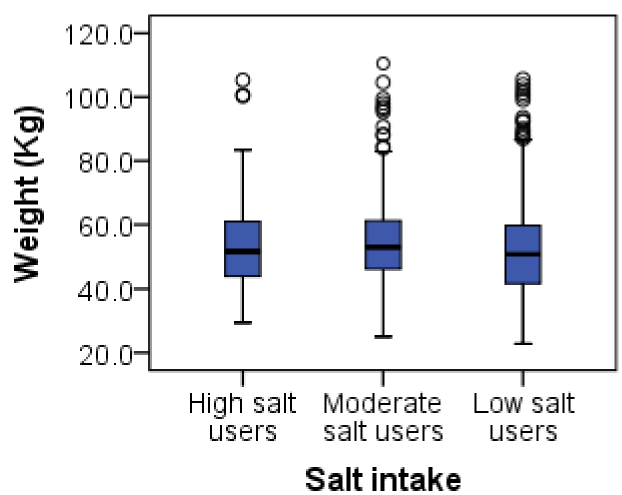
Box plot of Weight vs. School deprivation level



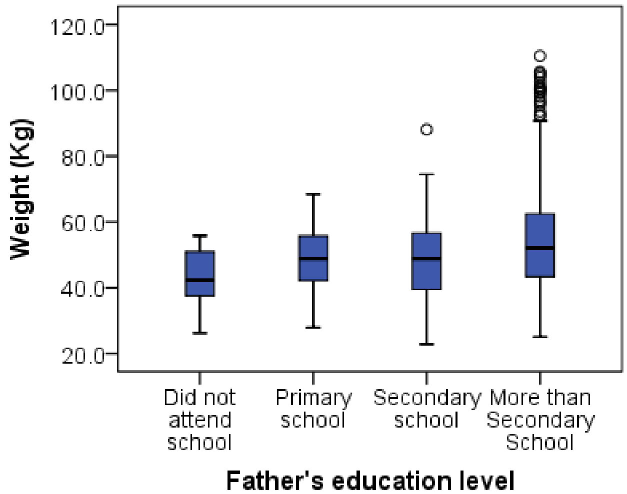
Box plot of Weight vs. Wealth index



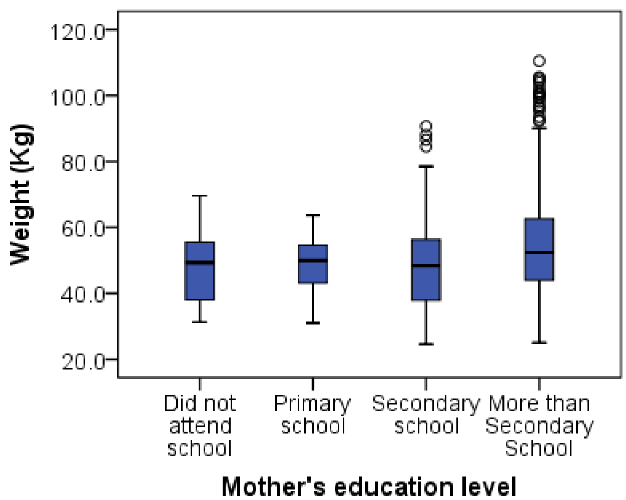
Box plot of Weight vs. Salt intake



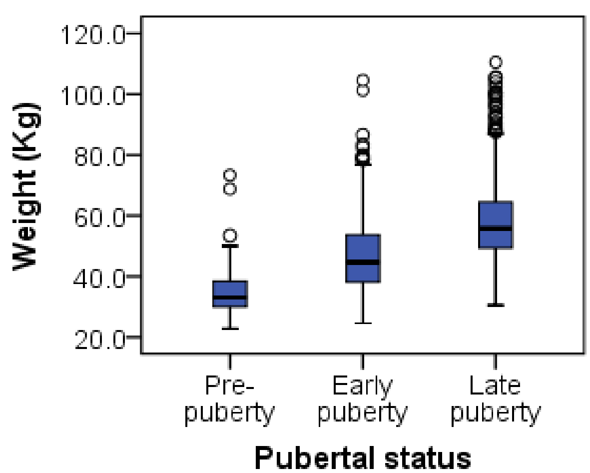
Box plot of Weight vs. Father's education level



Box plot of Weight vs. Mother's education level

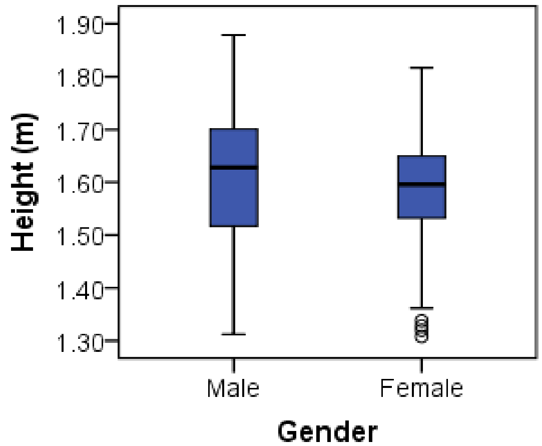


Box plot of Weight vs. Pubertal status

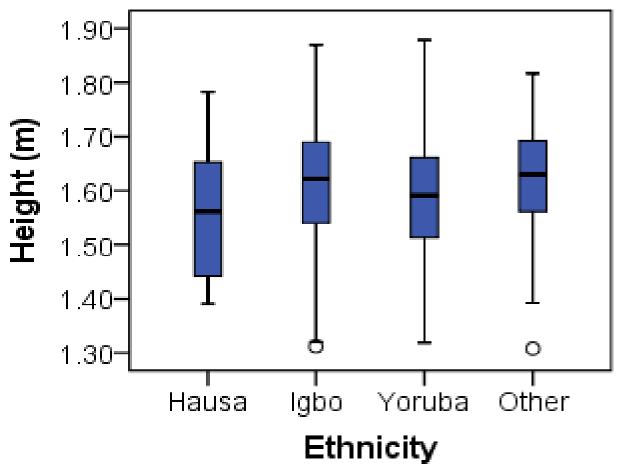


DISTRIBUTION OF HEIGHT WITHIN INDEPENDENT CATEGORICAL VARIABLES

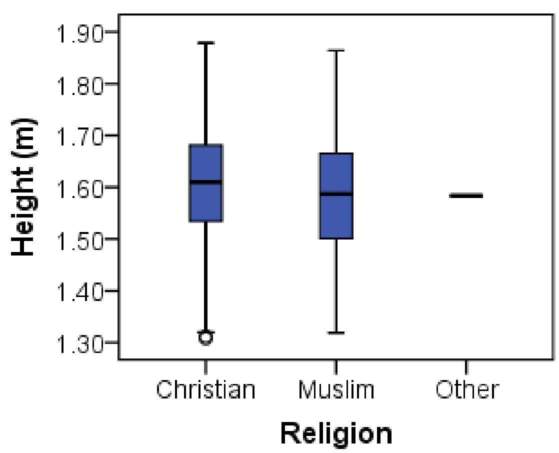
Box plot of Height vs. Gender



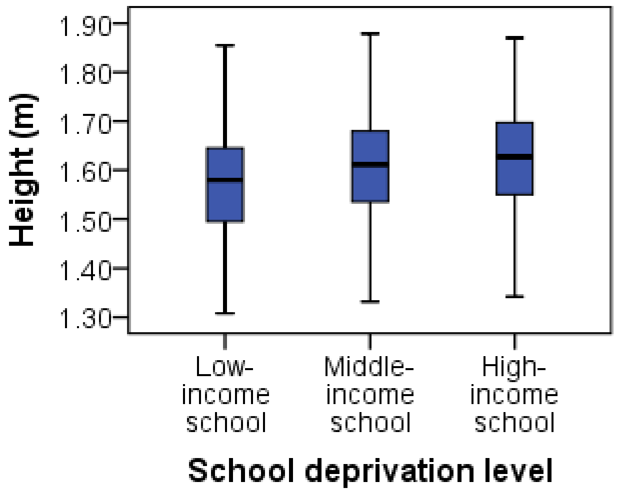
Box plot of Height vs. Ethnicity



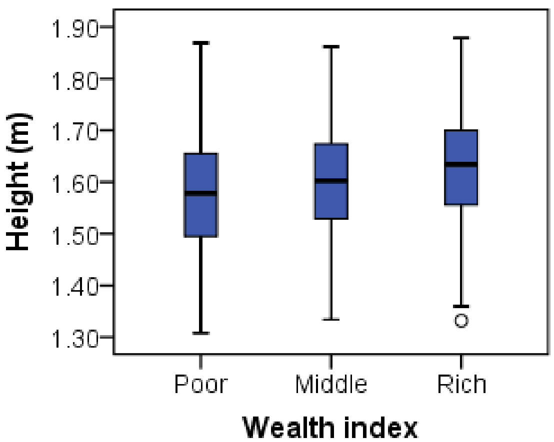
Box plot of Height vs. Religion



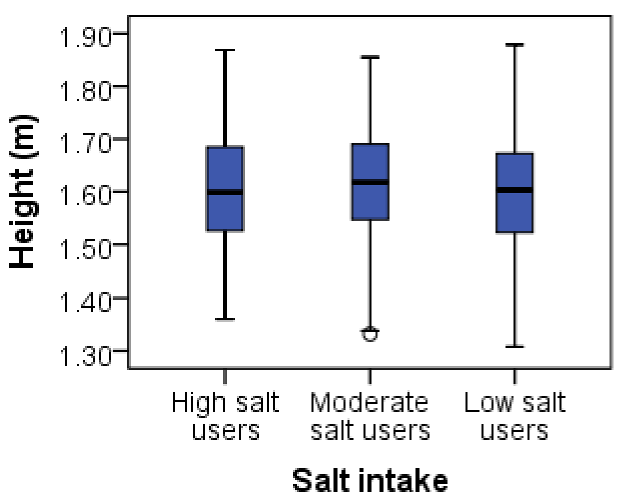
Box plot of Height vs. School deprivation level



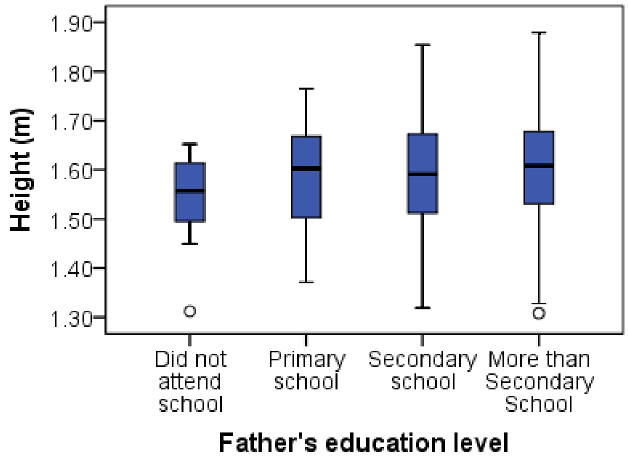
Box plot of Height vs. Wealth index



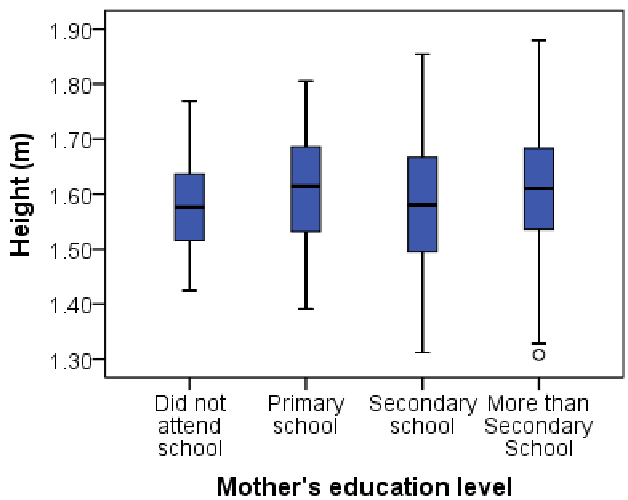
Box plot of Height vs. Salt intake



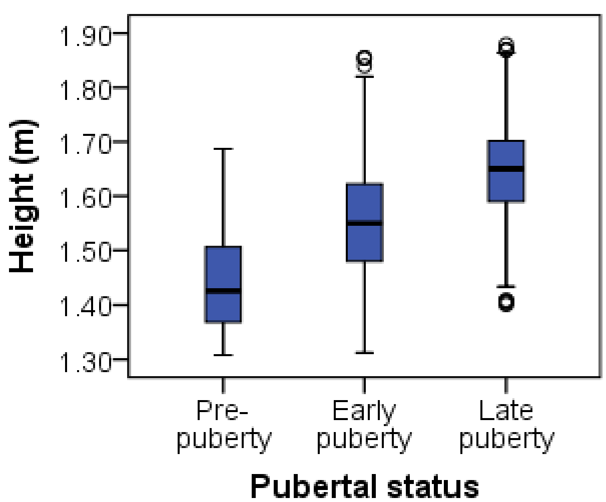
Box plot of Height vs. Father's education level



Box plot of Height vs. Mother's education level

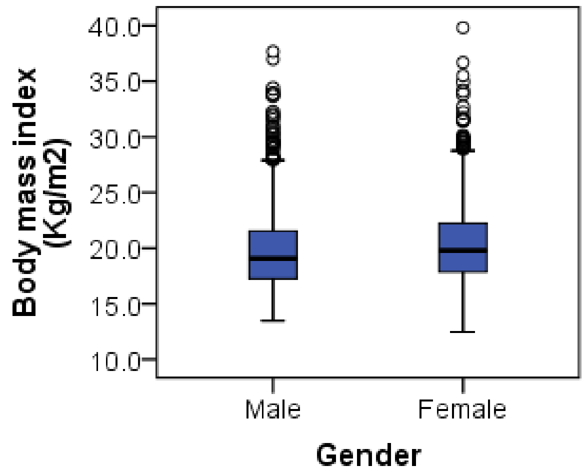


Box plot of Height vs. Pubertal status

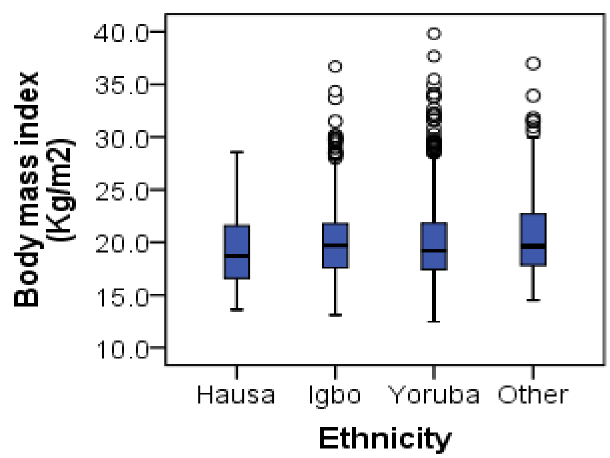


DISTRIBUTION OF BODY MASS INDEX WITHIN INDEPENDENT CATEGORICAL VARIABLES

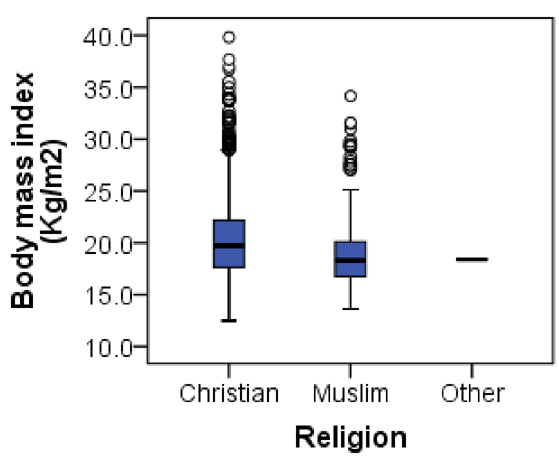
Box plot of Body mass index vs. Gender



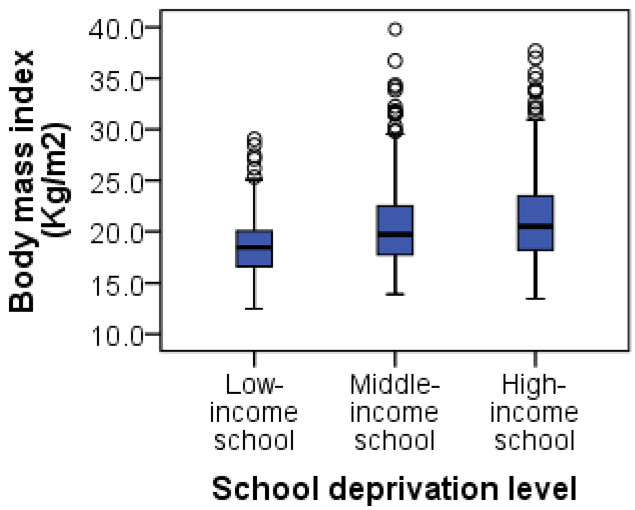
Box plot of Body mass index vs. Ethnicity



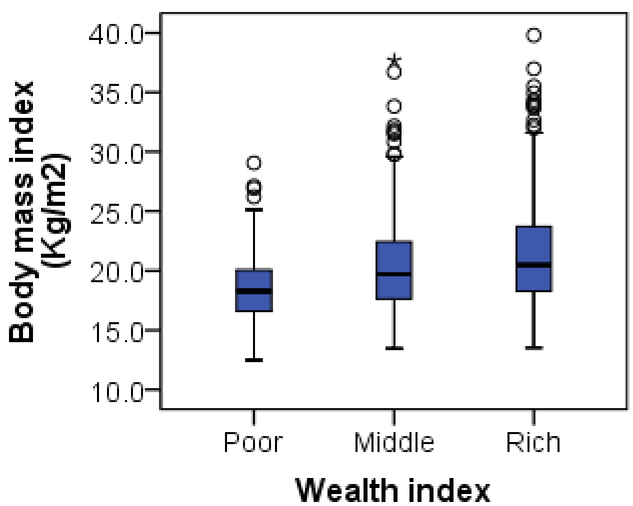
Box plot of Body mass index vs. Religion



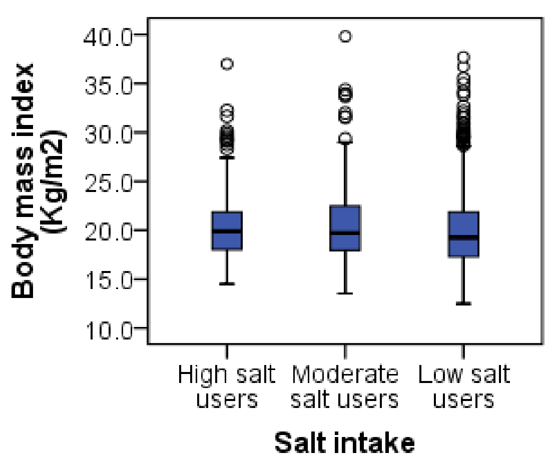
Box plot of Body mass index vs. School deprivation level



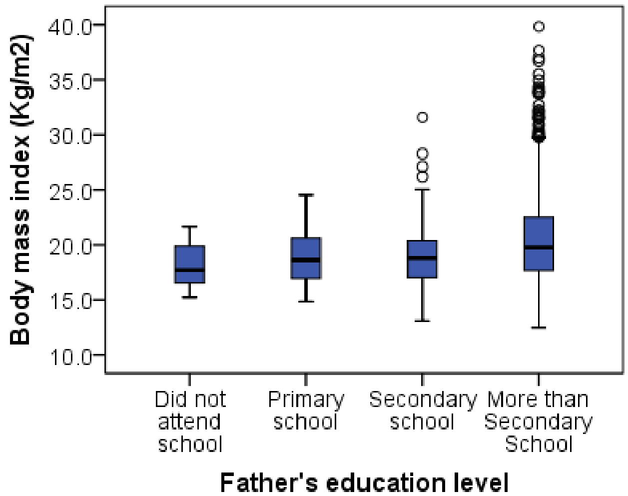
Box plot of Body mass index vs. Wealth index



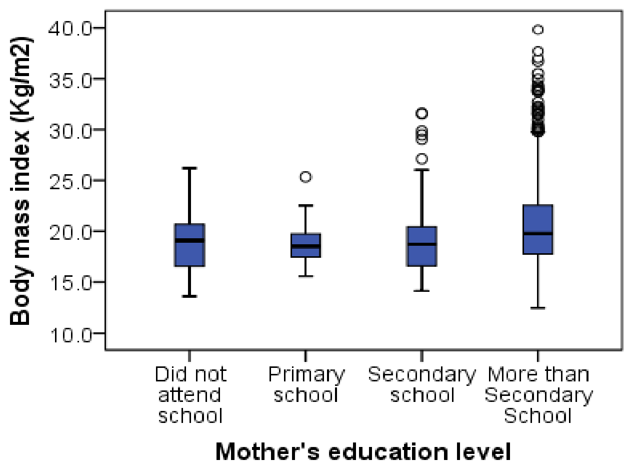
Box plot of Body mass index vs. Salt intake



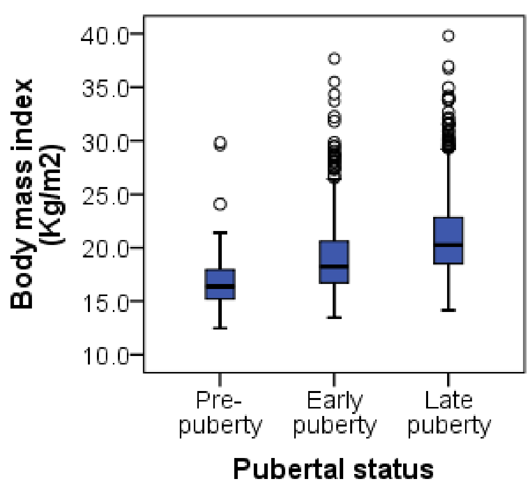
Box plot of Body mass index vs. Father's education level



Box plot of Body mass index vs. Mother's education level

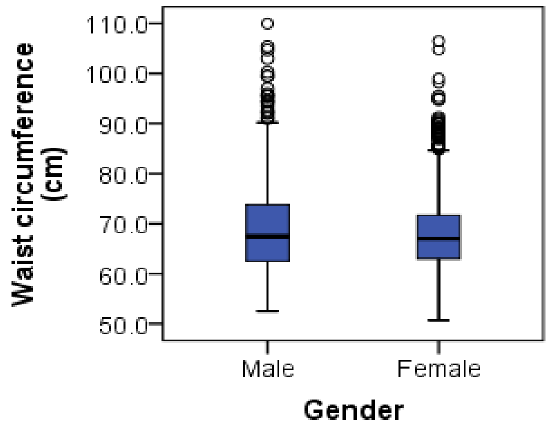


Box plot of Body mass index vs. Pubertal status

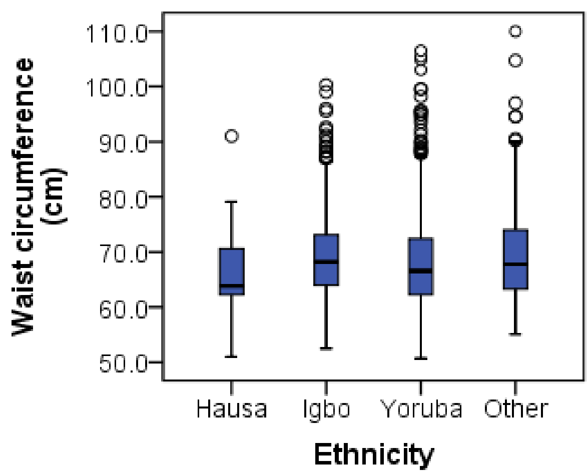


DISTRIBUTION OF WAIST CIRCUMFERENCE WITHIN INDEPENDENT CATEGORICAL VARIABLES

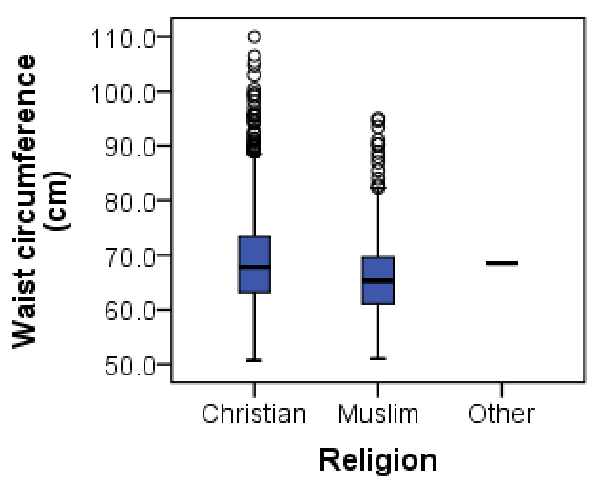
Box plot of Waist circumference vs. Gender



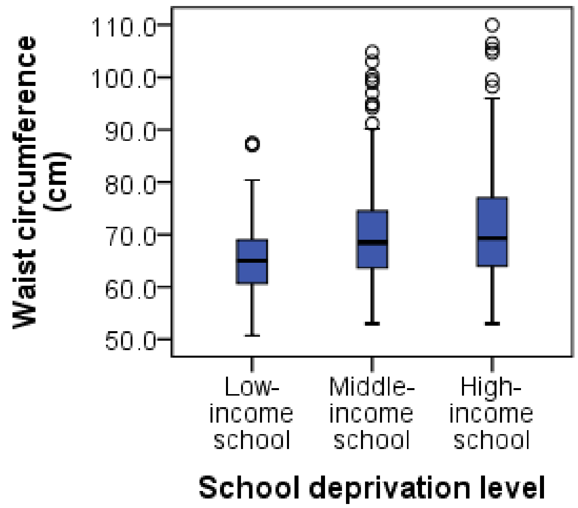
Box plot of Waist circumference vs. Ethnicity



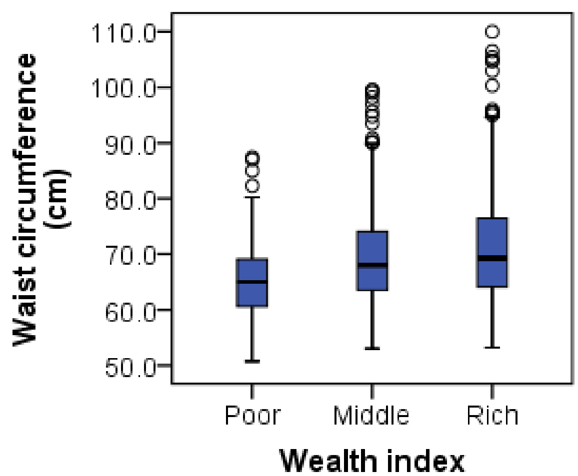
Box plot of Waist circumference vs. Religion



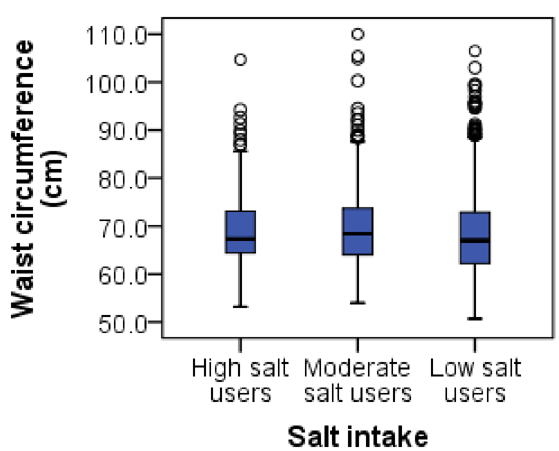
Box plot of Waist circumference vs. School deprivation level



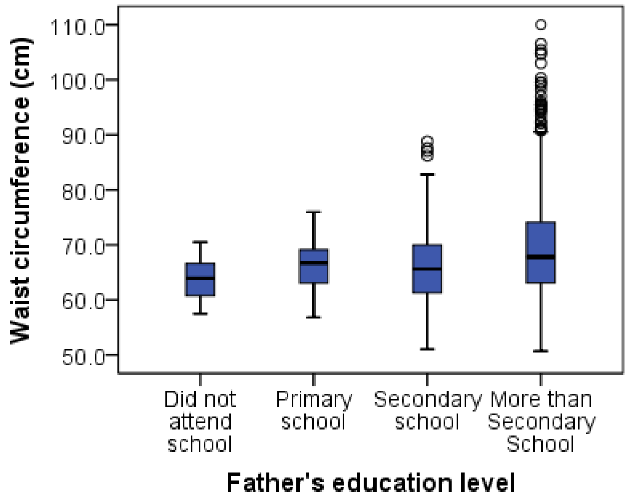
Box plot of Waist circumference vs. Wealth index



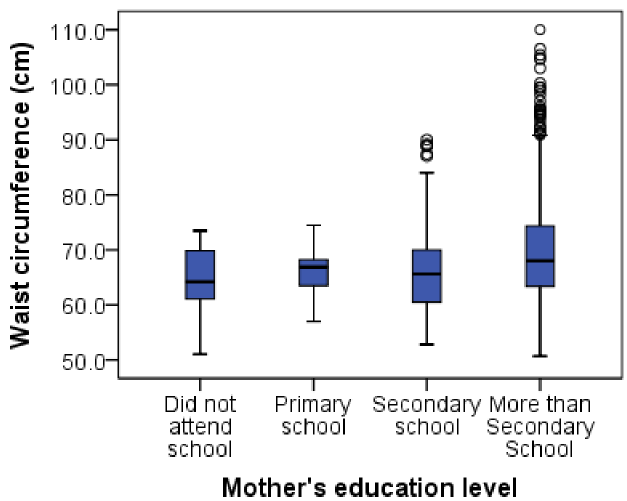
Box plot of Waist circumference vs. Salt intake



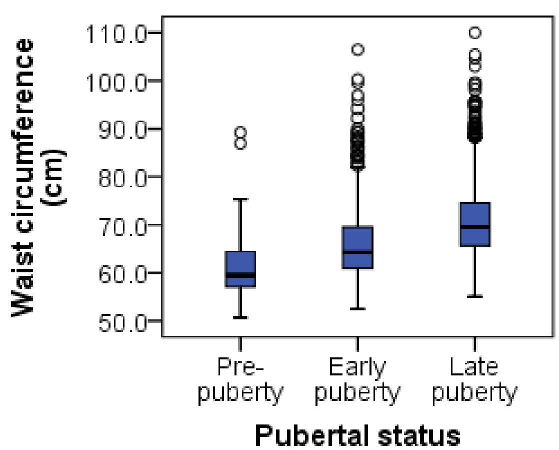
Box plot of Waist circumference vs. Father's education level



Box plot of Waist circumference vs. Mother's education level

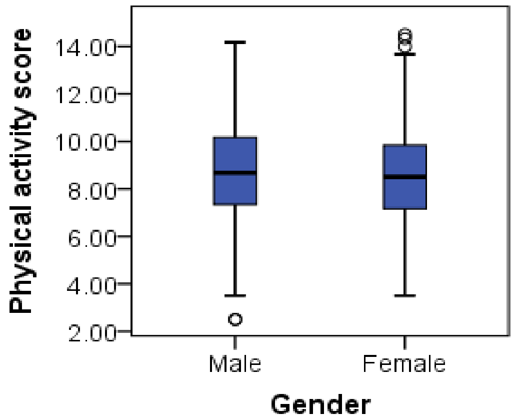


Box plot of Waist circumference vs. Pubertal status

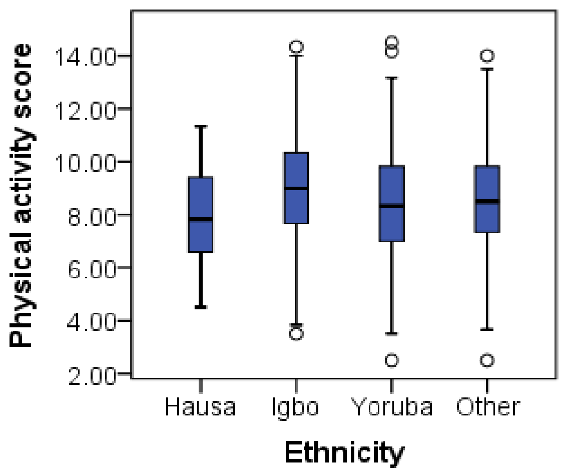


DISTRIBUTION OF PHYSICAL ACTIVITY WITHIN INDEPENDENT CATEGORICAL VARIABLES

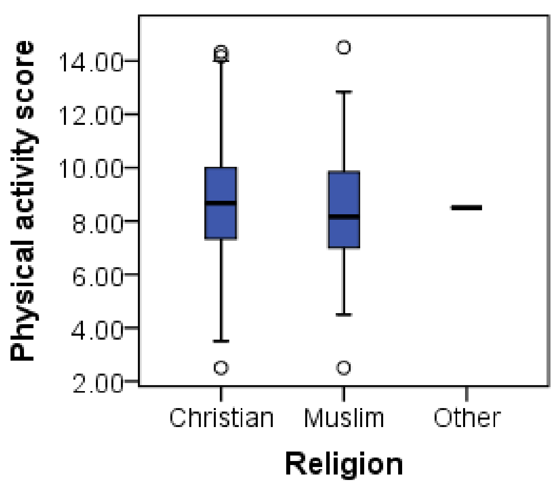
Box plot of Physical activity vs. Gender



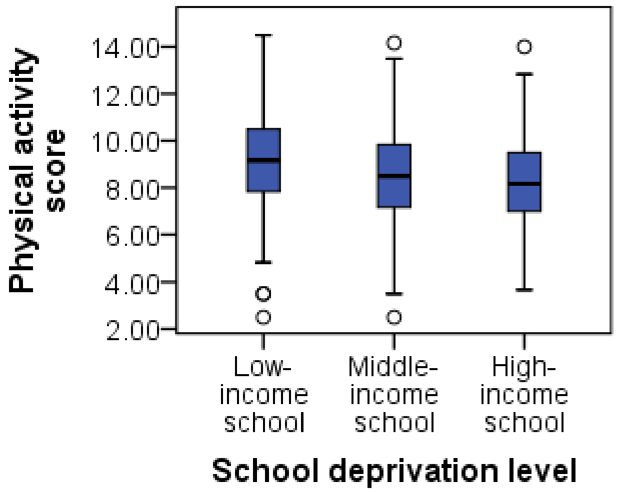
Box plot of Physical activity vs. Ethnicity



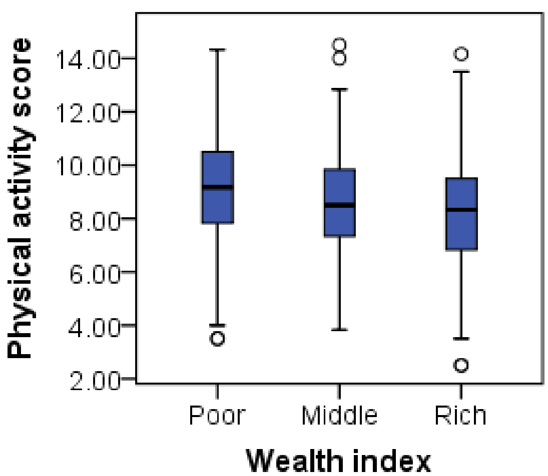
Box plot of Physical activity vs. Religion



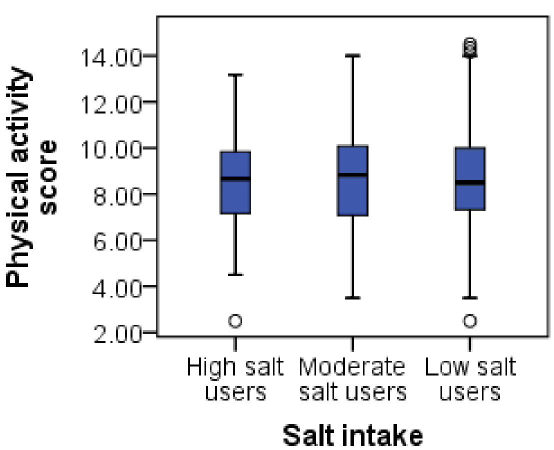
Box plot of Physical activity vs. School deprivation level



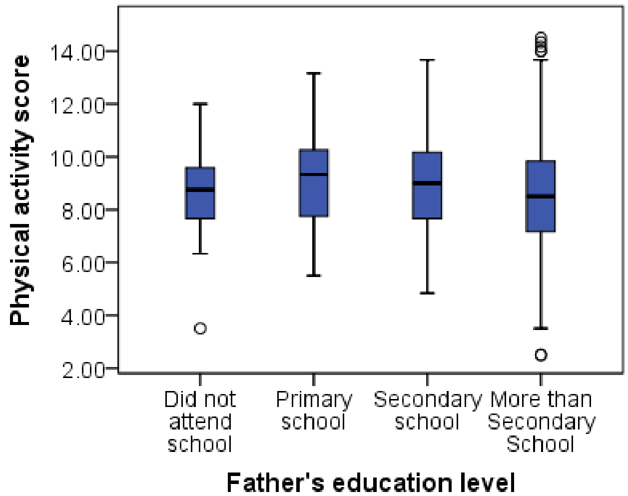
Box plot of Physical activity vs. Wealth index



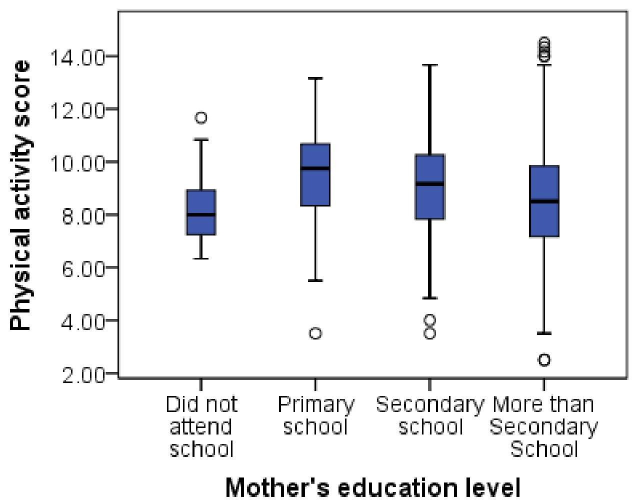
Box plot of Physical activity vs. Salt intake



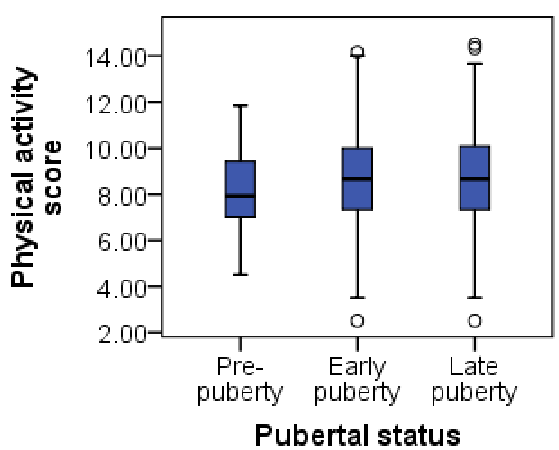
Box plot of Physical activity vs. Father's education level



Box plot of Physical activity vs. Mother's education level



Box plot of Physical activity vs. Pubertal status



ASSESSMENT OF THE RELATIONSHIP BETWEEN INDEPENDENT CATEGORICAL VARIABLES

Chi-square test - Gender vs Ethnicity

	Hausa	Igbo	Yoruba	Other	Total	P-value
Male	7 (1.3%)	172 (32.0%)	257 (47.8%)	102 (19.0%)	538 (100%)	0.280
Female	16 (2.9%)	163 (29.7%)	266 (48.5%)	103 (18.8%)	548 (100%)	
Total	23 (2.1%)	335 (30.8%)	523 (48.2%)	205 (18.9%)	1086 (100%)	

Chi-square test - Gender vs Religion

	Christian	Muslim	Other	Total	P-value
Male	440 (81.8%)	98 (18.2%)	0 (0.0%)	538 (100%)	0.221
Female	465 (84.9%)	82 (15.0%)	1 (0.2%)	548 (100%)	
Total	905 (83.3%)	180 (16.6%)	1 (0.1%)	1086 (100%)	

Chi-square test - Gender vs School fee level

	Low-income school	Middle-income school	High-income school	Total	P-value
Male	176 (32.7%)	180 (33.5%)	182 (33.8%)	538 (100%)	0.973
Female	178 (32.5%)	187 (34.1%)	183 (33.4%)	548 (100%)	
Total	354 (32.6%)	367 (33.8%)	365 (33.6%)	1086 (100%)	

Chi-square test - Gender vs Salt Use

	High salt users	Moderate salt users	Low salt users	Total	P-value
Male	90 (16.7%)	81 (15.1%)	367 (68.2%)	538 (100%)	0.050
Female	65 (11.9%)	98 (17.9%)	385 (70.3%)	548 (100%)	
Total	155 (14.3%)	179 (16.5%)	752 (69.2%)	1086 (100%)	

Chi-square test - Gender vs Father's education level

	Father's education level				Total	P-value
	Did not attend school	Primary school	Secondary school	More than Secondary School		
Male	4 (0.8%)	23 (4.3%)	113 (21.3%)	390 (73.6%)	538 (100%)	0.005
Female	8 (1.5%)	12 (2.3%)	78 (14.9%)	427 (81.3%)	548 (100%)	
Total	12 (1.1%)	35 (3.3%)	191 (18.1%)	817 (77.4%)	1086 (100%)	

Chi-square test - Gender vs Mother's education level

	Mother's education level				Total	P-value
	Did not attend school	Primary school	Secondary school	More than Secondary School		
Male	10 (1.9%)	21 (4.0%)	122 (23.2%)	373 (70.9%)	538 (100%)	0.186
Female	13 (2.5%)	17 (3.2%)	97 (18.3%)	403 (76.0%)	548 (100%)	
Total	23 (2.2%)	38 (3.6%)	219 (20.7%)	776 (73.5%)	1086 (100%)	

Chi-square test - Gender vs Puberty

	Pre-puberty	Early puberty	Late puberty	Total	P-value
Male	27 (5.0%)	219 (40.7%)	292 (54.3%)	538 (100%)	0.277
Female	17 (3.1%)	230 (42.1%)	299 (54.8%)	548 (100%)	
Total	44 (4.1%)	449 (41.4%)	591 (54.5%)	1086 (100%)	

Chi-square test - Ethnicity vs Gender

	Male	Female	Total	P-value
Hausa	7 (30.4%)	16 (69.6%)	23 (100 %)	0.280
Igbo	172 (51.3%)	163 (48.7%)	335 (100%)	
Yoruba	257 (49.1%)	266 (50.9%)	523 (100%)	
Others	102 (49.8%)	103 (50.2%)	205 (100%)	
Total	538 (49.5%)	548 (50.5%)	1086 (100%)	

Chi-square test - Ethnicity vs Religion

	Christian	Muslim	Other	Total	P-value
Hausa	2 (8.7%)	21 (91.3%)	0 (0.0%)	23 (100%)	0.000
Igbo	334 (99.7%)	0 (0.0%)	1 (0.3%)	335 (100%)	
Yoruba	374 (71.5%)	149 (28.5)	0 (0.0%)	523 (100%)	
Others	195 (95.1%)	10 (4.9%)	0 (0.0%)	205 (100%)	
Total	905 (83.3%)	180 (16.6%)	1 (0.1%)	1086 (100%)	

Chi-square test - Ethnicity vs School fee level

	Low-income school	Middle-income school	High-income school	Total	P-value
Hausa	3 (13.0%)	6 (26.1%)	14 (60.9%)	23 (100%)	0.000
Igbo	141 (42.1%)	81 (24.2%)	113 (33.7%)	335 (100%)	
Yoruba	152 (29.1%)	226 (43.2%)	145 (27.7%)	523 (100%)	
Other	58 (28.3%)	54 (26.3%)	93 (45.4%)	205 (100%)	
Total	354 (32.6%)	367 (33.8%)	365 (33.6%)	1086 (100%)	

Chi-square test - Ethnicity vs Salt use

	High salt users	Moderate salt users	Low salt users	Total	P-value
Hausa	3 (13.0%)	3 (13.0%)	17 (73.9%)	23 (100%)	0.089
Igbo	31 (9.3%)	62 (18.5%)	242 (72.2%)	335 (100%)	
Yoruba	87 (16.6%)	80 (15.3%)	356 (68.1%)	523 (100%)	
Other	34 (16.6%)	34 (16.6%)	137 (66.8%)	205 (100%)	
Total	155 (14.3%)	179 (16.5%)	752 (69.2%)	1086 (100%)	

Chi-square test - Ethnicity vs Father's education level

	Father's education level				Total	P-value
	Did not attend school	Primary school	Secondary school	More than Secondary School		
Hausa	1 (4.5%)	0 (0.0%)	2 (9.1%)	19 (86.4%)	22 (100%)	0.146
Igbo	2 (0.6%)	13 (4.1%)	71 (22.2%)	234 (73.1%)	320 (100%)	
Yoruba	6 (1.2%)	18 (3.5%)	79 (15.3%)	412 (80.0%)	515 (100%)	
Other	3 (1.5%)	4 (2.0%)	39 (19.7%)	152 (76.8%)	198 (100%)	
Total	12 (1.1%)	35 (3.3%)	191 (18.1%)	817 (77.4%)	1055 (100%)	

Chi-square test - Ethnicity vs Mother's education level

	Mother's education level				Total	P-value
	Did not attend school	Primary school	Secondary school	More than Secondary School		
Hausa	2 (9.1%)	1 (4.5%)	2 (9.1%)	17 (77.3%)	22 (100%)	0.033
Igbo	2 (0.6%)	10 (3.1%)	82 (25.1%)	233 (71.3%)	327 (100%)	
Yoruba	11 (2.2%)	19 (3.7%)	95 (18.7%)	384 (75.4%)	509 (100%)	
Other	8 (4.0%)	8 (4.0%)	40 (20.2%)	142 (71.7%)	198 (100%)	
Total	23 (2.2%)	38 (3.6%)	219 (20.7%)	776 (73.5%)	1056 (100%)	

Chi-square test - Ethnicity vs Puberty

	Pre-puberty	Early puberty	Late puberty	Total	P-value
Hausa	2 (8.7%)	12 (52.2%)	9 (39.1%)	23 (100%)	0.287
Igbo	14 (4.2%)	131 (39.2%)	189 (56.6%)	334 (100%)	
Yoruba	24 (4.6%)	224 (42.9%)	274 (52.5%)	522 (100%)	
Other	4 (2.0%)	82 (40.0%)	119 (58.0%)	205 (100%)	
Total	44 (4.1%)	449 (41.4%)	591 (54.5%)	1084 (100%)	

Chi-square test - Religion vs School fee level

	Low-income school	Middle-income school	High-income school	Total	P-value
Christian	269 (29.7%)	318 (35.1%)	318 (35.1%)	905 (100%)	0.000
Muslim	85 (47.2%)	49 (27.2%)	46 (25.6%)	180 (100%)	
Other	0 (0.0%)	0 (0.0%)	1 (100%)	1 (100%)	
Total	354 (32.6%)	367 (33.8%)	365 (33.6%)	1086 (100%)	

Chi-square test - Religion vs Salt use

	High salt users	Moderate salt users	Low salt users	Total	P-value
Christian	120 (13.3%)	153 (16.9%)	632 (69.8%)	905 (100%)	0.256
Muslim	35 (19.4%)	26 (14.4%)	119 (66.1%)	180 (100%)	
Other	0 (0.0%)	0 (0.0%)	1 (100%)	1 (100%)	
Total	155 (14.3%)	179 (16.5%)	752 (69.2%)	1086 (100%)	

Chi-square test - Religion vs Father's education level

	Father's education level				Total	P-value
	Did not attend school	Primary school	Secondary school	More than Secondary School		
Christian	6 (0.7%)	21 (2.4%)	149 (17.0%)	701 (79.9%)	877 (100%)	0.000
Muslim	6 (3.4%)	14 (7.9%)	42 (23.7%)	115 (65.0%)	177 (100%)	
Other	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (100%)	1 (100%)	
Total	12 (1.1%)	35 (3.3%)	191 (18.1%)	817 (77.4%)	1055 (100%)	

Chi-square test - Religion vs Mother's education level

	Mother's education level				Total	P-value
	Did not attend school	Primary school	Secondary school	More than Secondary School		
Christian	14 (1.6%)	25 (2.8%)	170 (19.4%)	669 (76.2%)	878 (100%)	0.000
Muslim	9 (5.1%)	13 (7.3%)	49 (27.7%)	106 (59.9%)	177 (100%)	
Other	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (100%)	1 (100%)	
Total	23 (2.2%)	38 (3.6%)	219 (20.7%)	776 (73.5%)	1056 (100%)	

Chi-square test - Religion vs Puberty

	Pre-puberty	Early puberty	Late puberty	Total	P-value
Christian	35 (3.9%)	366 (40.5%)	502 (55.6%)	903 (100%)	0.428
Muslim	9 (5.0%)	82 (45.6%)	89 (49.4%)	180 (100%)	
Other	0 (0.0%)	1 (100%)	0 (0.0%)	1 (100%)	
Total	44 (4.1%)	449 (41.4%)	591 (54.5%)	1084 (100%)	

Chi-square test - School fee level vs Salt use

	High salt users	Moderate salt users	Low salt users	Total	P-value
Low-income school	50 (14.1%)	63 (17.8%)	241 (68.1%)	354 (100%)	0.210
Middle-income school	63 (17.2%)	53 (14.4%0	251 (68.4%)	367 (100%)	
High-income school	42 (11.5%)	63 (17.3%)	260 (71.2%)	365 (100%)	
Total	155 (14.3%)	179 (16.5%)	752 (69.2%)	1086 (100%)	

Chi-square test - School fee level vs Father's education level

	Father's education level				Total	P-value
	Did not attend school	Primary school	Secondar y school	More than Secondary School		
Low-income school	12 (3.5%)	31 (9.0%)	161 (46.5%)	142 (41.0%)	346 (100%)	0.000
Middle-income school	0 (0.0%)	2 (0.6%)	17 (4.7%)	341 (94.7%)	360 (100%)	
High-income school	0 (0.0%)	2 (0.6%)	13 (3.7%)	334 (95.7%)	349 (100%)	
Total	12 (1.1%)	35 (3.3%)	191 (18.1%)	817 (77.4%)	1055 (100%)	

Chi-square test - School fee level vs Mother's education level

	Mother' education level				Total	P-value
	Did not attend school	Primary school	Secondary school	More than Secondary School		
Low-income school	23 (6.6%)	37 (10.6%)	176 (50.6%)	112 (32.2%)	348 (100%)	0.000
Middle-income school	0 (0.0%)	1 (0.3%)	30 (8.5%)	324 (91.3%)	355 (100%)	
High-income school	0 (0.0%)	0 (0.0%)	13 (3.7%)	340 (96.3%)	353 (100%)	
Total	23 (2.2%)	38 (3.6%)	219 (20.7%)	776 (73.5%)	1056 (100%)	

Chi-square test - School fee level vs Puberty

	Pre-puberty	Early puberty	Late puberty	Total	P-value
Low-income school	21 (5.9%)	149 (42.1%)	184 (52.0%)	354 (100.0%	0.065
Middle-income school	16 (4.4%)	155 (42.2%)	196 (53.4%)	367 (100%)	
High-income school	7 (1.9%)	145 (39.9%)	211 (58.1%)	363 (100%)	
Total	44 (4.1%)	449 (41.4%)	591 (54.5%)	1084 (100%)	

Chi-square test - Salt use vs Father's education level

	Father's education level				Total	P-value
	Did not attend school	Primary school	Secondary school	More than Secondary School		
High salt users	4 (2.6%)	6 (4.0%)	30 (19.9%)	111 (73.5%)	151 (100%)	0.422
Moderate salt users	2 (1.2%)	6 (3.5%)	36 (20.8%)	129 (74.6%)	173 (100%)	
Low salt users	6 (0.8%)	23 (3.1%)	125 (17.1%)	577 (78.9%)	731 (100%)	
Total	12 (1.1%)	35 (3.3%)	191 (18.1%)	817 (77.4%)	1055 (100%)	

Chi-square test - Salt use vs Father's education level

	Mother's education level				Total	P-value
	Did not attend school	Primary school	Secondary school	More than Secondary School		
High salt users	4 (2.7%)	7 (4.7%)	39 (26.0%)	100 (66.7%)	150 (100%)	0.190
Moderate salt users	2 (1.1%)	6 (3.4%)	44 (25.3%)	122 (70.1%)	174 (100%)	
Low salt users	17 (2.3%)	25 (3.4%)	136 (18.6%)	554 (75.7%)	732 (100%)	
Total	23 (2.2%)	38 (3.6%)	219 (20.7%)	776 (73.5%)	1056 (100%)	

Chi-square test - Salt use vs Puberty

	Pre-puberty	Early puberty	Late puberty	Total	P-value
High salt users	8 (5.2%)	56 (36.4%)	90 (58.4%)	154 (100%)	0.159
Moderate salt users	6 (3.4%)	64 (35.8%)	109 (60.9%)	179 (100%)	
Low salt users	30 (4.0%)	329 (43.8%)	392 (52.2%)	751 (100%)	
Total	44 (4.1%)	449 (41.4%)	591 (54.5%)	1084 (100%)	

Chi-square test - Father's education level vs Mother's education level

		Mother's education level				Total	P-value
		Did not attend school	Primary school	Secondary school	More than Secondary School		
Father's education level	Did not attend school	7 (58.3%)	3 (25.0%)	2 (16.7%)	0 (0.0%)	12 (100%)	0.000
	Primary school	5 (14.3%)	12 (34.3%)	13 (37.1%)	5 (14.3%)	35 (100%)	
	Secondary school	8 (4.3%)	15 (8.2%)	123 (66.8%)	38 (20.7%)	184 (100%)	
	More than Secondary School	3 (0.4%)	6 (0.7%)	80 (9.9%)	717 (89.0%)	806 (100%)	
	Total	23 (2.2%)	36 (3.5%)	218 (21.0%)	760 (73.3%)	1037 (100%)	

Chi-square test - Father's education level vs Puberty

		Pre-puberty	Early puberty	Late puberty	Total	P-value
Father's education level	Did not attend school	0 (0.0%)	8 (66.7%)	4 (33.3%)	12 (100%)	0.167
	Primary school	1 (2.9%)	9 (25.7%)	25 (71.4%)	35 (100%)	
	Secondary school	11 (5.8%)	75 (39.3%)	105 (55.0%)	191(100%)	
	More than Secondary School	32 (3.9%)	345 (42.3%)	439 (53.8%)	816 (100%)	
	Total	44 (4.2%)	437 (41.5%)	573 (54.4%)	1054 (100%)	

Chi-square test - Mother's education level vs Puberty

		Pre-puberty	Early puberty	Late puberty	Total	P-value
Mother's education level	Did not attend school	2 (8.7%)	11 (47.8%)	10 (43.5%)	23 (100%)	0.336
	Primary school	1 (2.6%)	13 (34.2%)	24 (63.2%)	38 (100%)	
	Secondary school	13 (5.9%)	84 (38.4%)	122 (55.7%)	219 (100%)	
	More than Secondary School	26 (3.4%)	329 42.5%	419 54.1%	774 100.0%	
	Total	42 (4.0%)	437 (41.5%)	575 (54.6%)	1054 (100%)	

Chi-square test - Gender vs Wealth index

	Wealth index			Total	P-value
	Low-income	Middle-income	High-income		
Male	186 (34.6%)	172 (32.0%)	180 (33.5%)	538 (100%)	0.634
Female	176 (32.1%)	176 (32.1%)	196 (35.8%)	548 (100%)	
Total	362 (33.3%)	348 (32.0%)	376 (34.6%)	1086 (100%)	

Chi-square test - Ethnicity vs Wealth index

	Wealth index			Total	P-value
	Low-income	Middle-income	High-income		
Hausa	4 (17.4%)	6 (26.1%)	13 (56.5%)	23 (100%)	0.040
Igbo	130 (38.8%)	102 (30.4%)	103 (30.7%)	335 (100%)	
Yoruba	166 (31.7%)	178 (34.0%)	179 (34.2%)	523 (100%)	
Other	62 (30.2%)	62 (30.2%)	81 (39.5%)	205 (100%)	
Total	362 (33.3%)	348 (32.0%)	376 (34.6%)	1086 (100%)	

Chi-square test - Religion vs Wealth index

	Wealth index			Total	P-value
	Low-income	Middle-income	High-income		
Christian	279 (30.8%)	307 (33.9%)	319 (35.2%)	905 (100%)	0.001
Muslim	83 (46.1%)	41 (22.8%)	56 (31.1%)	180 (100%)	
Other	0 (0.0%)	0 (0.0%)	1 (100.0%)	1 (100%)	
Total	362 (33.3%)	348 (32.0%)	376 (34.6%)	1086 (100%)	

Chi-square test - School fee level vs Wealth index

	Wealth index			Total	P-value
	Low-income	Middle-income	High-income		
Low-income	307 (86.7%)	46 (13.0%)	1 (0.3%)	354 (100%)	0.000
Middle-income	83 (46.1%)	190 (51.8%)	132 (36.0%)	367 (100%)	
High-income	10 (2.7%)	112 (30.7%)	243 (66.6%)	365 (100%)	
Total	362 (33.3%)	348 (32.0%)	376 (34.6%)	1086 (100%)	

Chi-square test - Salt use vs Wealth index

	Wealth index			Total	P-value
	Low-income	Middle-income	High-income		
High salt users	58 (37.4%)	45 (29.0%)	52 (33.5%)	155 (100%)	0.443
Moderate salt users	64 (35.8%)	50 (27.9%)	65 (36.3%)	179 (100%)	
Low salt users	240 (31.9%)	253 (33.6%)	259 (34.4%)	752 (100%)	
Total	362 (33.3%)	348 (32.0%)	376 (34.6%)	1086 (100%)	

Chi-square test - Father's education level vs Wealth index

		Wealth index			Total	P-value
		Low-income	Middle-income	High-income		
Father's education level	Did not attend school	12 (100.0%)	0 (0.0%)	0 (0.0%)	12 (100%)	0.000
	Primary school	31 (88.6%)	3 (8.6%)	1 (2.9%)	35 (100%)	
	Secondary school	156 (81.7%)	27 (14.1%)	8 (4.2%)	191(100%)	
	More than Secondary School	156 (19.1%)	309 (37.8%)	352 (43.1%)	817 (100%)	
	Total	355 (33.6%)	339 (32.1%)	361 (34.2%)	1055 (100%)	

Chi-square test - Mother's education level vs Wealth index

		Wealth index			Total	P-value
		Low-income	Middle-income	High-income		
Mother's education level	Did not attend school	22 (95.7%)	1 (4.3%)	0 (0.0%)	23 (100%)	0.000
	Primary school	34 (89.5%)	4 (10.5%)	0 (0.0%)	38 (100%)	
	Secondary school	180 (82.2%)	27 (12.3%)	12 (5.5%)	219 (100%)	
	More than Secondary School	119 (15.3%)	303 (39.0%)	354 (45.6%)	776 (100%)	
	Total	355 (33.6%)	339 (32.1%)	361 (34.2%)	1056 (100%)	

Chi-square test - Puberty vs Wealth index

	Wealth index			Total	P-value
	Low-income	Middle-income	High-income		
Pre-puberty	24 (54.5%)	13 (29.5%)	7 (15.9%)	44 (100%)	0.019
Early puberty	144 (32.1%)	151 (33.6%)	154 (34.3%)	449 (100%)	
Late puberty	193 (32.7%)	184 (31.1%)	214 (36.2%)	591 (100%)	
Total	362 (33.3%)	348 (32.1%)	376 (34.6%)	1084 (100%)	

APPENDIX 19: ASSOCIATION BETWEEN DIASTOLIC BLOOD PRESSURE AND SCHOOL FEE LEVEL

Multiple Regression Analysis of school fee level and Diastolic Blood Pressure – (BMI excluded)

Variable		**Diastolic Blood Pressure (mmHg)**		
		Regression Coefficient	**95% Confidence Interval**	**P-value**
Pubertal Status *Late puberty	Pre-puberty	-4.99	-7.49, -2.49	0.000
	Early puberty	-3.55	-4.61, -2.49	0.000
School fee level *High-income schools	Low-income schools	-2.17	-3.33, -1.01	0.000
	Middle-income schools	-1.42	-2.53, -0.321	0.011
Age (years)		0.64	0.35, 0.93	0.000
Gender *Female	Male	-1.669	-2.57, -0.77	0.000
Adjusted R^2		0.125		