The Prevalence of Hypertension and Stroke Survivors in the Polluted Environment: A Case Study of Rural Niger Delta

By

Martinsixtus Chidi Ezejimofor

A thesis submitted in partial fulfilment of the requirements for the degree of Doctor of Philosophy in Health Sciences

University of Warwick, Warwick Medical School

August 2016

WARWICK
THE UNIVERSITY OF WARWICK

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURE

DEDICATION

This thesis is dedicated to my beloved parents, Chief Jude Ibeike (IGWEKE) and Pauline Nwachukwu, and my brother Mars Ezejimofor all of blessed memory

ACKNOWLEDGMENT

I am indebted to many people who through their support, guidance, encouragement and prayers have made this project possible.

Firstly, I am very grateful to my supervisory team who worked tirelessly from the conception of this work until the end. In particular, Dr Olalekan Uthmam who took up the position of the primary supervisor when it matters most, and Dr Yen-Fu Chen who provided cover as secondary supervisor, Prof. Kandala Ngianga-Bakwin and Prof. Saverio Stranges both of whom laid the foundation for the study concept and design before leaving the University of Warwick. It was a huge privilege and rare opportunity to be taught by this wonderful team. The group dynamics, team spirit and an avalanche of skills that I tapped endlessly were amazing. It was your individual and collective support and encouragement that enabled me to complete my studies even when the odds seemed far outweigh the prospects in the final phase of this project.

I will also like to thanks the hardworking team of the division of Health Sciences, Warwick Medical School who guided me and provided the required help and assistance during the most difficult period of bereavement and data loss. This project could not have been completed and on time without your contributions covering ethical approval, training, and thesis completion funding.

I would like to express my gratitude to the Preventive and Social Medicine (PSM) and the Internal medicine department, the University of Port Harcourt who collaborated with me during the fieldwork stage. In particular, Prof. Arthur Onwuchekwa for providing the initial connection and direction right from the ethical approval stage until the project completion. Also remembered is Dr Omosivie Maduka for coordinating the PSM team that included Dr Ofoma and others.

My appreciation and acknowledgement also go to Petroleum Development Fund (PTDF) who awarded me the scholarship through its flagship programme, the Oversea Scholarship Scheme (OSS) for the doctorate degree. In particular, Mr Balarabe Ahmed, for his active role during the renewal period after completing an MPhil at Imperial College London.

I would also like to express my profound gratitude to Prof. Dora Akunyili of blessed memory, who during her stewardship as the director general of National Agency for Food and Drugs Administration and Control (NAFDAC) was instrumental in the award of the study scholarship and at the same time during its renewal. Her steadfastness, integrity and unalloyed defence for the oppressed made this dream come true. May her gentle soul continue to rest in the lord bosom. Amen.

I will like to appreciate Mr Chris Osondu, Dr Aloy Ezeabasili, Dr Andrew Okpalaeke and Chief Mike Ezenduka for their financial assistance and support. My experience in Warwick will also not be complete without Ahmed Sarki, Chidozie Nduka, Victor Adekanmbi, Lena Al-khudairi, Temple Azunda, Chinedu Nwaigwe, Michael Fabunmi, Ade Shonola, Ifeanyichukwu Chinonye and Peter Kimani, Ijeoma Mbaeri, Princess Cynthia Nekky, Tare Biu, David Keighe and Barclays Amadi. These people made it memorable. In a most special way, I say thank you all.

To my beloved wife, Benny, my daughter, Sasha-Diamond and my sons Martinsmario and McVianney, my siblings, Zitha, Faustina, Eucharia, Queenderline, Austin-Franklin, Marypat and Maryma, without your love, support and understanding, I could not have finished this arduous work. A big hug!

Lastly, I am grateful to God almighty for his blessings and for making this dream come true.

DECLARATION

I hereby declare that this thesis is my own work in both conception and execution, and has not been submitted previously to any institution for degree purposes. All the review evidence and theoretical information used or quoted herein have been duly acknowledged using appropriate references.

MARTINSIXTUS CHIDI EZEJIMOFOR

August, 2016

LIST OF PUBLICATIONS FROM THE THESIS

1. Ezejimofor MC, Uthman OA, Maduka OA, Ezeabasili AC, Onwuchekwa AC, Ezejimofor BC, et al. et al Stroke survivors in rural Nigeria: A door-to-door survey of the current status". *Journal of the Neurological Sciences (2016),* 372: 262-269.

2. Ezejimofor MC, Chen YF, Kandala NB, Ezejimofor BC, Ezeabasili AC, Stranges S, Uthman OA."Stroke survivors in Low-and middle-income countries: A meta-analysis of prevalence and secular trends". *Journal of the Neurological Sciences* (2016), 364:68-76

3. Ezejimofor MC, Uthman OA, Maduka OA, Ezeabasili AC, Onwuchekwa AC, Ezejimofor BC, et al. "The Burden of Hypertension in an Oil-and Gas-Polluted Environment: A Comparative Cross-Sectional Study." *American Journal of Hypertension* (2016): doi: 10.1093/ajh/hpw009

4. Ezejimofor, MC, Martinsixtus Ezejimofor, Kandala NB, Uthman OA, Stranges S, Ezejimofor BC, Ezeabasili AC, Chen YF. "Prevalence of stroke in low- and middle-income countries: a systematic review and meta-analysis". Centre for Reviews and Dissemination: University of York: *PROSPERO register, (2015) CRD42014015129*.

5. Ezejimofor MC, Kandala NB, Uthman OA, Stranges S, Guallar E, Ezejimofor BC, Chen YF. "The prevalence of hypertension among adults in Niger delta region of Nigeria: a systematic review and meta-analysis". Centre for Reviews and Dissemination: University of York: PROSPERO register (2014) CRD42014009107

6. Ezejimofor MC, Uthman OA, Maduka OA, Ezeabasili AC, Onwuchekwa AC, Ezejimofor BC, et al. "The burden of hypertension in the Niger delta region: A Systematic Review and Meta-Analysis". *Journal of Global Health (2016). In Press*

LIST OF ACRONYMS AND ABBREVIATIONS

AAPC	Average Annual Percentage Change
AGO	Aviation Gas Oil
AOR	Adjusted Odd Ratio
BMI	Body Mass Index
BRESC	Biomedical and Scientific Research Ethics Sub-committee
BRICS	Brazil, Russia, India, China, South Africa
CI	Confidence Interval
CT	Computed tomography
CVD	Cardiovascular Diseases
DBP	Diastolic Blood Pressure
DEP	Diesel Exhaust Particles
DPR	Department of Petroleum Resources
EDR	Exposure and Disease Relationship
EIA	Environmental Impact Assessment
EPA	Environmental Protection Agency
GDP	Gross Domestic Product
HBP	High Blood Pressure
HDI	Human Development Index
IHD	Ischemic Heart Disease
IPAQ	International Physical Activity Questionnaire
LGA	Local Government Area
LMICs	Low and middle-income countries
LNG	Liquefied National Gas
MDG	Millennium Development Goal
MINT	Mexico, Indonesia, Nigeria, Turkey
MRI	Magnetic resonance imaging
NCD	Non-communicable diseases
NHREC	National Health Research Ethics Committee
NNOC	Nigerian National Oil Corporation
NNPC	Nigerian National Petroleum Corporation

OECD	Organisation for Economic Co-operation and Development
OR	Odd Ratio
PAH	Polycyclic Aromatic Hydrocarbon
PBT	Persistent Bio-accumulative and Toxic
PCB	Polychlorinated Biphenyls
PM	Particulate Matter
POP	Persistent Organic Pollutants
PRISMA	Transparent Reporting of Systematic Reviews and Meta-analysis
PSM	Preventive and Social Medicine
RA	Research Assistants
RHD	Rheumatic Heart Disease
ROC	Receiver Operating Characteristic
ROFA	Residual Oil Fly Ash
ROS	Residual Oxygen Species
RR	Risk Ratio
SBP	Systolic Blood Pressure
SCF	Study Conceptual Framework
SDG	Sustainable Development Goals
SD	Standard Deviation
SIA	Socioeconomic Impact Assessment
SO_2	Sulphur Dioxide
STEPS	STEPwise approach to Surveillance
UNDP	United Nation Development Programme
UNEP	United Nations Environment Programme
VIF	Variance Inflation Factor
VOC	Volatile Organic Pollutant
WC	Waist Circumference
WHO	World Health Organisation
WHR	Waist Hip Ratio

ABSTRACT

Background

The risk of hypertension and/or stroke and prolonged exposure to crude oil pollution and gas flares remains unexplored. This was examined in the rural Niger Delta communities where decades of rampant oil and gas pollution and institutional neglect have been linked to increased cardiovascular diseases, poverty, and underdevelopment.

Study aim and Objectives

The aim of the study was to assess the prevalence of hypertension and stroke in the Niger Delta region. The overall objectives were to conduct a systematic review and meta-analysis of the prevalence of hypertension in Niger Delta region and the prevalence of stroke in low- and-middle-income countries (LMICs) including Nigeria; and to conduct a survey to evaluate the relative prevalence and correlates of both hypertension and stroke.

Methods

Relevant databases were searched and articles reporting hypertension and stroke prevalence were systematically reviewed to obtain a pooled prevalence estimates and secular trends based on the random-effect model. In the cross-sectional survey, 2,028 resident adults (aged 18-80) were recruited in both oil/gas polluted and non-polluted communities. Prevalence of hypertension and stroke and other important measures were examined and compared between the two communities.

Results

The review found a continuous increase in the prevalence of hypertension in the region such that the estimates have been increasing by 8.31% every 5 years. For stroke, the lowest prevalence was found in sub-Saharan Africa including Nigeria (3.5 per 1000, 95% CI, 1.9-5.7). However, the only study conducted in the rural Niger Delta found a higher prevalence compared to other areas in Nigeria and in sub-Saharan Arica (8.51 per 1000 95% CI, 3.9-16.1).

In the cross-sectional survey, the study found that one-third of participants were hypertensive (37.4%) while 27 stroke with a crude prevalence of 13.31/1000 persons (95% CI, 8·32-18·31) were found. In the adjusted model, participants living in oil-polluted areas were almost 5 times as likely to have developed hypertension (adjusted odds ratio (aOR) = 4.85, 95% confidence interval (CI): 1.84-112.82) compared to participants in non-polluted areas. Age-adjusted prevalence of stroke was 14.6/1000 person, which is about 7-folds higher than outside the Niger Delta region, and is the highest ever recorded in Africa as a whole. The study also found that participant's age, education attainment, and obesity modify the association between pollution status and risk of hypertension. In particular, age modifies the association between pollution status and risk of hypertension.

Conclusion

The increased prevalence of hypertension and stroke is consistent with ongoing epidemiological and environmental transitions. The study findings have huge socioeconomic implications in the Niger Delta population particularly in the rural oil and gas hosts-host communities suggesting a potential interplay between socioeconomic, lifestyle and environmental factors. The findings could be useful for screening purposes to identify high-risk population before a diagnosis is made and to target interventions appropriately. The study findings need to be investigated further in longitudinal studies. The influence of other extrinsic factors underscores the need for improved surveillance and better management of undetected or uncontrolled high blood pressure.

SECTION ONE

- **INTRODUCTION**
- **STUDY'S CONCEPTUAL FRAMEWORK**
- **AIMS AND OBJECTIVES**

CHAPTER ONE

1.0 INTRODUCTION

Global trends toward industrialisation and urbanisation are no longer a recent occurrence in Nigeria. This is because it is a consequence and stimulus associated with economic development (Ekpo 2005). Economic development may be sustainable or unsustainable. Sustainable development meets the needs of the present, without compromising the ability of future generations to meet their own needs (Robert, Parris et al. 2005). This concept remains the developmental agenda of every country and is being championed by the United Nations' department of economic and social affairs, and captured in its current sustainable development goals (SDGs) (Sachs 2012). Economic development in both developing and developed countries has led to tremendous improvements in people's well-being in many ways, but often at the expense of adverse effects on personal and environmental health (Griggs, Stafford-Smith et al. 2013).

As a result of uncontrolled urbanisation and increased industrialisation, environmental degradation has been occurring very rapidly leading to excessive noise, land and air pollution. Exposures to environmental pollution directly cause or increase the risk of diseases (Briggs 2003). The public health impact associated with environmental pollution was not limited to high-income countries like UK, USA, and Russia. Nigeria and some other low-and-middle-income countries (LMICs) experience similar problems albeit on a much smaller scale because of their low reliance on fossil fuels including coal, crude oil and gas for their energy need.

In Nigeria, both industrialisation and urbanisation have contributed significantly to the changing dietary and nutritional pattern, shifting modes of transportation and dramatic increase in air, land and water pollution (Suri and Chapman 1998). Specifically, urbanisation has given rise to rapid nutritional transition towards consumption of ready-to-eat food with high salt, sugar and fat contents, replacing unprocessed natural products that are still common in rural communities (Vlahov and Galea 2002, Eckert and Kohler 2014). In addition to diets, urban living also encourages high alcohol consumption and smoking, and sedentary lifestyles through the acquisition of new technology, increased office jobs, motorised transportation that make physical activity more difficult (Mendez and Popkin 2004). These exposures give rise to increased risk of hypertension and other metabolic conditions such as obesity and diabetes (Ezzati, Vander Hoorn et al. 2005, Arambepola, Allender et al. 2008).

Until the mid-1970s, it was generally thought that ambient pollution levels in Europe and America did not threaten human health (Holland, Bennett et al. 1979). However, reviews from epidemiological studies during the last two decades have consistently shown that moderate and low concentrations of traditional pollutants, such as ambient particles, black smoke, sulphur dioxide and nitrogen oxides, can have both short and long-term effects on health (Pope, Dockery et al. 1995). Review evidence associated with anthropogenic air pollution has also revealed that pollution is source-specific, for instance a change in emission sources influences the total ambient load, which gives rise to corresponding changes in the disease morbidity and mortality pattern at any given time (Katsouyanni, Touloumi et al. 2001, Pope III and Dockery 2006).

Even though some developed countries have recorded significant success in reducing emission from more traditional pollution sources such as vehicles, electrical power generation, and industrial facilities in urban areas, most developing countries have not. The enforcement of air quality standards in most regulated countries has seen changes in the processes and investments that encourage low emission of air pollutants and subsequent changes in diseases morbidities (Clancy, Goodman et al. 2002). Comparatively, in developing countries, severe air pollution episodes have increased the risk of respiratory morbidity and mortality (Seaton, Godden et al. 1995).

Today, many developing countries, especially oil-rich nations, are experiencing a unique industrial revolution of their own, with ever-increasing industrial growth, resulting in an ambient air pollution crisis (Hardoy and Satterthwaite 1991, Raji and Abejide 2013). In these countries, such as China, India, Brazil, South Africa and Nigeria, manufacturers take advantage of lax air quality regulations and cause pollution or what is now known as air pollutant dumping (Brennan 1999). With this "benefit" of profit-maximization, made possible by the availability of raw materials, low tax, large workforce as well as cheap labour, big industries prefer to move their facilities to such "pollution havens" rather than work in more regulated jurisdictions. The result of these unfriendly environmental practices is increased burden of health conditions associated with environmental pollution such as cancer and cardiovascular diseases driven by uncontrolled blood pressure and unrecognised hypertension.

With ongoing increases in vehicle number in the urban areas such as London, ambient air has continued to attract research focusing on the health and environmental impact of vehicular emissions without regard to other important sources, for example, crude oil exploration, refining operations and gas flaring. A review of air pollution in urban environment like London, revealed an important result associated with health morbidity and mortalities traceable to diesel exhaust particle (DEP) alone (Pope, Burnett et al. 2004, Ostro, Feng et al. 2007), however, rural areas of Niger-Delta in Nigeria present a different ambient particular matter (PM) scenario, in which the major sources of ambient PM are both vehicular emissions and oil/gas production activities.

This thesis concerns how polluted environment shapes the risk and prevalence of hypertension and stroke in rural communities, justifying why oil and gas companies, the government, epidemiological researchers and clinicians should come together and re-evaluate the public health implication of natural resources exploitation and processing, with a view to building a strong collaboration and increasing the understanding and knowledge-base necessary to mitigate the impact and protect the vulnerable population. In Nigeria, the Niger Delta rural landscape provides a good example of communities where poverty is endemic but are currently experiencing both epidemiological and environmental transitions (Kadafa 2012, Okeahialam, Ogbonna et al. 2014).

1.1 The issue

This thesis seeks to determine the prevalence of hypertension and stroke in the rural community where environmental pollution is currently occurring and also evaluate the association of environmental pollution and these health conditions.

Non-communicable diseases (NCDs), such as hypertension, heart disease, stroke, diabetes, cancer, and chronic respiratory conditions, are of huge public health importance in low- and middle-income countries (Ebrahim, Pearce et al. 2013, Lim, Vos et al. 2013). Many NCDs can be caused or worsened by environmental hazards, such as air pollution and toxic chemicals. These are in addition to the risk posed by fatty or sugary diets, ageing, and smoking, excess alcohol drinking and physical inactivity. Indirectly, NCDs can impair economic development not only by limiting individual, family and national investment but also by pushing people into poverty, due to lost in productivity and the costs of short and long-term therapy. Recent WHO report revealed that cardiovascular diseases account for most NCD deaths, or 17.5 million deaths annually (Micha, Khatibzadeh et al. 2014). This is followed by cancers (8.2 million), respiratory diseases (4 million), and diabetes (1.5 million). Of these premature deaths, 82% occurred in low- and middle-income countries (Lim, Vos et al. 2013, Micha, Khatibzadeh et al. 2014).

Environmental pollution is an important risk factor for cardiovascular disease throughout the world (Briggs 2003). Evidence of this link has widely been published as systematics reviews and meta-analysis of epidemiological studies (Brook 2007, Newby, Mannucci et al. 2014). Well known and largely researched environmental pollutants are heavy metals, volatile organic compound (VOC), polycyclic aromatic hydrocarbon (PAH) and PM (particularly PM_{10}, $PM_{2.5}$ and $PM_{0.1}$). Particulate matter air pollution alone has been implicated in more than three million deaths each year worldwide (Newby, Mannucci et al. 2014). PM can act as a prime vehicle for the transport of toxic chemicals into the human respiratory and cardiovascular system on a daily basis. There is substantial evidence that the acute cardiovascular effect of air pollution has significantly increased in recent years with experts agreeing that PM plays a leading role in triggering cardiovascular events particularly among those at risk of cardiovascular pathologies (Krzyzanowski, Bundeshaus et al. 2005, Brook, Rajagopalan et al. 2010). Even a small increase in the daily particulate concentration for a short period are associated with increased morbidity from hypertension, stroke, myocardial infarction, hospital admission and death from heart failure. The positive association of these according to review evidence could be mediated both by a direct and indirect effect of exposure to air pollutants species leading to initiation of high blood pressure potentiated by vascular inflammation, oxidative stress, and endothelial dysfunction in human subjects (Brook, Urch et al. 2009). Other studies have shown that air pollutant exposure is associated with atherosclerosis which hallmarks the development of hypertension (Künzli 2012).

Hypertension has continued to drive the global burden of cardiovascular disease as the most common cardiovascular disorder and number one risk factor for mortality (Kearney, Whelton et al. 2005). Recent estimate revealed that nearly one billion people have hypertension globally; of these, two-thirds are in developing countries (Kearney, Whelton et al. 2005). In real terms, about 640 million people have hypertension in LMICs. This is a huge contrast to 330 million people in high-income countries. However, this number is expected to increase to 1.56 billion adults living with hypertension in 2025 with more than two-third occurring in LMICs. The increase in the burden of hypertension in LMICs has been attributed to both intrinsic and extrinsic factors

(Lim, Vos et al. 2013). In particular, the ongoing epidemiological transition driven by nutritional and demographic changes, increasing trends in sedentary lifestyle and other modifiable risk factors and inadequate health systems have been major contributory factors.

In sub-Saharan Africa (SSA) particularly Nigeria, evidence of double burden of non-communicable diseases (such as stroke and hypertension and injuries), and communicable diseases such as HIV/AIDS, Malaria and other vaccine-preventable diseases in the face of chronic poverty and hunger dominates the public health landscape (Boutayeb 2006, Ekpenyong, NE et al. 2012). While infectious diseases have received huge attention given the near-success of the Millennium Development Goals (MDGs)[1], non-communicable diseases, particularly hypertension burden has continued to mount. Recent evidence revealed that SSA (including Nigeria) is at the early second stage of the epidemiological transition characterised by hypertensive heart disease driven by cardiovascular risk factors (Omran 2005). However, the surge in urbanisation and industrialisation and in recent time environmental risk transition appears to have worsened these occurrences owing to exposure to environmental pollution. Chronic high-level and prolonged low-level exposure to these contaminants comes with huge cost not only to humans, the flora and fauna but also to the environment comprising the air, soil and water bodies.

Environmental pollution is a big issue in both the rural and urban Nigeria particularly in the Niger Delta region where the major oil and gas production and allied operation are occurring on a large scale (Osuji, Adesiyan et al. 2004, Osuji and Adesiyan 2005, Kadafa 2012). Evidence linking the prevalence of hypertension and environmental pollution has concentrated in high-income countries where epidemiological research priority has continued to shape health policy.

[1] Millennium Development Goals are the United Nations global time-bound and quantified targets for addressing extreme poverty in its many dimensions including halting the spread of diseases and providing universal primary education. MDGs era comes to a conclusion at the end of the year 2015.

In those climes, public health preventive and disease management strategies are research-driven. However, the absence of health policy direction and lack of research funding support in Nigeria and other LMICs has continued to mounting pressure on the already weakened health system.

Recent reviews and meta-analysis evidence of the prevalence of hypertension in Nigeria have reported estimates ranging from 8.9 to 46% from younger adults to elderly population (Ogah, Okpechi et al. 2012, Adeloye, Basquill et al. 2015). The reviews also found that the burden of hypertension has been highest in urban areas compared to the rural environment with values of 30.6% versus 26.4% respectively (Adeloye, Basquill et al. 2015). This is consistent with evidence from other countries. There has not been any review or individual study with a central theme of environmental pollution and its association with hypertension and/or stroke in Nigeria to warrant comparison with the estimate from the entire country or part thereof. With the current evidence suggesting a significantly higher prevalence of hypertension in urban compared to rural areas in Nigeria, this evidence may not be generalised in all the regions in Nigeria particularly in the Niger Delta rural communities where oil and gas production and environmental pollution has been occurring over time with a potential increase in hypertension and stroke prevalence estimates.

This thesis is unique because it focuses on the risk associated with environmental pollution and the prevalence of hypertension and stroke. It is not just a routine survey which aims to report the proportion of hypertensives and stroke in a given population. Besides the small number of studies on environmental pollution and risk of hypertension associated with oil/gas industry, to our knowledge no study have so far investigated this relationship in Nigeria or Niger Delta where oil and gas exploration activities has been going on for decades and where residents were chronically exposed.

Using the recent fieldwork conducted in the Niger Delta region (Rivers State) in Nigeria, this thesis focuses on the comparative estimate of the prevalence and risk of hypertension and stroke in oil and gas polluted and non-polluted communities.

1.2 Why Nigeria?

Nigeria was chosen for this study for a number of reasons. It ranks as the largest oil and gas producer in Africa, 11^{th} in the world and the 12^{th} largest exporter in the whole world, averaging 2.28 million barrels per day (British Petroleum 2014). As the most populous country in Africa currently experiencing epidemiological transition, the burden of NCD and in particular hypertension and stroke has reached endemic proportion to warrant strong regional and global attention. Secondly, as a developing country, it has very weak environmental pollution regulations and has been reported to be a "pollution haven" with the highest emission record in the oil and gas sector (DPR 2010).

Recent estimates from the United Nation reported that 64.4 % of the Nigerian population live below one USA dollar ($1) per day while about 54.7% live below the national poverty line (United Nations Environment Programme 2011). With about 63.8% of the population living in the rural areas (National Population Commission 2007) which bear a huge burden of both communicable and non-communicable diseases, public health policy should be designed to offer more protection to these vulnerable individuals. Specifically, NCD deaths account for 41.7% among those under age 60 (percentage of all NCD deaths) while age-standardised death rate related to cardiovascular disease and diabetes stood at 455.8/100,000. A WHO report also found that the proportion of adults with elevated blood pressure stood at 42.8%, the second highest in sub-Sahara Africa behind Tanzania (Lawes, Vander Hoorn et al. 2006). Ignoring these estimates is a clear invitation to public health catastrophe. Therefore, targeting vulnerable population in rural areas where environmental pollution is endemic would reduce the large base dominated by untreated and uncontrolled hypertension which also exacerbates growing stroke morbidity and mortality.

1.3 Why Niger Delta?

Since the focus of this research is on hypertension and stroke, and the oil and gas pollution currently occurring in the rural areas, the rural communities in the Niger Delta region in the southern part of Nigeria is of paramount importance. This is because the rural communities of Niger Delta are the host communities where oil exploration and refining and gas flaring are taking place. Niger Delta consisted of 9 states that make up the oil producing states among the 36 states of Nigeria. Niger Delta region is the oil-rich coastal region which houses the crude oil and gas in Nigeria. The region is the largest oil and gas reserve in Africa. As at 2009, there are more than 150 oil-fields and 1,481 oil wells in the Niger Delta region. As a result, this natural deposit has attracted numerous international oil companies and other industrial establishments whose activities affect the quality of the environment and health of the populations, particularly in the rural areas. The increasing level of environmental pollution in this region has led to serious international controversy and conflict (United Nations Environment Programme 2011). Niger Delta also represents areas where both epidemiological and environmental transitions are currently occurring.[2]

1.4 Why Rural Communities like Ebubu?

Ebubu represents a typical rural area in Niger Delta region. It is located in River State (One of the nine states of Niger Delta) designated as the oil and gas capital state in Nigeria (Niger Delta Development Commission, 2001). This area is one of the communities that make up the major four local government councils namely Eleme, Tai, Khana and Gokana (Ogoniland) with a combined local indigenous population of 850,000 as of 2008 (National Population Commission

[2] 2011 UNEP report and reconnaissance visit to the study area in 2012 proved that this assumption holds.

2007). This rural area is chosen for this study because of its poor public health and environmental quality records. Recent evidence showed that there were 2,976 oil spills of about 2.1 million barrels of oil in Ogoniland (United Nations Environment Programme 2011). This accounts for about 40% of combined oil spills involving Shell Petroleum Development Company (SPDC) worldwide (United Nations Environment Programme 2011). The impact of these spills is increased in socio-economic and public health burden. The region is abundantly endowed; it is oil-rich, yet grapples with alarming health inequality (Kandala, Ji et al. 2008, Antai 2011). Therefore, I assumed that this polluted-environment may have increased the risk of hypertension and stroke independent of other contextual and modifiable variables.

1.5 Justification for the Study

The concentrations of oil and gas production activities and unending environmental pollution in Niger Delta have continued to change not only individual experiences but also rural neighbourhood and household socio-economic situations (United Nations Environment Programme 2011). Social conflict and civil strife between the oil companies and these rural communities particularly in Ogoni were evident (Frynas 2001, United Nations Environment Programme 2011). Even though stable communities have returned as a result of many strategic initiatives, the inequality in health and environmental pollution persists (Kandala, Ji et al. 2008, Antai 2011).

With the current demographic and nutrition transitions, along an epidemiological shift in disease pattern in Nigeria, it would be noted that rural communities in Niger Delta are not immune to these transitions owing to socio-economic investments (Ikelegbe 2005, Idemudia 2009, Ordinioha and Brisibe 2013). While cardiovascular disease prevalence has continued to peak in the Niger Delta, it is important to understand whether the increased prevalence is occurring as a result of increased risk factors in the rural communities where economic opportunities are not only created but also destroyed, resulting in socio-economic dynamics that redefines the public health situation.

The big question is whether the risk and prevalence of hypertension and other major cardiovascular risk factors in oil-polluted rural Niger Delta communities compare with the current prevalence in both urban and rural areas outside the Niger Delta? Many studies in developing countries including Nigeria have explored CVD risk factors particularly hypertension, BMI, smoking and alcohol consumption (Opie and Mayosi 2005, Addo, Smeeth et al. 2007, Agyemang, Addo et al. 2009, BeLue, Okoror et al. 2009). It is worth exploring further the size and distribution of these in Niger Delta and the rural communities in particular.

Previous studies on the long-term impact of pollutants exposure to adults living in environmental polluted areas have been associated with increased disease morbidity and mortality (United Nations Environment Programme 2011). In addition to causing a direct loss of income for the individual, oil pollution significantly impacts household's socio-economic assets which directly or indirectly influence the proximal as well as distal risk factors for CVDs. Past literature has shown that poor socio-economic circumstances directly affect hypertension in the developed world (Grotto, Huerta et al. 2008, Minor, Wofford et al. 2008, Lam 2011). However, there is a positive correlation between hypertension and increased socio-economic level in urban areas of developing countries particularly Nigeria due to consumption of unhealthy diets and adoption of lifestyle associated with urbanisation (Addo, Smeeth et al. 2007, Ogah, Okpechi et al. 2012).

Pollution is a strong risk factor for hypertension and stroke. In addition, hypertension is the strongest independent risk factor for stroke especially in the elderly (Willmot, Leonardi-Bee et al. 2004, Kario, Ishikawa et al. 2006). Evidence found that hypertension causes about 50 percent of ischemic strokes and also increases the risk of haemorrhagic stroke (Qureshi 2008, Tsze and Valente 2011). Therefore, a peak in hypertension prevalence leads to a corresponding increase in the risk stroke even without additional pollution risk. A review of literature on cardiovascular morbidities and mortalities in both secondary and tertiary hospitals in Nigeria revealed that there is huge increase in stroke, ischemic heart disease and heart failure in Niger Delta (Danbauchi 1996, Van der Sande 2003, Unachukwu, Agomuoh et al. 2008, Onwuchekwa, Onwuchekwa et al. 2009, Desalu, Wahab et al. 2011, Onwuchekwa, Tobin-West et al. 2014). It also emerged that 70% of the patients are unaware of the underlined risk factors, particularly hypertension (Ekwunife and Aguwa 2011, Ogah, Okpechi et al. 2012, Adeloye, Basquill et al. 2015)

A critical appraisal of few primary studies (blood pressure only) conducted within environmental polluted communities in Niger Delta reported a high prevalence of hypertension and stroke, and associated risk factors (Ordinioha and Brisibe 2013, Onwuchekwa, Tobin-West et al. 2014). Even though the studies found a very high prevalence of hypertension (32.2-68.9%) and stroke (8.51/1000) there are some obvious methodological issues in design and analytical protocols. Specifically, these studies did not include environmental pollution as one of the potential risk factors for hypertension and stroke which this present study would address. Addressing these deficiencies would clarify the potential contribution of pollution towards the high prevalence of hypertension and stroke in the Niger Delta.

Similarly, a previous survey of oil company workers in urban areas of Niger Delta revealed very high prevalence (45.45%) of diabetes among oil company workers (high socio-economic level) compared to non-oil workers of lower socioeconomic level ($P<0.0001$), with a mean blood glucose concentration level of 7.45 ± 2.25 mmol/l[3] against 5.33 ± 0.48 mmol/l, respectively (Nwafor and Owhoji 2010). It is not yet known if the socioeconomic effects observed in the urban study could be generalised in rural areas particularly within the oil producing communities of Niger Delta where oil production activities have continued to transform the economic fortunes of the rural households. This current study will also fill this gap.

[3] Mmol/l - Millimoles per litre is the international standard unit for measuring the concentration of glucose in the blood.

Maternal exposure to PAH (an environmental pollutants and endocrine disruptors) as previously reported is significantly associated with childhood obesity (Rundle, Hoepner et al. 2012). A critical appraisal of relevant studies revealed that PAH and other similar pollutants play a role in the obesity epidemic by altering metabolic programming in early life (La Merrill and Birnbaum 2011). While young people are at the core of the epidemiological transition, it could be possible that clusters of middle age adult with high BMI and body fat distribution may be higher in these polluted rural communities owing to their maternal exposure to pollutant threats. Even though no prospective cohort studies have been undertaken in Nigeria, a peak in high BMI of middle age adult in these rural communities may provide an entry point to an emerging hypothesis, vis-à-vis the prevailing socio-economic and structural situations.

In the whole, this work would make an original contribution to our understanding of the distribution and prevalence of hypertension and its risk factors and how this increased risk if any is associated with stroke burden among vulnerable adults in Niger Delta. In the presence of additional risk factor apart from hypertension, there is a significant increase in Framingham CHD risk scores (Anderson, Wolson et al. 1991). This knowledge will be very important not only for clinician but also for the institution of adequate public health intervention especially in Niger Delta and Nigeria as a whole.

1.6 Overview of Thesis Structure

This thesis comprises eight chapters:

Chapter two will describe the conceptual framework linking the major risk factors, contextual factors, environmental pollutants related to crude oil and gas flaring, and hypertension/stroke. Specifically, it will provide theoretical basis underpinning the exposure-disease relationships including the direct and indirect route of pollutants entry to human and how these could increase the risk and prevalence of diseases. The framework will also provide the analytical construct to be used in addressing the research questions and study objectives.

Chapter three will present the study aims and objectives including the research questions and study hypothesis.

Chapter four will provide the methodological protocol used to conduct the systematic review and meta-analysis of hypertension and stroke in LMICs. The protocol will include detailed data sources and extraction, study eligibility criteria, study selection, quality assessment criteria and statistical analysis procedure used in the analysis of the data.

Chapter five will provide the results of systematic reviews and meta-analysis of hypertension and stroke. It will include detailed results of all databases searched, study characteristics and the pooled estimates of both hypertension and stroke across different regions, sociodemographic (or socioeconomic) and WHO income groups. This chapter will also provide discussion on the key findings including the gaps in the literature. The implication of the findings from the reviews with respect to public health policy and practice will also be presented.

Chapter six aims to provide the background of the research. It will also provide detailed information on the study area of Niger Delta in general and the study communities in particular. This will include the state of health care and health-related investment in Nigeria and Niger Delta.

Chapter seven will describe detailed methodological issues and procedures undertaken before and during data collection in the study areas. This will also include a description of research methods and design approaches used. This chapter will also provide details on data collection instruments/materials and all the study outcomes measures of interest.

Chapter eight aims to provide the study results based on the data collected and analysed for hypertension prevalence in the study communities. The results are then summarised using appropriate statistical presentation.

Chapter nine aims to provide the study results based on the data collected and analysed for stroke prevalence in the study communities. The results are then summarised using appropriate statistical presentation.

Chapter ten aims to provide the summary of the main findings. It will also provide details on the study limitations, original contributions and strengths of the research. It then concludes the thesis by discussing the lessons learnt from the research and its implication for research and public health policy and clinical practice. This will also provide relevant proposition and/or recommendations for informing policies related to environmental pollutants exposure risk reduction and management of hypertension/stroke in the Niger Delta. The Chapter also makes suggestions for further research and then conclude with key learnings from the study.

Summary

In this chapter, a detailed introduction of the main health issue and the study justification were presented. The structure of the thesis was also presented in this chapter. In the next chapter (Chapter 2), the study's conceptual framework will be presented.

CHAPTER TWO

2.0 THE CONCEPTUAL FRAMEWORK

INTRODUCTION

This chapter provides the background knowledge on energy use and industrialisation, environmental pollution and socioeconomic factors, and how these have linked to the health conditions (hypertension and stroke) relevant in this thesis. Considering the complexities inherent in understanding the health effects of environmental pollution, the concept of exposure and disease relationship (EDR) has been widely adopted as an organising framework for monitoring pollutants and tracking disease in the population. Although it is possible to quickly think of the framework as a policy tool, it has also become a focus of extensive research in the areas of exposure science. EDR will underpin some conceptual theory and background analyses conducted in the rest of the thesis. It does this by first providing a brief historical perspective on domestic energy use and industrialisation, environmental risk transition, oil and gas pollution, the environmental and socioeconomic impact and predictable interactions resulting from important health outcomes.

More specifically, in this thesis, the theoretical thinking about environmental and socioeconomic impacts is well situated. The pathophysiological mechanisms and important stressors, pathways and route of entry of pollutants species into the human body to increase the risk of disease particularly hypertension and stroke are discussed. A broader health and socioeconomic perspectives which include not only the biological effect of pollutants but also the socioeconomic impact of oil and gas industry that can influence other risk factors are also presented. In addition, socioeconomic and environmental impact assessment as an assessment tool and the livelihood situation within the oil and gas host communities are presented. Finally, the chapter sets out the study's conceptual framework and how it addresses the study objectives.

2.1 Brief Historical Perspective

Pollution and health issues are concepts that have received significant attention in the development and environmental health literature. Huge reliance on oil and gas is now an inevitable price for industrialisation and globalisation. The understanding of fossil energy use on economic development must take into account its impact on the environment as well as human health. To achieve sustained industrial development, therefore, all jurisdictions must continue to emphasise effective energy production and utilisation driven by adequate environmental and health policy and research. Models like the exposure-disease paradigm have been developed to help us broaden our understanding of the concept of disease epidemiology and evidence-based policy and public health practice (Hill 1965, Horwitz, Feinstein et al. 1984, Kosinski and Flanders 1999).

Many achievement and accomplishments of civilisation depended largely on the efficient and extensive use of various forms of energy to extend human capabilities and dominance. This means that the indispensability of energy cannot be underestimated for economic growth and human development. While economic growth is an essential prerequisite for overcoming poverty, it is important to note that affordable energy is not only essential for eradicating poverty but also elevating living standard and population welfare globally (International Energy Agency 2010).

Historically, the genesis of the link between energy and human development is a familiar pattern right back to the domestication of fire some thousands of years ago. The industrial revolution of the nineteenth century decisively seals the relationship between energy and modern economic development (Kranakis 2009, Brand Correa 2014). Specifically, during the last half of the 19^{th} century, energy dependence for industries and transportation grew in a concerted fashion fuelled by coal. Global coal consumption continued on the upward swing until after the Second World War when reliance on petroleum and nuclear energy took centre stage (Fouquet 2010). Safety standard and labour issues increased not only the cost of coal production but also led to its decline leading to the revolutionisation of the transport and manufacturing sectors (Smil 1994). The era of steam engine deepened and accelerated global economic development with a series of historical revolution and evolutions. Crude oil and natural gas replaced coal in the early 1950s albeit on a marginal scale in high-income countries.

To date, huge reliance on crude oil and natural gas for industrialisation have resulted in the global oil and gas market boom and this has been the fundamental enabler of socio-economic development in many oil producing countries like Nigeria (Oyedepo 2012). The issue of climate change and the global threat posed by industrialisation and urbanisation has made hydroelectric and wind power a preferred option which modern economies has continued to embrace (Bauen 2006).

Although the process of industrialisation and urbanisation implies breaking away from a certain state-of-nature society[4], it has its roots in a deeply ingrained historical momentum which has not been altered significantly in sub-Saharan African, India and parts of Asia. The inroads of non-renewable energy brought in its stead had enormous consequences. Until then, reliance on the energy of biological origin did not affect the stability of the carbon cycle. Specifically, non-renewable fossil energies, and oil and gas, in particular, became the pillar of economic growth resulting in a combination of factors and circumstances among which is environmental pollution.

2.2 Theory of Environmental Transition

In poor household worldwide, the most inelastic segment of demand for energy is that for cooking and heating need. Today, an estimated 2.7 billion people still rely on biomass such as charcoal, fuelwood, animal dung and agricultural waste (International Energy Agency 2010). However, rich economies have transited from this towards simultaneous utilisation of several

[4] Wild primitive state untouched by civilization

forms of energy ever known to man to unlock economic growth and global development. Compared to developed world where technological innovation has accelerated a shift from biomass to petroleum products to renewable sources for general energy need, it would be noted that developing countries like Nigeria and India are catching up in this petroleum products utilisation especially in major cities in the urban areas with higher vehicular traffic, power generators and concentration of cottage industries (World Bank 2013).

Table 1: Number of People Relying on the Traditional Use of Biomass, 2009 (Million)

Regions/Economy	Number of lacking access to electricity	Number of relying on traditional use of biomass for cooking
Africa	587	657
Sub-Saharan Africa	585	653
Developing Asia	799	1937
China	8	423
India	404	855
Other Asia	387	659
Latin America	31	85
Developing countries[5]	1438	2679
World[6]	1441	2679

(International Energy Agency 2010)

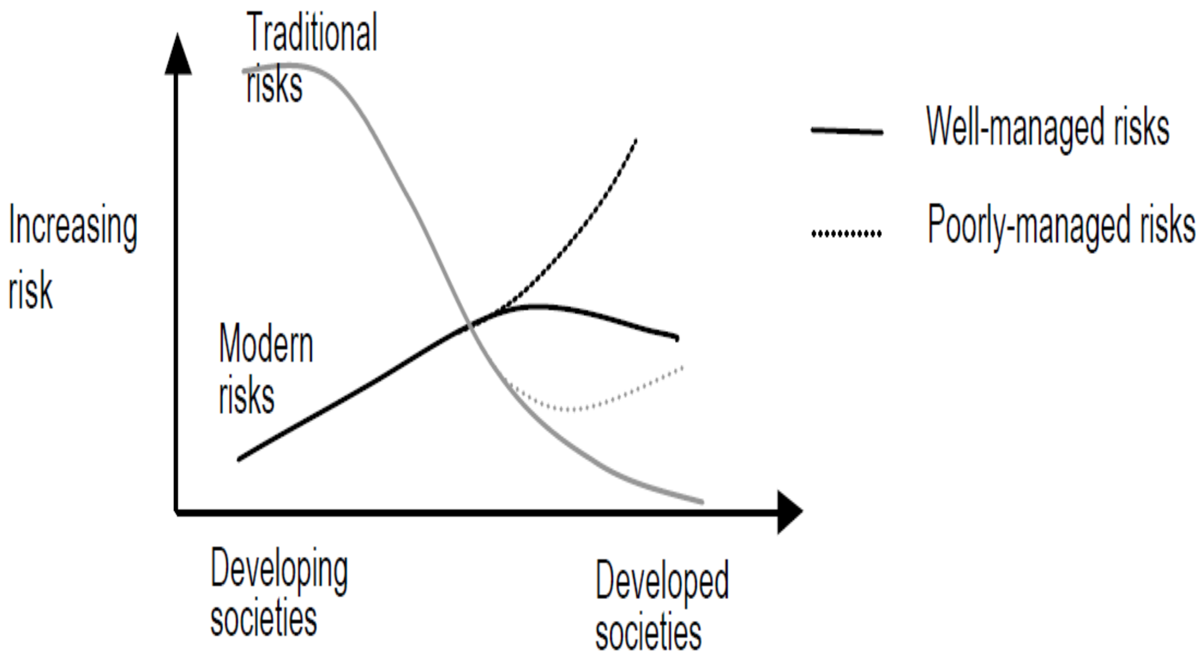
This pollution generation pattern and changes underpin the theory of environmental risk transitions characterised by a shift from traditional risk (such as biomass-indoor pollution, waste disposal and poor sanitation) to modern environmental risk (such as outdoor air pollution-vehicle traffic, crude oil pollution and refining operations) as shown in figure 1.

[5] Include middle east countries
[6] Include OECD and transition economies

(Smith, Corvalán et al. 1999, Gundlach, Imevbore et al. 2005)

Figure 1: Environmental Risk Transitions Curve

A review of studies found that both the rural and urban poor in most developing countries pays a relatively huge price of industrialisation. This is because they are particularly exposed to environmental hazards such as air pollution, poor housing, bad working environment and limited access to service and care. Environmental risk factors according to study evidence play a role in more than 80% of the diseases regularly reported by the World Health Organization (Jeppesen, Andersen et al. 2006). The rate at which pollution occurs is highly influenced by environmental risk management effort. However, due to weak environmental risk regulation and lack of appropriate management effort, it has led to a double burden (Figure 2) of these risks in many developing countries particularly Nigeria (Oyedepo 2012).



(Smith, Corvalán et al. 1999, Gundlach, Imevbore et al. 2005)

Figure 2: Double Burden of Environmental Risk in Developing Countries

2.3 Environmental Pollution

The success of an industrial society, national development and livelihood of the masses depend on the available resources in their immediate environment. Accessing these resources is a function of the quantities and types of energy resources it exploits and the efficiency with which it converts potential energy into work and heat (International Energy Agency 2010). However, the overall activities that involve the exploitation and processing of some of these resources result in environmental pollution and degradation. Environmental pollution or the undesirable change brought about by pollutants in the biological, physical and chemical characteristics and component of the air, water and land has continued to attract global attention due to the fact that the problem is on the increase day in day out as a result of industrial and economic activities (Jeppesen, Andersen et al. 2006).

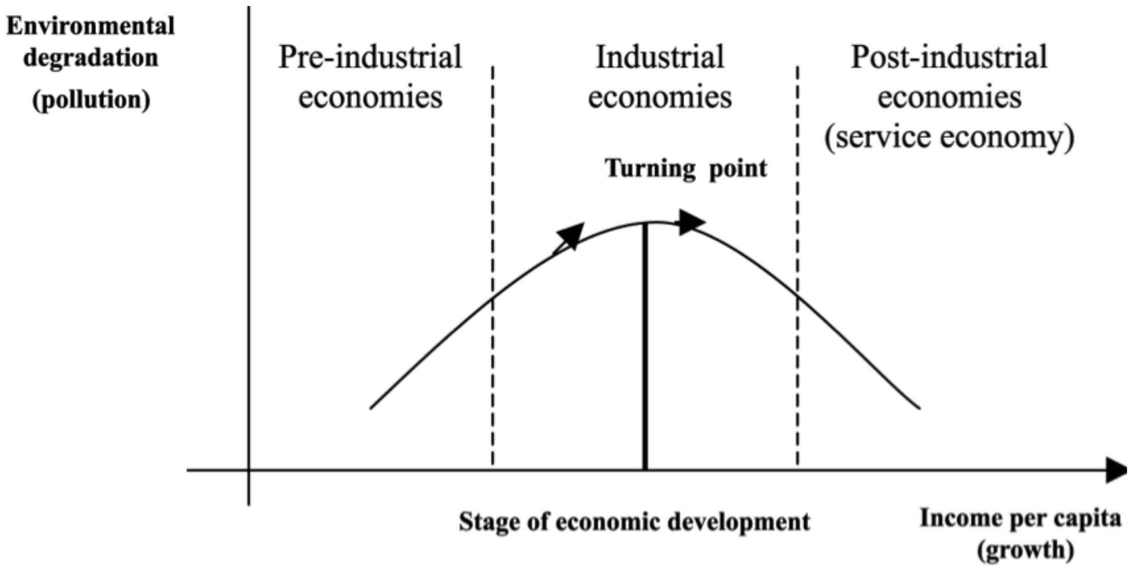
Environmental pollution is as old as civilisation and is undoubtedly greatest in the developing world or emerging economies comprising of the BRICS[7] where traditional sources of pollution such as industrial emissions and traffic-related air pollution, poor sanitation, inadequate waste management, contaminated water supplies and exposures to indoor air pollution from biomass fuels and outdoor affect more than fifty percent of the global population (Economy 2006, Jeppesen, Andersen et al. 2006). The latest report also found that MINT[8] has combined with BRICS to wreak havoc on the global environment (Economy 2006, Jeppesen, Andersen et al. 2006). Despite the major efforts and strategic initiatives that have been made over recent years to clean up the environment and/or reduce man-made activities or anthropogenic pollution, it remains a major problem and poses continuing risks to human health and the global climate change. Developed countries have achieved substantial economic growth which confers a significant advantage for environmental pollution reduction, however, halting environmental pollution may undermine economic growth and competitiveness of developing countries whose economies depends on abundant natural resources and cheap energy utilisation (International Energy Agency 2010).

For instance, the exploration and exploitation of oil and gas, and the activities of multinational oil companies and allied industries in the Niger Delta region in Nigeria has caused substantial increases in pollutant concentrations leading to land, water and air pollution (Gallagher, Edino et al. 2011). The inevitability of environmental pollution in the current economic climate in Nigeria has been demonstrated in the Environmental Kuznets Curve (Figure 3) where an increase in countries GDP or per capita income has a corresponding increase in pollution intensity (Panayotou 1993). To date, the concentration of environmental pollutants has continued to overwhelm the carrying capacity of the natural environment resulting in huge decline in

[7] Acronym for Brazil, Russia, India, China and South Africa who are currently the emerging industrialised nations due to their population size and technology acquisition

[8] MINT is an acronym referring to the economies of Mexico, Indonesia, Nigeria, and Turkey

environmental quality and a sharp increased risk of cardiovascular diseases and other health conditions in Nigeria in general and the Niger Delta region in particular (Gallagher, Edino et al. 2011, Onwuchekwa, Mezie-Okoye et al. 2012, Onwuchekwa, Tobin-West et al. 2014).



(Panayotou 1993)

Figure 3: The Environmental Kuznets Curve: a development-environment relationship

2.4 Pollution and Petroleum Industry

The global economic boom and rapid industrialisation characterised by the discovery of crude oil and gas has led to a relentless effort to discover more in commercial quantity by many countries. The process was accelerated by the invention of the internal combustion engine which relies on cheap and more efficient petroleum products including petrol, diesel and natural gas worldwide.

The oil and natural gas industry is the largest industrial source of emissions of environmental pollutants that cause significant harm to the natural environment. The majority of activities taking place in the oil and gas industry have been implicated in environmental pollution. There is quality evidence that various units of the operations are potential sources of environmental pollution. These sources include; crude oil drilling, flaring, refining and transportation and storage and refuelling operations, and petrochemical plants activities covering distillation, catalytic cracking, separation and treatment units are major sources of pollutants emissions. Every stage of this operation has a potential for emitting pollutants of varying properties. For instance, in the process of drilling and transportation of crude oil in heavy duty tanker or through pipelines, offshore platforms, drilling rigs and wells, the product could accidentally spill due to human error or machine failure leading to what is generally known as oil spillage. This spillage can occur over land or in water bodies. Similarly, in oil wells, rigs and oil refineries, gaseous waste products or non-waste gas produced are routed to an elevated vertical chimney and burned off in the process known as gas flaring. Non-waste gases are burnt off to protect the processing equipment when unexpected high pressure develops or because it is difficult to store and transport them for other purposes.

Many spill incidents are barely reported especially in developing countries where environmental regulations and enforcements are weak. However, some of the biggest oil spills ever known in history have continued to occur in the Niger Delta region of Nigeria and little attention has been paid to such huge environmental incidents (Aigbedion 2005, Nwilo and Badejo 2005, Aghalino and Eyinla 2009, Gallagher, Edino et al. 2011). Although about 240 to 336 million gallons of crude oil flowed into the Persian Gulf in the Gulf war spill incident, it is a far cry from the situation in Ogoniland and other communities in the Niger Delta, where according to UNDP report a total of 6,817 oil spills were officially reported between 1976 and 2001 (UNDP 2006). The most recent UNEP assessment report revealed that remediation effort in Ogoni would take up to 30 years of relentless clean-up operations (Gallagher, Edino et al. 2011).

Other known and well-reported incidents are the recent oil spill in the Gulf of Mexico (the BP-owned Transocean-operated Macondo Prospect) which released between 172 - 180 million gallons of crude oil into the environment (Griggs 2011, Hayworth, Clement et al. 2011). Outside of the United States, oil spills both in water and land have happened in many oil production countries, a few cases of these incidents are shown in table 2.

Table 2: Some of the Largest International Oil Well Blowouts and Spill Volume

Date	Name of Platform	Location	Volume of Oil Released (Barrels)
June 1979 - April 1980	Ixtoc I	Bay of Campeche, Mexico	3,500,000
October 1986	Abkatun 91	Bay of Campeche, Mexico	247,000
April 1977	Ekofisk Bravo	North Sea, Norway	202,381
January 1980	Funiwa 5	Forcados, Nigeria	200,000
October 1980	Hasbah 6	Persian Gulf, Saudi Arabia	105,000
December 1971	Iran Marine intl.	Persian Gulf, Iran	100,000
January 1969	Alpha Well 21	Pacific, California, U.S.A.	100,000
March 1970	Main Pass Block 41	Gulf of Mexico	65,000
October 1987	Yum II/Zapoteca	Bay of Campeche, Mexico	58,643
December 1970	South Timbalier B-26	Gulf of Mexico, USA	53,095

(King 2010)

Gas flaring is common in oil and gas production countries like Nigeria. It is a common feature when petroleum crude oil is extracted and produced from onshore and offshore oil wells and in refining operations. Raw natural gas associated with the oil is produced. However, the gas is mostly flared in countries where there is less investment in converting the natural gas to domestic and industrial use or in areas or countries lacking pipelines and other gas transportation infrastructure. In crude oil refineries and petrochemical plants, most of the gas produced are flared to fuel the various processes involved in turning crude into fuels such as petrol, kerosene, diesel and coal tar and others (Ubani and Onyejekwe 2013). In the most refinery, natural gas is constantly burnt to generate steam required in refining operation, and in some cases to generate some of the electrical power required to operate the refinery (Ghg 1999).

The sources described above are stationary sources. Other stationary sources of environmental pollutants linked to petroleum industry products use includes; indoor and outdoor air pollution resulting from domestic cooking with petroleum refined products like cooking gas and kerosene.

Industrial plants relying on petroleum products for its operations constitute a huge source of non-mobile or stationary source of environmental pollution. However, mobile sources or traffic-related air pollution also arise from the use of refined petroleum products in petrol, gas and diesel powered vehicles. Other mobile sources include marine vessels, trains, construction vehicles (utilising bitumen and tar for road construction) and aircraft which rely on aviation gas oil (AGO) and other refined petroleum products for their operations. All these sources release an enormous amount of different types and species of pollutants in the surrounding environment and pose significant health effects.

2.4.1 Environmental Pollutants

Evidence from exposure assessment and risk characterization of environmental pollutants led to the grouping of pollutants by EPA in line with the clean air act (EPA 2003). These are divided into two broad groups known as hazardous air pollutants and the persistent organic pollutants (POP).

2.4.1.1 Hazardous Air Pollutants

These are diverse range of air pollutants present in the ambient air in relatively low concentration but present the greatest threat to public health due to their characteristics such as toxicity or persistence. They are volatile and semi-volatile organic compounds including Benzene, 1, 3-butadiene, formaldehyde, acrolein, acetaldehyde, and others such as "criteria pollutants". Criteria Pollutants are six main air pollutants recognised by the United States Environmental Protection Agency as needing standards on a national level. They include particle pollution (often referred to as particulate matter or PM), carbon monoxide (CO), ground-level ozone (O_3), sulphur oxides (SO_x: SO_2, SO_3), nitrogen oxides (NO_x: NO, NO_2) and lead (Pb). They are called "criteria" air pollutants because EPA sets National Ambient Air Quality Standards (NAAQS) for them based on their human health-based and/or environmentally-based criteria. As a result of their historical importance, concentration, and overall effects on human, plants and animals, they are now being monitored regularly by many jurisdiction and agencies in many countries such as the London air quality network (LAQN). Crude oil refining and gas flaring release a large concentration of these air pollutants to the ambient air. The species of PM in this group (criteria pollutant) also include diesel exhausts particles (DEP) and residual oil-fly ash (ROFA), which are mostly PM species released around oil refining surroundings.

2.4.1.2 Persistent Organic Pollutants

This group includes pollutants whose most significant exposure routes are ingestion and dermal exposure or contact. They are highly toxic and can persist in the environment for a long time and are known as Persistent organic pollutants (POPs). Their inhalation risk estimates are not large compared to the air toxics, hence, are not expressed using mass-based concentrations. Examples are persistent, bio-accumulative and toxic (PBTs) substances. They are highly toxic and resistant to degradation from abiotic and biotic factors and are highly mobile in the environment. Some of these are the by-product of crude oil refining processes such as petroleum cracking or a creation of petrochemical industry. These compounds include polychlorinated biphenyls (PCBs) mercury, dioxin and polycyclic aromatic hydrocarbon (such as naphthalene, anthracene, phenanthrene and pyrene). Given their natural characteristics and high tendency of bio-accumulation and biomagnification with very long retention times in the environmental media, and widespread distribution across the globe, they are carried in water, food and soil.

2.4.2 Exposure Route or Pathways

Pollutant exposures are most frequently assessed by environmental exposure assessment and personal exposure studies. The targets of these studies are to estimate how many of the pollutants are present in the surrounding environment and how much of them get in contact with human. Gaseous and liquid pollutants from oil and gas production facilities are dispersed in three major environmental media. These include the air (outdoor or indoors), soil and water. The pathways through which these pollutants get into human include inhalation, ingestion and dermal contact. These are illustrated in figure 4.

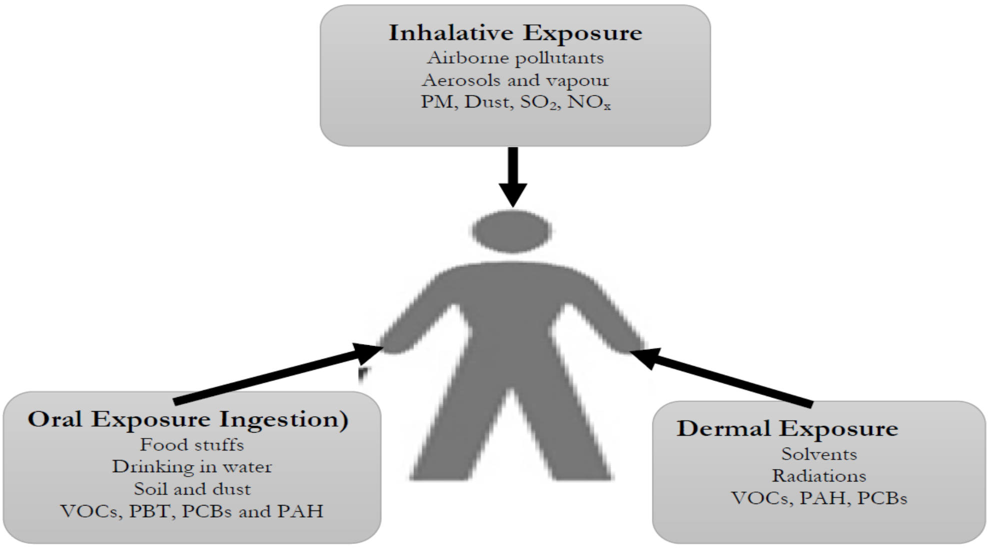


Figure 4: Pollution Sources and Health Effects Pathway

Gaseous pollutants from flaring and refining activities are dispersed in the ambient air in the form of PM, NOx and other air toxics. Some of these are inhaled by both human and animals within the vicinity. Some lighter fractions are transported very far from the source while heavier components are deposited on the soil, vegetation and water bodies. Significant others are deposited on human and animal external body. Similarly, the components of the liquid fraction of these are spilt over land and in water or partly evaporated in the outdoor air.

The various biotic and abiotic processes that occur in nature also influence the final destination, toxicity and bioaccumulation levels of the resultant pollutants. For instance, liquid pollutants that flow into the river or washed into water bodies during rainfall may be taken up by the fishes and other marine creatures. These are subsequently consumed by man through ingestion. Similarly, pollutants that are deposited in the green vegetation many be eaten up by livestock that grazes in the field. These are passed on to man in the food chain. Natural processes such as leaching and flooding may transport these pollutants into the sub-soil and down the water bed or surface water to distant areas and communities. This water may be taken up (in wells and surface) for drinking, cooking and other purposes. The complex pathways described above is represented in figure 5.

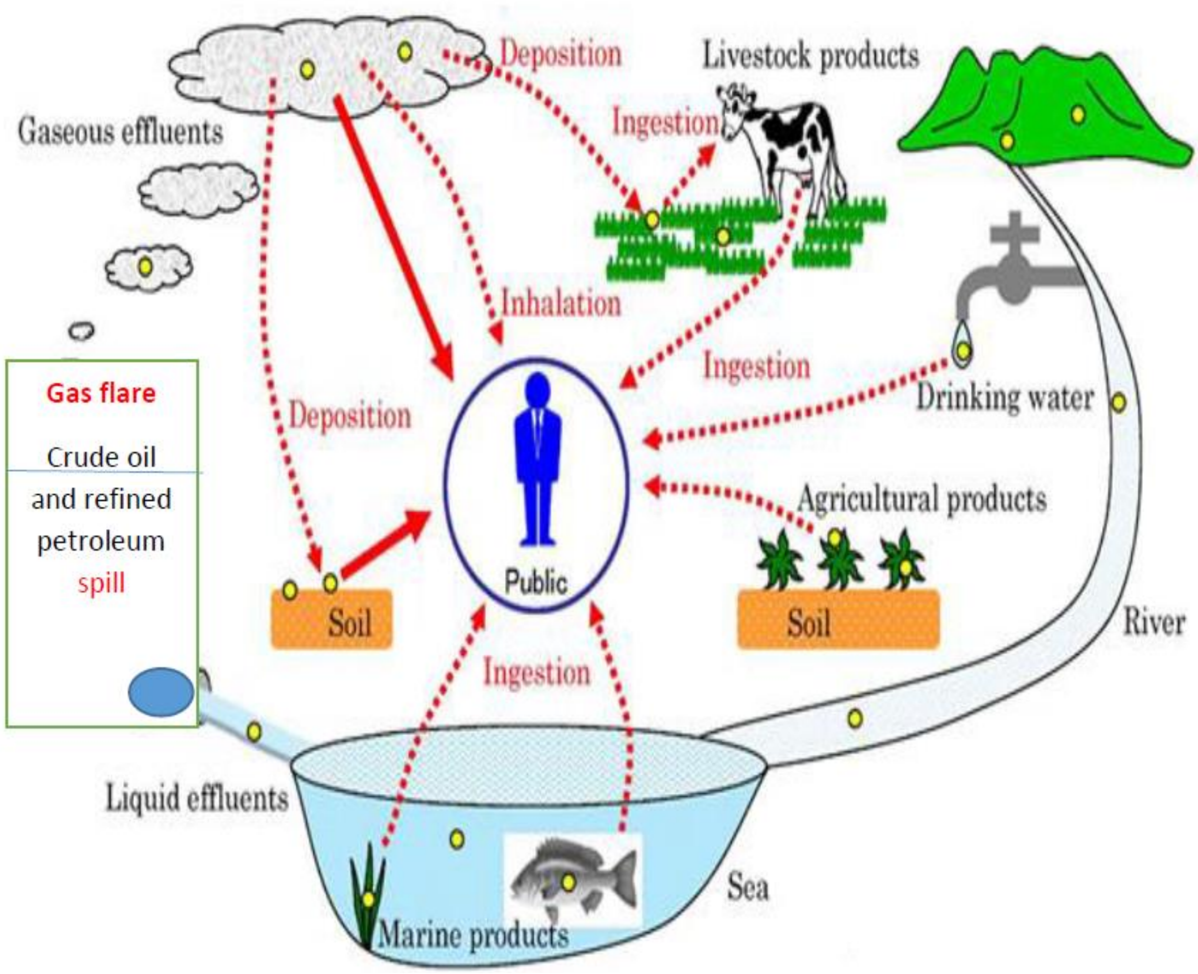


Figure 5: Sources and Routes of Pollutants Exposure in the Environment

2.4.3 Adverse Effect of Pollutants on Human Health

Adverse health effects of environmental pollution in general and of oil spills and gas flaring, in particular, have been well established, but what is not known is their relative impact on cardiovascular health in areas like the Niger Delta where these industries bring about economic prosperity as well as environmental pollution, and therefore the need for the research carried out and reported in this thesis.

The human population exposed to the oil spill and gas flares inhale a variety of poisonous chemicals (such as PM, oxides of nitrogen, sulphur dioxide and PAH) in the surrounding (Cavalieri, Higginbotham et al. 1991, Straif, Baan et al. 2005). These vulnerable individuals also suffer from a variety of respiratory, morbidities including aggravation of asthma, chronic bronchitis, respiratory symptoms and an increase in hospital admissions (Arowosegbe 2009, Anderson, Favarato et al. 2013, Lee, Shah et al. 2014, Shah, Lee et al. 2015). Mortality from cardiovascular and respiratory diseases and cancer, developmental and metabolic abnormalities including insulin resistance and obesity have also been reported (Dunton, Kaplan et al. 2009, Rankin and Nieuwenhuijsen 2011, Hoek, Krishnan et al. 2013, Hamra, Guha et al. 2014, Eze, Hemkens et al. 2015). However, no study or survey carried out in the Niger Delta has examined exposure to these pollutants and the prevalence of hypertension and stroke. The pathways underpinning these impacts could take biochemical or socioeconomic mechanism (Brook, Rajagopalan et al. 2010, Lee, Shah et al. 2014).

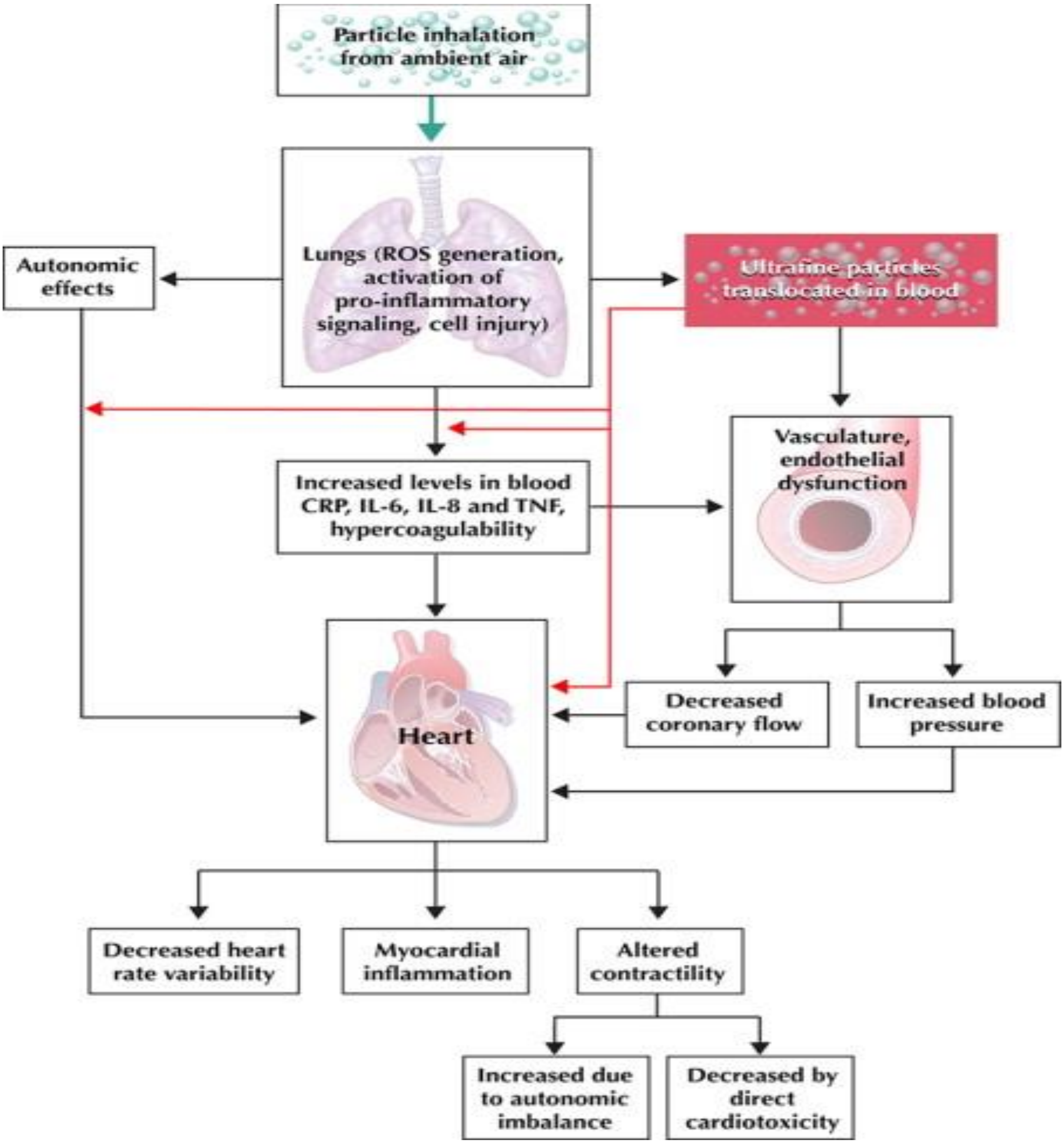
2.5 Environmental Pollutants and Mechanism of Disease

The direct and indirect exposure to oil and gas pollution have been shown to have an adverse effect on human health. The biochemical pathways depend fundamentally on the nature and composition of the pollutants, the concentration in the environmental media, time of individual exposure and route of entry and the policy and socioeconomic interaction taking place in the areas where pollution is occurring. According to the World Health Organization, social determinants of health represent the circumstances in which people are born, grow up, work and age, and all integrated systems put in place to deal with diseases and improve living standard (Chokshi 2010). It noted that these circumstances, on the other hand, are shaped by a wider set of social policies, politics and economic forces (Chokshi 2010, Satcher 2010). Environmental pollution and activities taking place around oil and gas facilities or host communities impact on the surrounding environment by increasing the pollutant toxic concentration in the air, water and ground. This results in huge health risk to both human and animal species. On the other hand, the oil and gas activities not only shape peoples' socioeconomic status but also affect the livelihood situation.

2.5.1 Pathophysiological Mechanism

The association between increased ambient air pollution and adverse health outcome have been studied widely (Brook, Rajagopalan et al. 2010). Various pathophysiological mechanisms implicated in these relationships are shown in figure 6. The major driving processes are inflammation and oxidative stress (Pope, Burnett et al. 2004, Brook, Rajagopalan et al. 2010). Exposure to environmental pollutants such as ambient PM (DEP or ROFA) are associated with elevated systemic residual oxygen species (ROS), after translocation from the lung into the circulation triggering inflammation and oxidative stress.

Pro-inflammatory mediators are involved in the development of inflammation, which is an important factor in many disease processes including direct toxicity and injury leading to endothelial dysfunction. Increased systemic ROS, which are potential triggers of inflammation and oxidative stress, are potentiated by both acute and chronic exposures (Pope, Burnett et al. 2004). Initial reports found associations with day-to-day variation in acute-phase proteins, such as C-reactive protein (CRP), fibrinogen, or white blood cell counts (Lagrand, Visser et al. 1999, Brook, Rajagopalan et al. 2010). An elevated level of reactive oxygen or nitrogen species arising from exposure to pollutants is capable of exerting many adverse biological effects such as lipid/protein/deoxyribonucleic acid [DNA] oxidation and initiation of pro-inflammatory cascades leading to cell injury and endothelial dysfunction.



(Simkhovich, Kleinman et al. 2008)

Figure 6: Pathophysiological mechanism of air pollution and cardiovascular outcomes

Other conditions implicated include thrombosis and coagulation resulting from increased plasma viscosity and fibrinogen concentration due to changes in ambient PM concentrations (Brook, Rajagopalan et al. 2010). Environmental pollutants through the induction of cellular oxidative stress and pro-inflammatory pathways augment the development and progression of atherosclerosis via detrimental effects on platelets, vascular tissue, and the myocardium carotid artery. These effects underpin the atherothrombotic or embolic consequences of acute and chronic exposure to environmental pollution (Pope, Dockery et al. 1995, Peters, Döring et al. 1997, Brook, Rajagopalan et al. 2010).

2.5.2 Socioeconomic Impact and Mechanism of Disease

Evidence of complex social interactions taking place in the oil and gas polluted communities has widely been published (Ipingbemi 2009, Gill, Picou et al. 2011, McCrea-Strub, Kleisner et al. 2011, Ebegbulem, Ekpe et al. 2013). Though some of these interactions may be of beneficial effects, cases of loss of income, poorer health and loss of opportunities have been on the increase due to poor regulation of oil and gas industrial operation in developing countries (Solomon and Janssen 2010, Finkel and Law 2011, Ordinioha 2013). The negative impact of environmental pollution on livelihood has continued to attract huge attention. Livelihood is a concept that involves a social unit (individual, household or group) meeting economic and/or consumption needs (Scoones 1998, Marschke and Berkes 2006). It embraces the capabilities, assets and activities required for a means of living'. Assets can be referred to as the building block of a livelihood or as the stock from which various productive activities are constructed and outcomes such as income are derived. Therefore, when assets (such as land, water, health) are impaired a livelihood becomes unstable and it undergoes a process of change that can influence other components of the livelihood (Davies 1996).

In the socio-economic pathways, the various activities underlining the production of oil and gas may interact to impact on health leading to increased vulnerability or risk factors to cardiovascular health such as chronic stress and poverty (Pickering 1999). These activities may include increased competition and struggle for limited opportunities. For instance, oil and gas facilities attract a huge number of migrant workers both skilled and unskilled in any locality. Such population pressure may hugely impact on the inadequate social infrastructure. Housing cost and prices of local commodities may also rise as a result. The income inequality created by these may widen particularly among those at the lower rung of the socio-economic ladder. The outcome may include psychosocial stress and behavioural changes due to changing adaptation to the prevailing circumstances. These may lead to changes in diet and inadequate investment in health and worsening of health outcome including hypertension and stroke.

In addition, oil spills in fishing water are generally damaging and increases the vulnerability of a fisherman whose livelihood depended on fishing stock as a source of food and income (McCrea-Strub, Kleisner et al. 2011). This applies to farmland belonging to a farmer who depends on it for subsistence (Emmanuel 2006, Alaba and Ifelola 2011, Ahmadu and Egbodion 2013). The oil spill in fishing water can spread for hundreds of nautical miles in a thin oil slick and can affect many individual and communities in the wake of one single spill accident. This can kill seabirds, mammals, shellfish and other organisms it coats. Even though the spill on land are more readily containable if a makeshift earth dam can be rapidly bulldozed, in local communities particularly in developing countries such intervention and containment are non-existent. Oil spills shock touches on various aspects of livelihoods such as drinking water, loss of fishing opportunity, income, crops and grazing land. As a result, there are increased market prices of alternative crops and protein sources and disruption of the fish supply chain in the local markets among others. This unstable nature driven by oil pollution and industrial activities will also impact not only on health as an asset but will have the tendency to tilt the health equality balance among residents of the affected communities such as those in the in Niger-Delta.

Therefore, the externalities of oil and gas production activities in the livelihood systems represent the external factor or the vulnerability context which can encompass a shock or stress to different demographic variables such as age, gender, job types, ethnicity, educational level, health status and socioeconomic position. The link connecting key determinants with contextual variables are shown in figure 7.

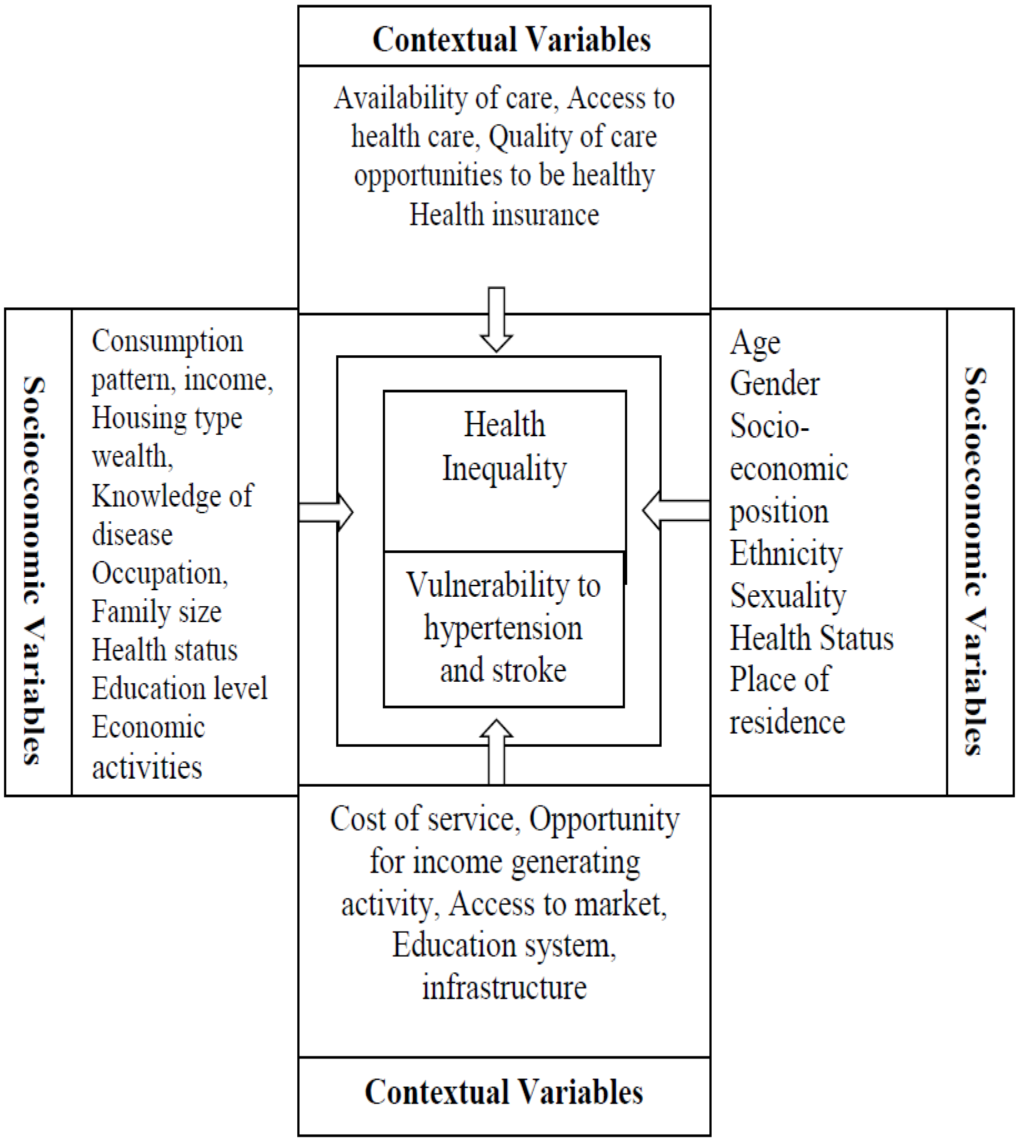


Figure 7: Mechanism linking key Determinants with Socioeconomic and Contextual Variables

2.6 Concept of Environmental and Socio-Economic Impact Assessment

Evidence of impact or consequences of a new project or an existing project on the environment and the socioeconomic changes occurring in a given locality has spurred government and researchers to carry out impact assessment studies (Ortolano 1997).

2.6.1 Socioeconomic Impact Assessment

A socio-economic impact assessment examines how a proposed development or project will change the lives of current and future residents of the host community. The assessment requires the measurement of the expected and unexpected impact. Similarly, post impact assessment (post-SIA) evaluates the impacts of existing projects or facilities long after the initial assessment is undertaken. The goal of SIA or post-SIA is to mitigate expected or unexpected social and economic consequences of a proposed project or existing project in a community respectively (Kirkpatrick and Lee 1997, Nwoko 2014)

Changes in socioeconomic structure and interactions among community members may occur once a new project is proposed to the community. Such proposal may trigger attitude formation toward the project: For instance, interest groups and other coalitions may adopt strategies to protect their interest, speculators may lock up potentially important properties, and community leaders, influential people and politicians can manoeuvre for positions. There may be migration or influx of people in the area. In addition, real, measurable and oftentimes significant effects on the human environment can begin to take place as soon as there are changes in socioeconomic conditions.

Indicators used to measure the potential socio-economic impacts of a development include;

- Changes in community demographics
- Results of retail/service and housing market analyses

- Demand for public services
- Changes in employment opportunities
- Changes in income levels and availability
- Effect on culture including mode of worship and nutrition
- Changes in arranged method of gathering food and care
- Changes in the aesthetic quality of the community

2.6.2 Environmental Impact Assessment

Environmental Impact Assessment (EIA) is the process of evaluating the anticipated effects or consequences of proposed development or project on the environment (Canter, Canter et al. 1996). The purpose of an EIA is to ensure that the environmental effects of a proposed development are properly considered (Ortolano 1997). For instance, the establishment of a mining or oil refining facility in a pristine community would not only endanger community health but also destroy the socioeconomic and natural environment. EIA would, therefore, help to put in place abatement strategies such that the health or socioeconomic situation of the residents of the area will not be affected. In the whole, EIA or SIA aim to prevent, reduce and offset any adverse environmental, health and socioeconomic impacts that may be caused by the project. Such impact is the basis of EDR which researchers may rely on to assess the impact of the exposure such as pollution.

2.7 Study's Conceptual Framework

I have shown that EDR can be useful in understanding the health effect of oil and gas pollution. I have also used this knowledge to develop the study conceptual framework (SCF) shown in figure 8. The SCF starts with a pollution or emission sources which impact on the environment. The concentration of these pollutants that result from the sources influences the magnitude of human exposure through the exposure routes or human organs such as the nose, mouth and the skin. The exposure time or pollutant dose, in turn, determines the health outcomes through various biochemical processes. On the other hand, the socioeconomic impact of pollution or oil and gas industrial operations can mount a huge influence on other risk factors that are associated with disease outcomes. Residents affected by oil soil/pollution on their farm or cultivated soil or crops may be affected psychologically or mentally leading to chronic stress which predicts hypertension and stroke. Exposure to armed conflict which as common feature in the Niger Delta no doubt increases vulnerability to psychological and mental impact suffered by residents of oil and gas polluted areas (Onyechi et al, 2016). This also leads to chronic stress that predicts hypertension or stroke. In addition to lifestyle factors, demographic transition has also been linked to higher prevalence of cardiovascular condition including hypertension and stroke (Defo 2014). The pathway through this can occur could be explained by aging population resulting in improved living standard and healthcare. As stated previously, oil production activities may impose severe economic hardship leading to behavioural changes or it may lead to increases in individual socioeconomic circumstance that may trigger adoption of western lifestyle including consumption of bad diets such as fatty or salty food. Abandoning farming practice that encourages moderate-to-high intensity physical activity for oil-and gas related jobs may also led to a cascade of events and condition that would lead to physical inactivity, overweight/obese and sleep deprivation.

Building on the work of Pope and Dockery (2006) in the area of PM exposure and cardiovascular disease, and the widely published work of Michael Marmot (2005) on socioeconomic inequality and disease, I developed the study framework using EDR which provides a more realistic scope to conceptualise the pathways linking pollution (risk factor) and the outcomes of interest (hypertension and stroke) in the highly polluted communities of Niger Delta region in Nigeria. The relationships between the key outcomes (hypertension and stroke) and the evidentiary pathway underpinning these have also been shown in the SCF (figure 8)

Evaluating the outcomes as shown in the SCF while minimising the various types of error that could occur remain the core of this thesis. Hypertension and stroke cases are the major outcomes of interest. Hence in this study, hypertension was considered a measurable outcome of interest or a risk factor for stroke.

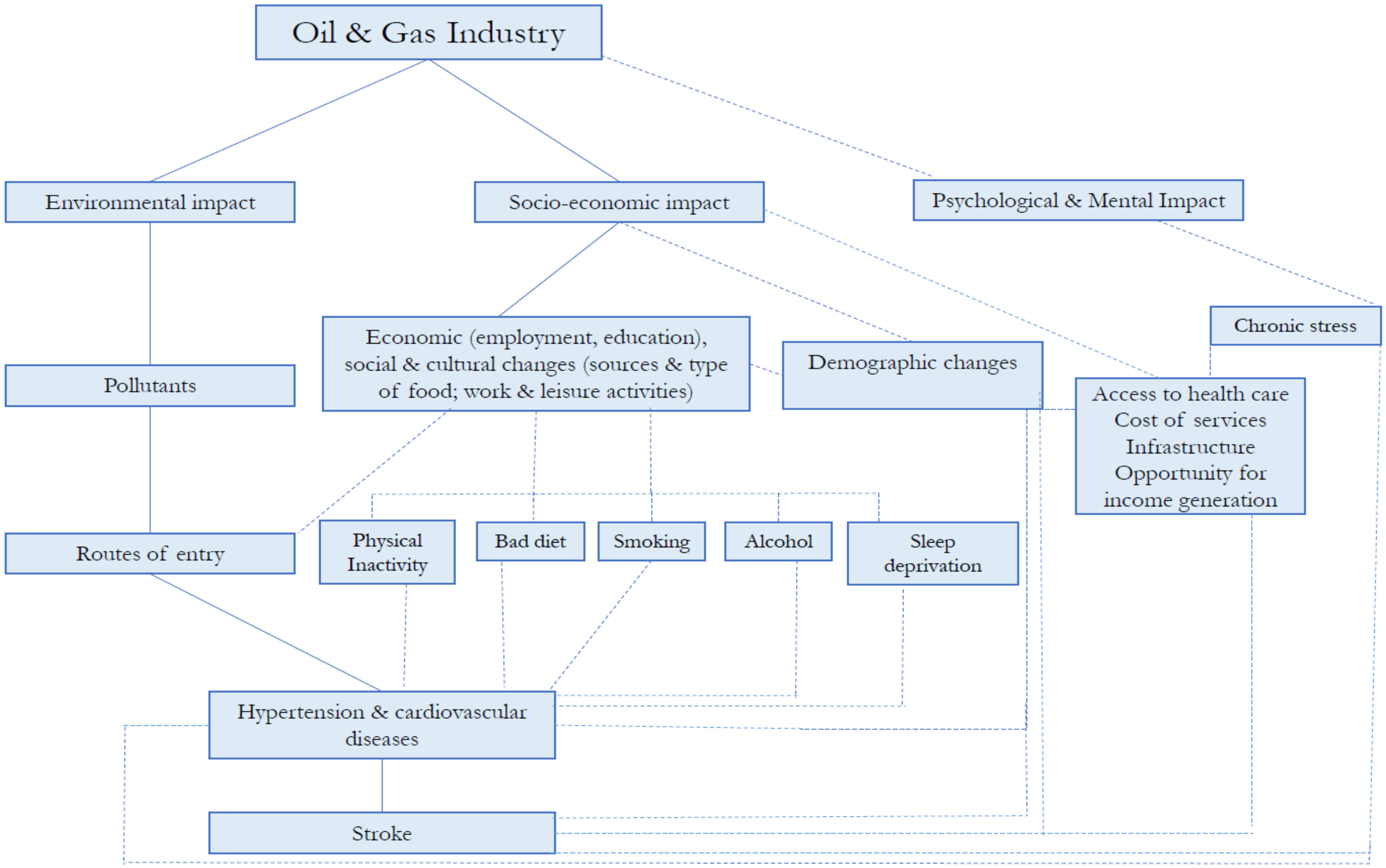


Figure 8: Conceptual Framework for Evaluating the Risk and Prevalence of Hypertension and Stroke

Hypertension is a disease condition which occurs as a result of elevated blood pressure (Woo, Haverbusch et al. 2004). Therefore, I will be evaluating the prevalence of hypertension and stroke as measurable outcomes in the study areas. As shown in figure 8, other factors that could confound the relationship between environmental pollution and the disease (hypertension and stroke) will also be estimated objectively and controlled for using appropriate statistical measures. These include; socioeconomic factors (participant's age, education attainment, gender, income level, employment and marriage status etc.), lifestyle factors (smoking, alcohol consumption, fatty food intake, and physical activity) and other factors. The relationship between hypertension, stroke and socioeconomic and lifestyles variables are described in the SCF (figure 8).

Summary

Exposure disease relationship adapted in this chapter forms the basis upon which the survey was developed and variables identified for the empirical study described in chapter 7 of this thesis. The underline theme in the vulnerability and exposure context leading to diseases is that individuals and communities in Niger Delta are differentially exposed (to environmental pollution) and this is based on factors such as income, education, employment status, gender, age and other factors including institutional and community response. Therefore, a comparative estimate of the outcomes of interests between participants carefully selected from the exposed and non-exposed communities with similar baseline characteristics other than the exposure factor of interest (environmental pollution) remains an ideal approach in measuring the difference between disease frequencies associated with the exposure.

In the whole, the chapter presented the theoretical background and analytical framework linking disease (hypertension and stroke), and environmental pollution. The next chapter outlines the study aims and objectives.

CHAPTER THREE

3.0 STUDY AIMS AND OBJECTIVES

INTRODUCTION

This chapter provides the study's aims and objectives. The study's research questions and how these are linked to the specific objectives are also presented. The chapter also provides a schematic diagram linking the study's hypothesis and the rest of the thesis.

3.1 Study Aims and Objectives

The aim of this research was to investigate the impact of environmental pollution on hypertension and stroke among adult residents of rural communities in the Niger Delta, with the overall objectives of assessing the relative prevalence and correlates of both hypertension and stroke between polluted and non-polluted areas. To address the overall objective, four thematic areas of investigation were undertaken. Each of these addresses a specific objective and relevant research question. These are described as follows;

3.1.1 Thematic Area I: Systematic Review and Meta-Analysis of Hypertension and Stroke Prevalence in resource-limited settings

- To conduct a systematic review and meta-analysis of hypertension prevalence and secular trends among adults in the Niger Delta.
- To conduct a systematic review and meta-analysis of the prevalence of stroke in LMICs including Nigeria. This will allow the determination of secular trends and geographic variations in the prevalence of stroke particularly in Nigeria (Niger Delta)

Our plan is to expand the systematic review of stroke (and not hypertension) to cover LMICs which included Nigeria (Niger Delta), and thereafter conduct a subgroup analysis because of the low number of studies for stroke in Nigeria and in Niger Delta in particular.

The primary interest is the accurate prevalence of hypertension and stroke in the Niger Delta. This interest arises from the suspicion that the current estimates reported for the whole country may have underestimated the true value for Niger Delta region where decades of rampant oil and gas production may have led to increased prevalence. This is in addition to the increased urban-rural shift (or reverse migration) and socioeconomic influences associated with oil and gas production activities in rural communities. The review will, therefore, allow identification of the extent of the problem and gaps in literature which this thesis will address.

Specifically, the review on hypertension will include all observational studies conducted within Niger Delta urban and rural communities. The review on stroke will be expanded to include studies conducted in LMICs. The reason for this is due to limited studies on the prevalence of stroke in Nigeria in general and Niger Delta in particular. I reasoned that the estimates of stroke prevalence and secular trends in LMICs may provide a comparable measure necessary to understand the Niger Delta situation.

The review is expected to provide answers to the following research questions;

- What is the pooled prevalence of hypertension among adults in the Niger Delta?
- Is there any significant difference between the prevalence estimates of hypertension in the rural compared to the urban population in the Niger Delta?
- What are the risk factors for hypertension and stroke among adults' population in Niger Delta and LMICs respectively?
- Is there any secular trend in the prevalence estimates for hypertension and stroke?
- Is there any difference between the prevalence estimates for hypertension/stroke in the Niger Delta region compared to the national survey estimates?
- Is there any regional variation in the prevalence of stroke in LMICs?
- Does the prevalence of stroke differ across individual countries/ regional income group?

3.1.2 Thematic Area 2: Prevalence of Hypertension and Stroke

- To estimate the prevalence of hypertension among adult population aged 18-80 years residing in rural areas of the Niger Delta region in Nigeria.
- To estimate the prevalence of stroke among adult population aged 18-80 years residing in rural areas of Niger Delta region in Nigeria.

Evidence found that the prevalence of hypertension and stroke and their risk factors are significantly higher in urban cities in Nigeria (Ogah, Okpechi et al. 2012, Adeloye, Basquill et al. 2015). This is consistent with review evidence in other LMICs due to the influence of urbanisation and nutritional transition (Sarki, Nduka et al. 2015). However, due to increased environmental pollution occurring in the rural areas of the Niger Delta, it is worth exploring further the current estimates of these important outcomes.

For the purpose of this thesis, I will use a cross-sectional survey (prevalence study) design to estimate the prevalence in the study communities. Detailed explanation on the choice of the design is presented under methodological issues (Chapter seven). Although hospital-based estimates could have provided some important metrics (such as case fatality rate) for the burden of hypertension and stroke, however, I decided to reduce the risk of selection bias by selecting studies which considered the source population only. This arose from the fact that rural residents particularly in sub-Saharan Africa including Nigeria rarely utilise the hospital for their health care needs due to socioeconomic factors including high out-of-pocket costs for health care and distance to the hospital (Ogah, Okpechi et al. 2012, Adeloye, Basquill et al. 2015).

The following research questions will be to be addressed:

- What is the prevalence of hypertension in both oil-polluted and non-polluted environment in the Niger Delta rural communities?

- What is the prevalence of stroke in both oil-polluted and non-polluted environment in the Niger Delta rural communities?
- Is there any significant difference between the prevalence of hypertension and stroke in both polluted and non-polluted communities?

3.1.3 Thematic Area 3: Risk factors for Hypertension and Stroke

- To determine the risk factors for hypertension and among adult population aged 18-80 years residing in rural areas of the Niger Delta region in Nigeria.

Since oil and gas which represent a significant source of foreign exchange for the country are located in the rural communities in the Niger Delta, demand and supply created by global oil and gas boom has led to increased production output which in turn increases pollution of the surrounding environment. At the country level, nothing is known or documented on the various risk factors for hypertension and stroke apart from the traditional factors including lifestyle and socioeconomic factors. The major risk factor of interest in this thesis is environmental pollution, however, other risk factors for hypertension and stroke will be considered. Knowledge of these is important to understanding the key drivers of hypertension and stroke prevalence in the study areas. I did not intent to evaluate the concentration of several pollutants in the study areas as this evidence has been covered by UNEP independent assessment report on the Niger Delta (United Nations Environment Programme 2011). These among others are few limitations of this study discussed in chapter 10.

The research questions that will be addressed include;

- What are risk factors for hypertension and stroke in the study areas?
- Is there any significant difference in the estimates of traditional risk factors for hypertension and stroke?

3.1.4 Thematic Area 2: Relationships of Risk factors and Study Outcomes

- To evaluate the relationship between hypertension and stroke on one hand and the association with pollution and other risk factors on the other.

To better understand the influence of environmental pollution on the prevalence of hypertension and stroke, their relationship must be known and validated. Knowledge of the relationship between the disease and exposure or non-exposure remains an important element for estimating the rate of disease occurrence and how widespread the disease is in the study population. Therefore, this thesis will evaluate the relationship between hypertension and stroke on one hand, and between environmental pollution and hypertension and stroke while controlling for the influence of various confounding variables.

The research questions that will be addressed include;

- Is there any relationship between the prevalence of hypertension/stroke and residing in an oil-polluted or non-polluted area?
- What are the relationship between environmental pollution and socioeconomic factors, lifestyle and other factors such as measures of obesity?

3.2 Addressing the Study Objectives and the overall thesis Structure

In order to address the research objectives detailed above, this thesis seeks to test relevant hypothesis generated as a result. These are described and linked to the rest of the thesis using conceptual linkage as presented in figure 9.

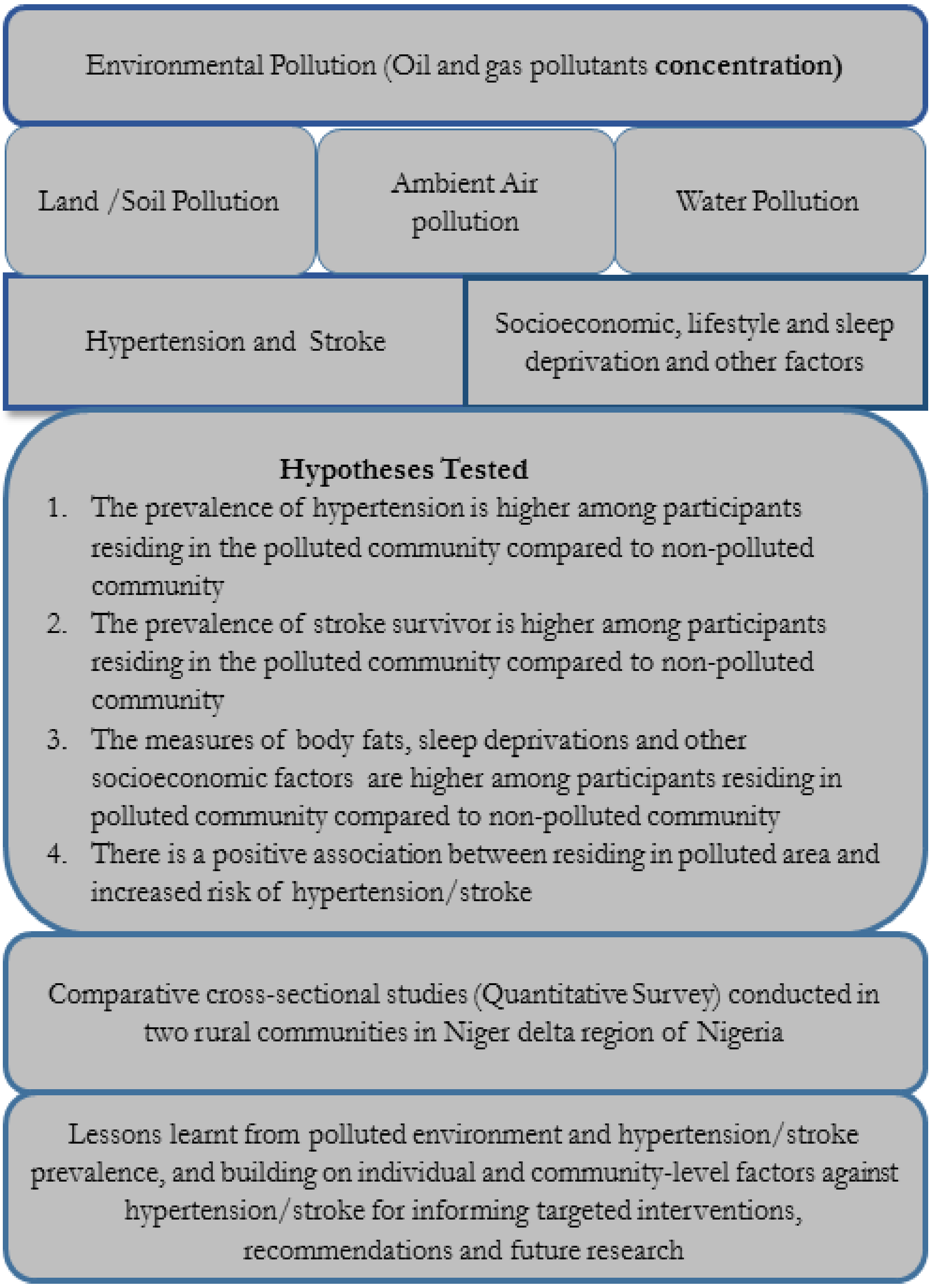


Figure 9: Conceptual Linkages of Study Hypothesis and the Thesis

Summary

In this chapter, the aims and objectives of this project have been presented. In the next chapter, the methodological protocols used for the conduct of systematic review and meta-analysis of hypertension and stroke prevalence will be presented.

SECTION TWO

- **METHODOLOGICAL PROTOCOL**
- **RESULTS OF SYSTEMATIC REVIEWS AND META-ANALYSIS**

CHAPTER FOUR

4.0 EVIDENCE SYNTHESIS: METHODOLOGICAL PROTOCOLS

INTRODUCTION

This chapter provides the methodological protocol and research methods employed in the conduct of the systematic review and meta-analysis of the study. It does this based on the study's broad aims targeting hypertension and stroke prevalence in Niger Delta. The two protocols (hypertension and strokes) followed a consistent and standard format for reporting systematic reviews protocols using PRISMA-P (Shamseer, Moher et al. 2015).

4.1 Protocol for Hypertension Prevalence Review in the Niger Delta

The protocol for systematic review and meta-analysis of hypertension prevalence in the Niger Delta was registered in the PROSPERO International prospective register of systematic reviews with reference number- PROSPERO 2014: CRD42014009107. The protocol is also presented here in greater detail. The completed review has also been accepted for publication as stated in the list of publication page.

4.1.1 Review Objectives

i. To determine the prevalence of hypertension among adults (15 years and over) in the Niger Delta region in Nigeria

ii. To examine the pattern of hypertension across different socioeconomic characteristics (e.g. age, gender, educational attainment, and employment status) in the population studied.

iii. To compare the geographic variations (urban and rural population) on the prevalence estimates of hypertension in the Niger Delta.

4.1.2 Search strategy

A thorough literature search was conducted to identify relevant studies on hypertension prevalence in the Niger Delta. Electronic databases of Medline, Embase, African index Medicus and African Journal online were systematically searched from inception to 30th October 2015, without any language restriction. Relevant articles were identified using the following combinations of MeSH controlled terms, keywords and boolean operators. These include; ("hypertension" OR "blood pressure" OR "hypertens*") AND ("surveillance" OR "survey" OR "prevalence" OR "burden" OR "population-base" OR "community-based" OR "etiology" OR "aetiology" OR "epidemiolog*") AND ("Niger Delta"; - including all the individual States"- OR "oil producing communit*") (Appendix 1). Reference lists of eligible articles were also scrutinised for additional studies that could have been omitted from the database searches. Additionally, authors of selected articles were also contacted to provide specific or missing information regarding their studies and any other published or unpublished work.

4.1.3 Selection Criteria

Retrieved articles were initially screened by their titles and abstracts to obtain studies that met the following selection criteria. These include; a population and/or community-based studies conducted from inception to October 30, 2015. I considered studies that recruited participants aged 15 years and over living in any of the States in the Niger Delta, Nigeria. Such study must report the prevalence of hypertension or provide numerical estimates from which the prevalence of hypertension could be estimated. I included all studies in which hypertension was defined based on 140/90, 160/95 and 160/100mmHg (Krakoff, Gillespie et al. 2014). Studies were excluded if they recruited pregnant women or participants below 15 years of age. Equally excluded were studies without clearly defined diagnostic criteria and blood pressure measurement protocols. Hospital-based studies, policy report or reviews, and studies that did not contain original data (primary data) or focused on non-humans were also excluded. Apart from the current and previously accepted definitions of hypertension, (systolic blood pressure of 140-160 mmHg or a diastolic blood pressure of 90-100 mmHg), based on recommendations of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood

Pressure (Krakoff, Gillespie et al. 2014), I also adopted studies with a subjective definition of hypertension based on the patient self-reported health professional-diagnosed hypertension, patients' medical record or hospital report or use of antihypertensive medication due to elevated systolic or diastolic blood pressure measurement.

4.1.4 Study Selection

Appropriate studies included in the review were obtained through clearly defined stages of selection process. First, the titles and abstracts of the articles obtained through the search were screened for relevance by two reviewers. Any disagreement was resolved through consensus. In the second stage, full texts of the selected articles were retrieved. Reference list of the selected articles was also scanned for additional publications. All the retrieved articles were read for compliance based on the established selection criteria. In the final stage, only studies that met the selection criteria were included in the quality and risk of bias assessment and subject to data extraction.

4.1.5 Quality and Risk of Bias Assessment

The methodological and reporting qualities of the individual studies were independently evaluated using the modified version of Newcastle-Ottawa Scale (Appendix 2). The risk of bias was graded as low, moderate, high or unclear on the basis of study features including the selection of participants (selection bias), sample size justification (selection bias), outcome measurement (detection bias), and confounding adjustment (Appendix 3). I used funnels plot and Egger's test to assess publication bias /small study effect (Egger, Smith et al. 1997)

4.1.6 Data Extraction

For each included study, data and other details were abstracted systematically using a standardised protocol and piloted online data extraction form. Relevant study information extracted includes author's name, publication date, study period, publication type, State, sampling procedure, gender proportion, study setting, ethnicity, age range, mean age, crude prevalence of hypertension, age-adjusted prevalence and sample size, diagnostic criteria/case ascertainment, confounders, comorbidities, analytic method, limitations and key finding from each studies.

4.1.7. Statistical Analysis

The overall prevalence of hypertension was pooled and compared across study settings using a meta-analysis. Before this, I first stabilised the raw proportions of subjects with hypertension from each of the included study using the Freeman-Tukey variant of the arcsine square root transformed proportion suitable for pooling (Miller 1978). Thereafter, the DerSimonian and Laird random-effects model (DerSimonian and Laird 1986) was used to summarise the data. I assessed these variations (within-and between-studies variability) by inspecting the forest plot and by using the chi-square test and the I^2 statistics (I interpret a value of 50% as representing moderate heterogeneity). The result was presented as forest plots with 95% confidence intervals (CIs) expressed in percentage. Study-level influence on the estimated hypertension prevalence was also evaluated using study-level data on participant characteristics (age group, gender, alcohol use, smoking status, and overweight/obesity) in a multivariate meta-regression. The time trends in the prevalence estimates of hypertension from 1980 to 2015 was also examined using Poisson regression models with the absolute cases of hypertension as the outcome variable and the calendar year of the publication as the predictor. This method allows for estimation of time trends across individual calendar years to obtain average annual percentage change (AAPC), assuming that the rate of change is at a constant rate of the previous year (Ezejimofor, Chen et al. 2016). A significance level of 0.05 for *P*-values was used in all statistical analysis. All data analysis was conducted using Stata version 12 for Windows (Stata Corp, College Station, Texas). This systematic review and meta-analysis were conducted in line with the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) guideline (Liberati, Altman et al. 2009, Moher, Liberati et al. 2009) (Appendix 4).

4.1.8 Analysis of Secular Trends

I examined time trends in the hypertension prevalence estimates from 1980 to 2015 using Poisson regression models with the absolute cases of stroke as the outcome variable and the calendar year of the publication as the predictor. This method allows for estimation of time trends across individual calendar years to obtain average annual percentage change (AAPC), assuming that the rate of change is at a constant rate of the previous year (Clegg, Hankey et al. 2009). The Poisson regression procedure fits a model of the following form:

$$\log(cases_y) = b_0 + b_1 y + \log(samplesize) \qquad (1)$$

where *'cases'* equals a number of hypertension cases reported per year, the log is the natural log, *b0* is the intercept, *b1* is the trend, *y* is the year – year is given as 0, 1, 2, … 34 (year 0 is 1980, year 1 is 1981, and so on to 2015), and the log of 'sample size' was entered as the offset. The AAPC was calculated using the following formula:

$$AAPC = \left(e^{b_1} - 1\right) \times 100$$

4.2 Protocol for Stroke Survivor Review in Low and Middle-Income Countries

The protocol for the systematic review and meta-analysis of stroke prevalence in LMICs was registered in the PROSPERO International prospective register of systematic reviews with reference number- PROSPERO 2014: CRD42014015129. The protocol is also presented here in greater detail. The review has also been published in a peer-reviewed journal (Ezejimofor, Chen et al. 2016) as stated in the list of publication page.

4.2.1 Review Objectives

i. To determine the prevalence of stroke in LMICs

ii. To examine the estimate across different socioeconomic characteristics and population subgroups (e.g. age, gender, place of residence, educational attainment, and employment status) in the population studied.

iii. To determine and compare the global (LMICs) variations across geographical regions and WHO income groups

iv. To determine the accurate estimates of secular trends across geographical regions and incomes groups in LMICs

4.2.2 Search Strategy

I conducted a thorough literature search to identify relevant studies on stroke prevalence in LMICs. Electronic databases of MEDLINE, EMBASE, SCOPUS and Web of Science were searched from inception to July 2015 without any language restriction. Relevant journals and reference lists of included primary articles were also scrutinised for additional studies that could have been omitted from the database searches. The following combinations of controlled review terms and keywords covering the study characteristics were used. These include: outcomes; "stroke", “cerebrovascular disease", “cerebrovascular accident", “brain infarction”, “brain stem infarctions”, “cerebral infarction,” study design; "surveillance”, “survey”, “population-based”, “community based", and low-and-middle-income countries; including all individual countries (Appendix 9).

4.2.3 Eligibility Criteria

The eligibility of studies obtained from the literature search was evaluated using a predefined protocol. Only community-based studies that reported prevalence of stroke ‘survivors’ and conducted in LMICs as defined by World Bank (Nielsen 2011) were included Also included were studies that used WHO's definition of stroke, “rapidly developing clinical signs of focal (or global) disturbance of cerebral function lasting longer than 24 hour, unless interrupted by death, with no apparent cause other than that of vascular origin”(Sacco, Kasner et al. 2013), however, less rigorous case ascertainment were allowed due to inadequate facilities in most LMICs. Studies that reported a prevalence of stroke using some elements of the Sudlow–Warlow criteria (Sudlow, Warlow et al. 1997) were also included.

4.2.4 Data Extraction

Relevant information that met the selection criteria were extracted, compared and inputted in the database. In cases of discrepancy, an agreement was reached by consensus following discussion. A standardised protocol and piloted online data extraction form were used. Relevant study information extracted includes author's name, publication date, study period, publication type, WHO region, WHO income group, sampling procedure, gender proportion, study setting, age-range, mean-age, crude prevalence of hypertension, age-adjusted prevalence and sample size, diagnostic criteria/case ascertainment, confounders, comorbidities, analytic method, limitations and key finding from each studies.

4.2.5 Assessment of Methodological Quality

Two authors (AE[9] and I) independently evaluated the methodological and reporting quality of each study using the modified version of Newcastle-Ottawa Scale (Appendix 10). Essentially, I graded the risk of bias in each study as low, moderate, high or unclear according to five study areas namely; selection of participants (selection bias), sample size, detection instrument (outcome measurement tool), adjustment for confounding. Publication bias/small study effects were assessed using funnel plots and Egger's test.

4.2.6 Statistical Analysis

For the meta-analysis, I first stabilised the raw prevalence of stroke from each study using the Freeman-Tukey variant of the arcsine square root transformed proportion (Miller 1978) suitable for pooling. I used a DerSimonian-Laird random-effects model (DerSimonian and Laird 1986)

[9] AE-Aloysius Ezeabasili

due to anticipated variations in the study population, health care delivery systems and stage of epidemic transition. I performed leave-one-study-out sensitivity analysis to determine the stability of the results. This analysis evaluated the influence of individual studies by estimating the pooled stroke prevalence in the absence of each study (Normand 1999). I assessed heterogeneity among studies by inspecting the forest plots and using the chi-squared test for heterogeneity with a 10% level of statistical significance, and using the I^2 statistic where I interpret a value of 50% as representing moderate heterogeneity (Higgins and Thompson 2002, Higgins, Thompson et al. 2003). A co-author and I assessed the possibility of publication bias by evaluating a funnel plot for asymmetry. Because graphical evaluation can be subjective, I also conducted an Egger's regression asymmetry test (Egger, Smith et al. 1997) as formal statistical tests for publication bias. I also explored the effect of study-level factors on stroke prevalence estimates using subgroup and meta-regression analyses. Univariate and multivariate random-effects meta-regression analyses were conducted to investigate the impact of study-level factors on estimate stroke prevalence. Univariate random-effects meta-regression analyses were used to investigate the bivariate relationship between each study-level factors and prevalence of stroke estimates. Multivariate random-effects logistic regression analyses were carried out to determine which study-level factors were independently associated with the prevalence of stroke estimates. Only factors statistically significant in the univariate models were included in the multivariate model. Meta-analysis results were reported as combined stroke prevalence with 95% confidence intervals (CIs), while meta-regression results are reported as odds ratio with 95% CIs. All P values are exact and P<.05 was considered significant. Analyses were conducted using Stata version 14 for Windows (Stata Corp, College Station, Texas). This systematic review was performed following the PRISMA guideline (Liberati, Altman et al. 2009, Moher, Liberati et al. 2009) and PRISMA checklist (Appendix 11).

4.2.7 Analysis of Secular Trends

I examined time trends in the stroke prevalence estimates from 1970 to 2014 using Poisson regression models with the absolute cases of stroke as the outcome variable and the calendar year of the publication as the predictor. This method allows for estimation of time trends across individual calendar years to obtain average annual percentage change (AAPC), assuming that the rate of change is at a constant rate of the previous year (Clegg, Hankey et al. 2009). The Poisson regression procedure fits a model of the following form:

$$\log(cases_y) = b_0 + b_1 y + \log(samplesize) \tag{1}$$

where *'cases'* equals a number of stroke cases reported per year, the log is the natural log, *b0* is the intercept, *b1* is the trend, *y* is the year – year is given as 0, 1, 2, … 44 (year 0 is 1970, year 1 is 1971, and so on to 2014), and the log of 'sample size' was entered as the offset. The AAPC was calculated using the following formula:

$$AAPC = \left(e^{b_1} - 1\right) \times 100 \tag{2}$$

Summary

This chapter has presented the overall methodology protocol used in the systematic reviews and meta-analysis of hypertension in the Niger Delta as well as stroke in LMICs conducted in this thesis. In the next chapter, I will present the results of the systematic review and meta-analysis of hypertension and stroke in Niger Delta and LMICs. The findings of this review will form the basis for the survey as indicated in the introductory chapter.

CHAPTER FIVE

5.0 RESULTS OF SYSTEMATIC REVIEWS AND META-ANALYSIS

INTRODUCTION

The results of the systematic reviews and meta-analysis for hypertension and stroke are presented in this chapter. In the first part of the chapter, a detailed result of the systematic review and meta-analysis of the community-based study of hypertension prevalence and risk factors conducted in Niger Delta region will be presented. This will provide epidemiological evidence on the geographic and socioeconomic variations of hypertension among adults' population in Niger Delta and identify gaps in the literature. The second part will present the result of the systematic review and meta-analysis of the prevalence of stroke in LMICs. The review of stroke in LMICs also included a country-specific analysis (Nigeria, Niger Delta) for stroke. The findings will provide an up-to-date estimate of the prevalence of stroke including an evaluation of the geographic and socioeconomic variations and secular trends. The review also compared study results between those conducted in the Niger Delta and others conducted outside Niger Delta region in Nigeria.

5.1 Results for Hypertension Review

5.1.1 Database Search Result

Figure 10 showed the literature search strategy and study selection process. The literature searches of databases returned 1590 publications. After removing duplicates and following the screening of the titles and abstracts of the publications, I selected 60 articles with full texts for critical reading. A further 39 articles were excluded (24 were conducted outside the Niger Delta, 8 were review articles 4 were among children and 2 did not specify study designs and blood pressure measurement protocols and I have no hypertension prevalence estimates).

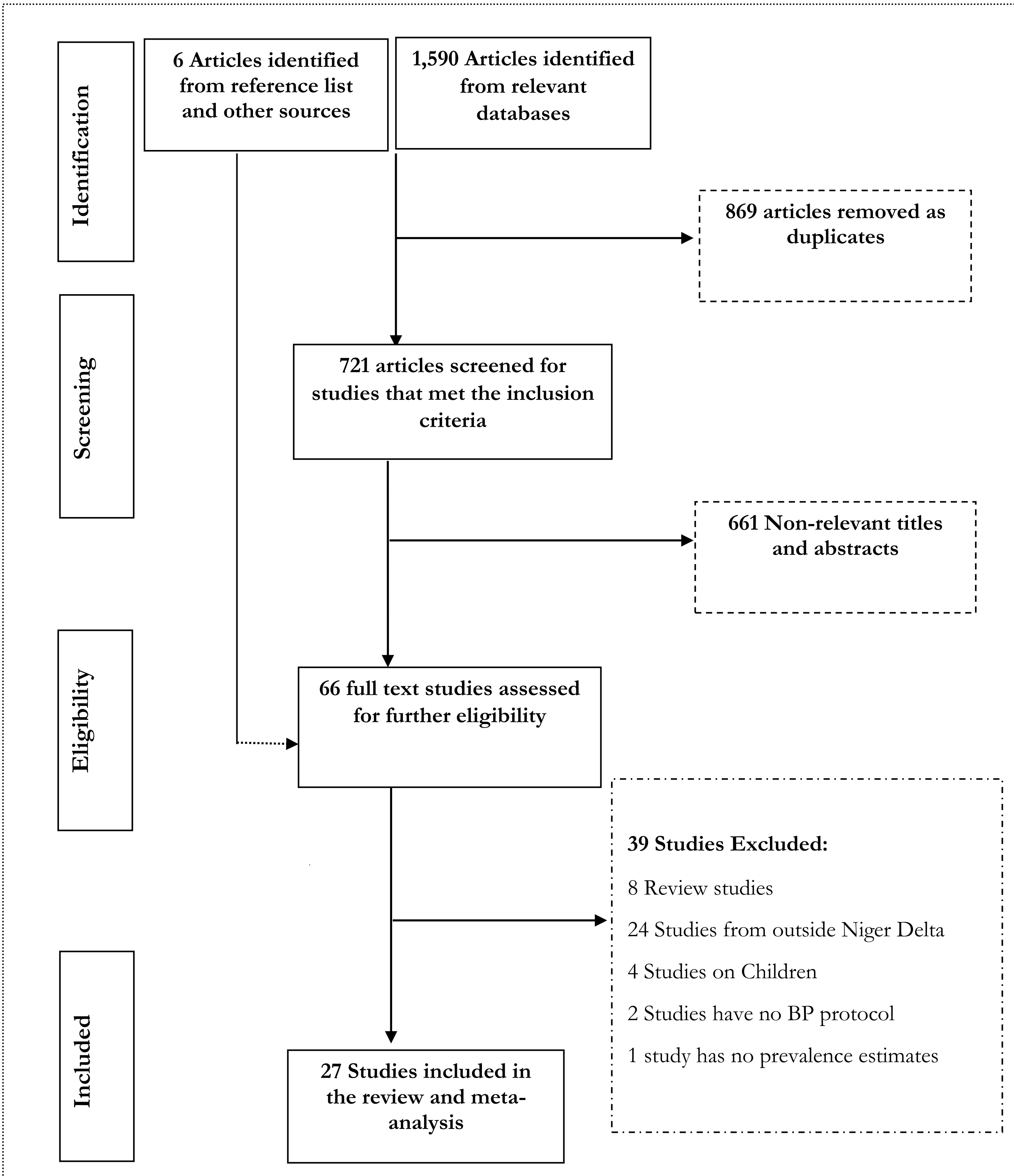


Figure 10: Flow Diagram of Search Results

I also obtained 6 relevant articles from the reference list of the selected studies. In all, 27 quality studies (Ganiyu, Kpokiri et al. , Idahosa 1987, Bunker, Ukoli et al. 1992, Okojie, Isah et al. 2000, Ofuya 2007, Abu and Dike 2008, Akpa, Emem-Chioma et al. 2008, Omuemu, Okojie et al. 2008, Omorogiuwa, Ezenwanne et al. 2009, Andy, Peters et al. 2012, Ekpenyong, NE et al. 2012, Onwuchekwa, Mezie-Okoye et al. 2012, Ekanem, Opara et al. 2013, Ijezie, Chuku et al. 2013, Mbah, Eme et al. 2013, Okpechi, Chukwuonye et al. 2013, Ordinioha 2013, Suleiman, Amogu et al. 2013, Egbi, Rotifa et al. 2015, Ibekwe 2015, Isara and Okundia 2015, Odili and Abatta 2015, Oguoma, Nwose et al. 2015) that satisfied our selection criteria were included in the meta-analysis shown in figure 11.

5.1.2 Study Characteristics

The breakdown of the 27 included studies showed that Edo State has the highest number (n=5) of studies (Idahosa 1987, Okojie, Isah et al. 2000, Omuemu, Okojie et al. 2008, Omorogiuwa, Ezenwanne et al. 2009, Isara and Okundia 2015) while Cross River State has only one study (Andy, Peters et al. 2012). There were variations in the study characteristics in terms of settings, sample size and case definitions. All the studies were cross-sectional population or community-based studies employing a door-to-door, multi-stage cluster or simple random sampling technique in the recruitment of participants. The included studies had a total sample size of 21910 made up of 9822 men (44.83%) and 12,088 women (55.17%). I found that 10 studies (36%) (Idahosa 1987, Bunker, Ukoli et al. 1992, Okojie, Isah et al. 2000, Abu and Dike 2008, Omorogiuwa, Ezenwanne et al. 2009, Ekpenyong, NE et al. 2012, Ekanem, Opara et al. 2013, Suleiman, Amogu et al. 2013, Egbi, Rotifa et al. 2015, Ibekwe 2015) were conducted in

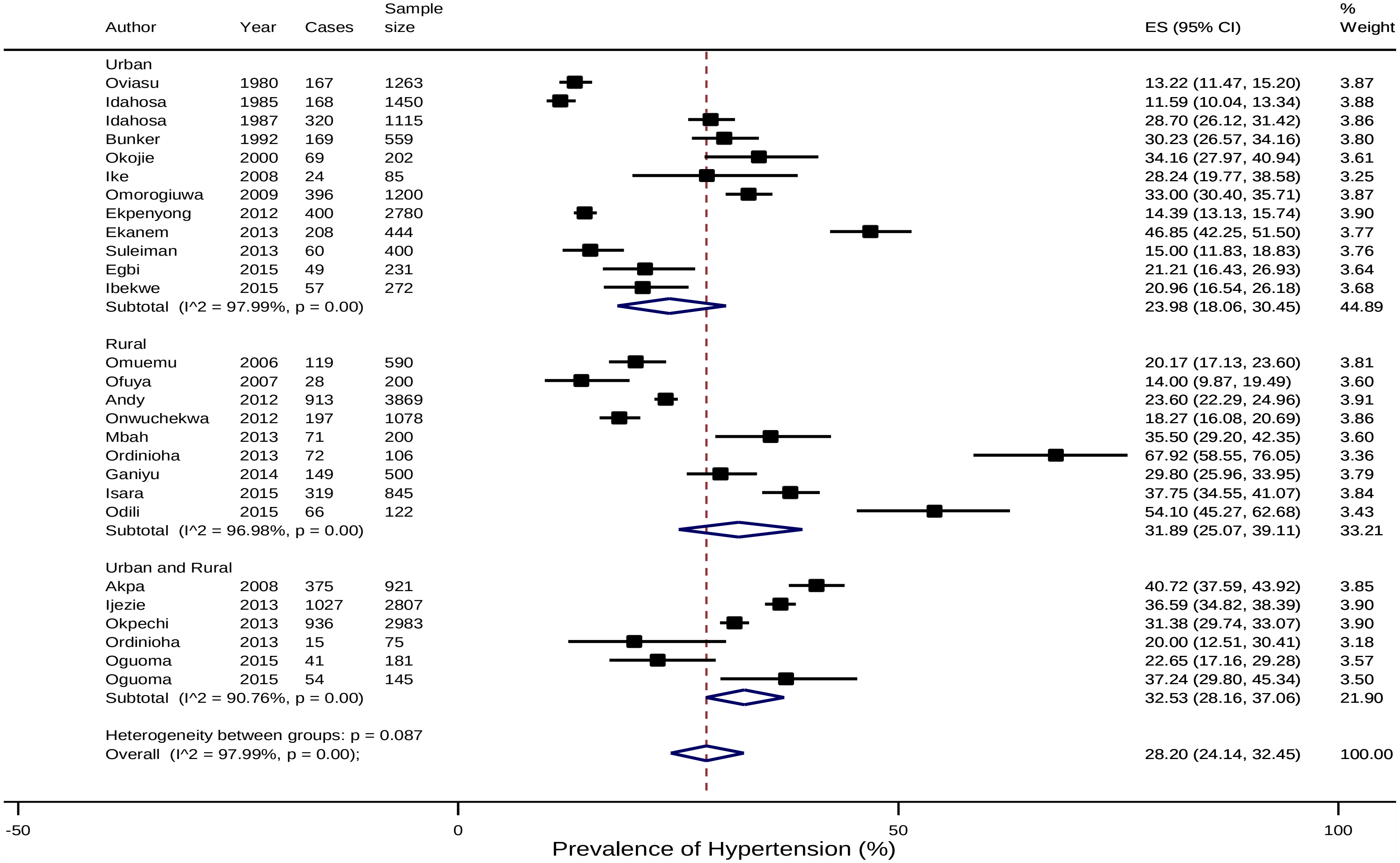


Figure 11: Forest Plot for all the Included Studies by Study Setting

predominantly urban settings, while a total of 9 (36%) studies (Ganiyu, Kpokiri et al. , Ofuya 2007, Omuemu, Okojie et al. 2008, Andy, Peters et al. 2012, Onwuchekwa, Mezie-Okoye et al. 2012, Mbah, Eme et al. 2013, Ordinioha 2013) and 6 (24%) studies (Akpa, Emem-Chioma et al. 2008, Ijezie, Chuku et al. 2013, Okpechi, Chukwuonye et al. 2013, Ordinioha 2013, Oguoma, Nwose et al. 2015) were conducted in rural and rural/urban settings respectively. The studies have an overall mean-age of 38.77±8.98 years with values of 39.19±12.26 in the rural, 35.58±5.40 in the urban and 41.49±7.70 in rural/urban settings.

5.1.3 Result of Quality Assessment and Publication Bias

All studies included in the review were classified as being of moderate to a high quality with low risk of bias. I also assessed publication bias using Egger's test**.** The funnel plot did not reveal evidence of obvious asymmetry (Appendix 5). The estimated bias coefficient was 0.151 with a standard error of 0.459. I also provided evidence of the funnel plot symmetry using the Egger's test, which did not reveal any publication bias or small study effects (P=0.746).

5.1.4 Prevalence of Hypertension

The prevalence of hypertension in Niger Delta varied significantly across States and study settings. On the basis of prevalence rates reported by individual studies using 140/90mmHg diagnostic measure, I found that the lowest and highest prevalence of hypertension was recorded in studies conducted in Rivers State both having a prevalence of 14.0% in 2007 and 68.90 in 2013 respectively (Ofuya 2007, Ordinioha and Brisibe 2013). The two studies were conducted in the rural areas, however, there was a significant difference in their mean-age (24.0±1.41 versus 56.50±4.10, $P<0.001$). In contrast, Idahosa (1985) reported the least prevalence of hypertension among the two studies with 160/95 and 160/100mmHg diagnostic measures. Other sites with the highest prevalence rates were in Imo and Akwa Ibom States with prevalence rates of 54.10% in 2015 and 47% in 2013 respectively (Ekanem, Opara et al. 2013, Odili and Abatta 2015).

Prevalence of hypertension and 95% Cis from individual studies with a pooled estimate is shown in figure 11. The pooled prevalence of hypertension for all studies yielded an estimate of 28.20% (95% CI, 24.14-32.45). The I^2 statistics was 97.40%, indicating statistically significant heterogeneity among the studies. There was no evidence of funnel plot asymmetry suggesting no evidence of publication bias. I compared the pooled prevalence estimates of hypertension on the basis of two different hypertension cut-offs. I found that the pooled prevalence of hypertension for studies utilising the 140/90mmHg measure (25 studies) only was significantly higher than the current estimates which provided pooled estimates for both 140/90 and 160/95 and 160/100 mmHg measures (27), 29.85% (95% CI, 25.91-33.94).vs 28.20% (95% CI, 24.14-32.45), $P<0.037$

5.1.5 Pooled Prevalence of Hypertension by Study Level Characteristics

The pooled prevalence of hypertension in rural setting, 32.0% (95% CI 25.13–39.28, I^2=97.02%, P=0.001) was significantly higher than the urban settings, 24.07% (95% CI 18.13—30.58, I^2=98.0%, P=0.001) (figure 11). I summarised the patterns of hypertension prevalence in percentages (%) or the pooled estimates presented as effect size (ES) across different study level characteristics (such as age group, gender, smokers, BMI, and alcohol use) in the Niger Delta were also summarised as shown in figure 12. For instance, the prevalence of hypertension increases significantly with increasing age. Among adults aged 65 years and over, the prevalence of hypertension was significantly higher compared to those aged 45-64 years, and more than 2-fold compared to those between 15-44 years 47.26% (95% CI 35.72-58.93) *versus* 38.10% (95% CI 28.93-47.70) versus 17.94% (95% CI 14.04-22.19), $P<0.001$. I also found a significant difference in the pooled prevalence rate of hypertension among men as against women 30.26% (95% CI 23.26–37.17) versus 22.99% (95% CI 17.60–28.86, P<0.001).

Table 3: Study Characteristics for all the Included Studies of Hypertension in Niger Delta

First Author (Year)	Data Collection Year	State	Setting	Age	Mean age	Sample size	Male percentage	Hypertension prevalence	BP cut-off (mm Hg)
Oviasu (1980)	1977	Edo	Urban	15-60	NR	1263	NR	13.3	160/100
Idahosa (1985)	1983	Edo	Urban	15-70	31.8	1450	100	11.6	160/95
Idahosa (1987)	1983	Edo	Urban	20-62	27.8	1115	NR	28.7	140/90
Bunker (1992)	1987-88	Cross River	Urban	25-54	36.4	559	78.35	30.41	140/90
Okojie (2000)	NR	Edo	Urban	25-64	NR	202	76.7	34.65	140/90
Omuemu (2006)	NR	Edo	Rural	≥15	30.7±14.6	590	60.2	20.2	140/90
Ofuya (2007)	NR	Rivers	Rural	16-56	23.3	200	NR	14	140/90
Ike (2008)	2004	Abia	Urban	21-70	43.7±10	85	91.7	28.3	140/90
Akpa (2008)	NR	Rivers	Urban/Rural	≥18	39.9±8.6	921	48.75	40.82	140/90
Omorogiuwa (2009)	NR	Edo	Urban	≥18	NR	1200	40	33	140/90
Onwuchekwa (2012)	2008	Rivers	Rural	≥18	35.8±14.8	1078	44	18.3	140/90
Andy (2012)	NR	Cross River	Rural	≥15	34.1±14.4	3869	41.6	23.6	140/90
Ekpenyon (2012)	2009-10	Akwa Ibom	Urban	18-60	NR	2780	52	14.4	140/90
Suleiman (2013)	2011	Bayelsa	Urban	≤ 20	NR	400	40	15	140/90
Ordinioha (2013)	NR	Rivers	Urban/Rural	15-60	46.1±10	75	65.33	21.33	140/90
Okpechi (2013)	2011-12	Abia	Urban/Rural	≥18	41.7	2983	47.9	31.4	140/90
Ordinioha (2013)	2012	Rivers	Rural	≥18	56.5±4.1	106	100	68.86	140/90
Ijezie (2013)	NR	Abia	Urban/Rural	≥18	41.8±18.7	2807	49.09	36.59	140/90
Ekanem (2013)	2010	Akwa Ibom	Urban	16-64	31.7±7.6	444	51.6	47	140/90
Mbah (2013)	NR	Imo	Rural	40-60	NR	200	40	35.5	140/90
Ganiyu (2014)	2013	Delta	Rural	≥25	39.2±12.1	500	51.8	29.8	140/90
Egbi (2015)	2013	Bayelsa	Urban	≥18	37.2±8.9	231	36.4	21.3	140/90
Oguoma (2015)	2014	Delta	Urban/Rural	≥18	51.3±2	145	38.6	37.3	140/90
Oguoma (2015)	2014	Delta	Urban/Rural	≥18	28.2±1	181	28.2	23.2	140/90
Isara (2015)	2013	Edo	Rural	≥18	NR	845	31.12	37.8	140/90
Ibekwe (2015)	2012	Delta	Urban	≥18	36.7±14	272	51.1	21	140/90
Odili (2015)	2012	Imo	Rural	≥18	54.7±16.3	122	45.1	54.1	140/90

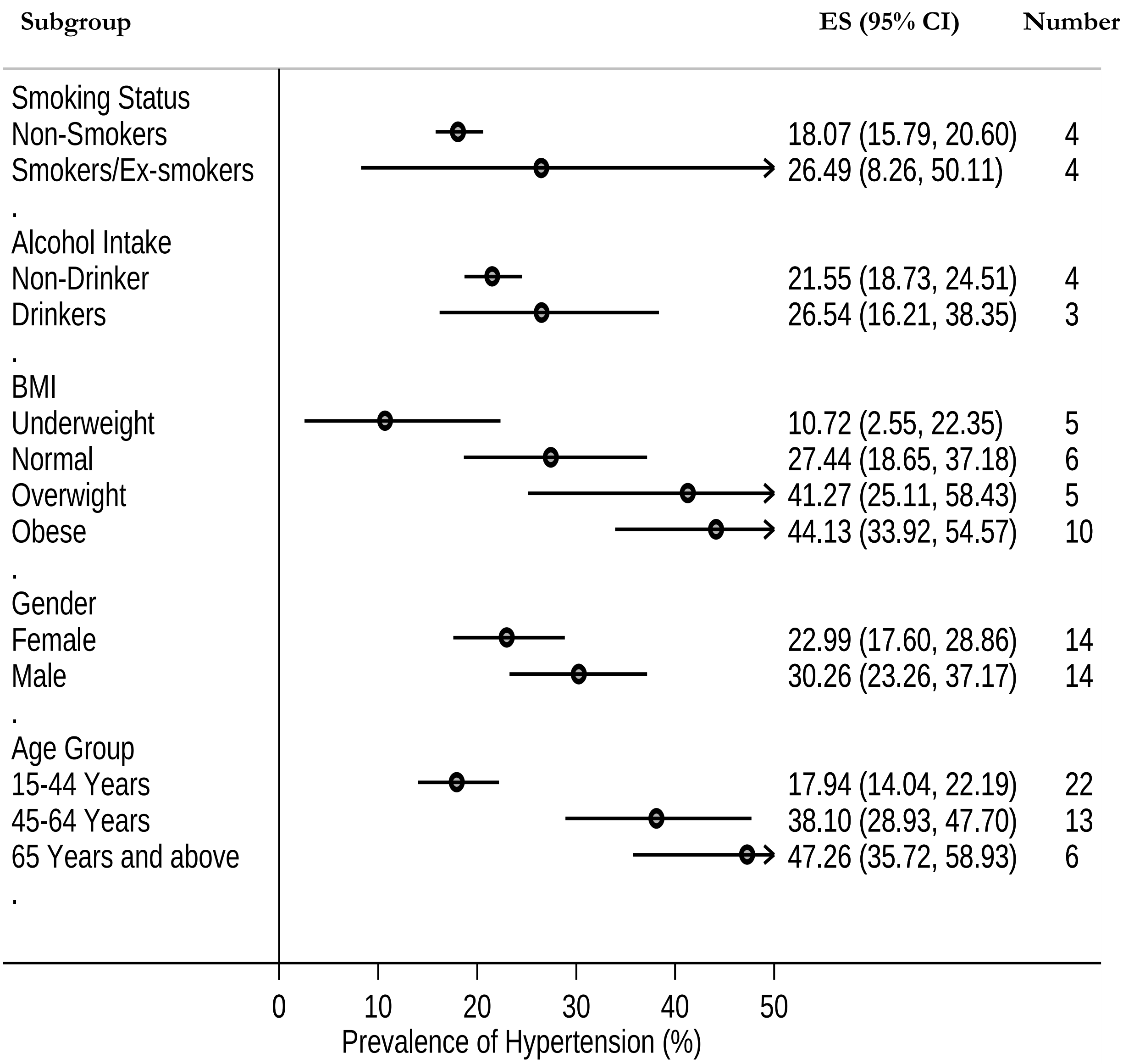


Figure 12: Prevalence of hypertension by different risk factors

In addition to participant's age, the influence of lifestyle factors and BMI were also observed in our studies. Specifically, I found higher proportions of hypertensives among smokers compared to non-smokers 26.49% (95% CI 8.26–50.11) *versus* 18.07% (95% CI 15.79-20.60), $P<0.001$. Hypertension prevalence was also clearly associated with BMI categories. Compared to overweight, normal and underweight persons, I found that the prevalence estimate among obese persons was significantly higher, 44.13% (95% CI 33.92–54.57) *versus* 41.27% (95% CI 25.11-58.43) versus 27.44% (95% CI 18.65-37.18) versus 10.72% (95% CI 2.55-22.35), $P<0.001$

5.1.6 Factors Modifying Hypertension Estimates and Secular Trend

A meta-regression analysis was performed to investigate the potential influence of lifestyle and sociodemographic factors on between-study heterogeneity in the prevalence of hypertension. I found a logarithm of hypertension prevalence rose by a factor of 0.02 with an increase in the proportion of drinkers/alcohol consumption (95% CI, 0.00-0.05, P<0.046) (Appendix 6). Similarly, a statistically significant effect was observed between hypertension prevalence which rose by a factor of 0.04 and 0.05 with an increase in the proportion of smokers/ex-smokers (95% CI, 0.03-0.12), P<0.016 and participants mean study age (95% CI, 0.02-0.07, P<0.001) respectively (Appendix 7 and 8).

I also observed a continuous increase in the prevalence of hypertension in the region (trend = 0.139, P-value = 0.0001), such that the prevalence estimates have been increasing by 8.31% every 5 years (figure 13).

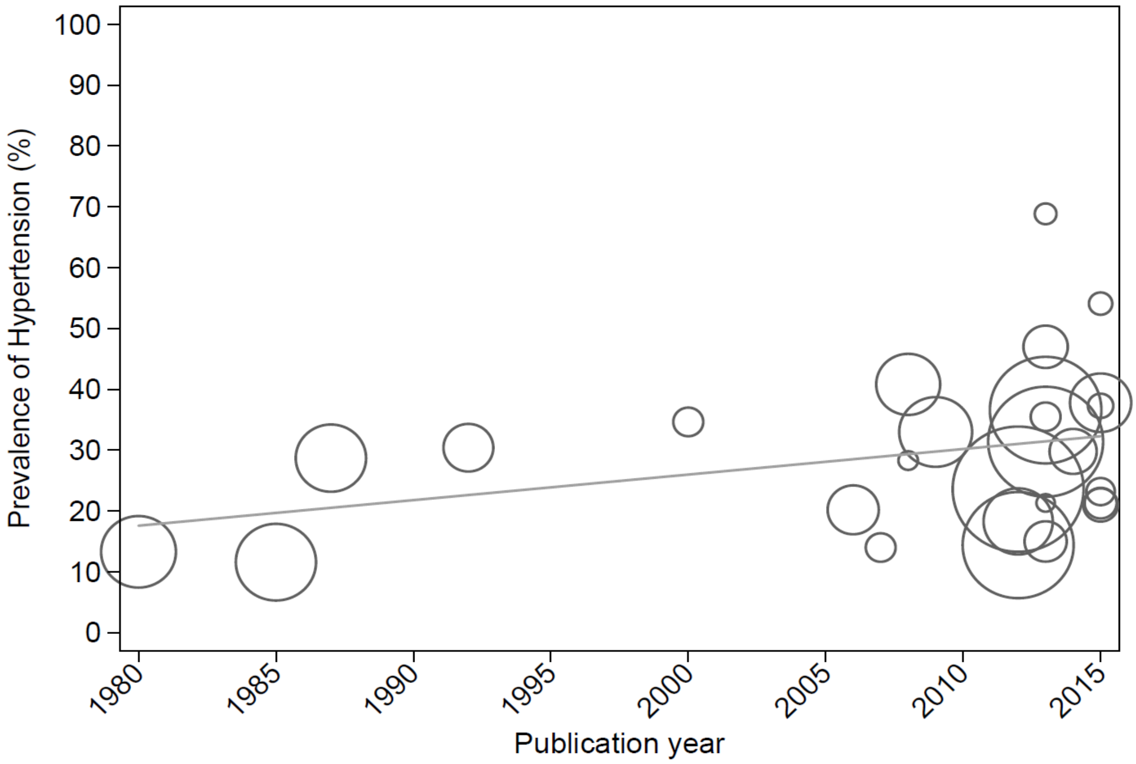


Figure 13: Annual trend in the prevalence of hypertension

5.1.7 Discussion

To our knowledge, this is the first and most comprehensive review to date that attempted to present the burden of hypertension in an oil and gas-polluted environment. I presented the pooled analysis of the burden of hypertension among vulnerable adults' populations living in a hugely environmentally polluted region. Our study corroborates the notion that hypertension is already a major public health burden in both the population and the health services. Considering the socio-demographic nature of the population studied and the level of socio-economic development, there appears to be a striking difference in population dynamics seen in all the studies. I collated data on 21910 adults from 8 out of 9 States that make up the Niger Delta where about 31 million people (according to 2006 Nigerian census) currently live. An overall hypertension prevalence of 29.86% was estimated. This result is higher than previous estimates of 18.4% (Ogah, Okpechi et al. 2012) and 28.9% (Adeloye, Basquill et al. 2015) for the whole country in the years 2012 and 2015 respectively.

Interestingly, our rural-urban estimates of 32.0% versus 26.84% were significantly different from 15.0 % versus 22.30% reported in 2012 (Ogah, Okpechi et al. 2012), and the most recent estimates of 26.40% versus 30.60% published this year (Adeloye, Basquill et al. 2015). Our result is also higher than the prevalence in many countries and population groups in sub-Saharan Africa suggesting interplay of epidemiological, demographic and more recently environmental transitions (Marcotullio, Rothenberg et al. 2005, Orogun 2010). This may also be due to nutritional changes and potentially better public health response including activities that increases surveillance system with better detection of hypertensive cases (Adeloye, Basquill et al. 2015). Our study also noted that across all the States were the data for the study were available, I found that the mean-age of the participants was 38.77±8.98 years, which is about a decade younger than the previous review which reported lower hypertension prevalence for the whole country (Egwurugwu, Nwafor et al. 2013, Adeloye, Basquill et al. 2015).

I found a positive association of hypertension and several risk factors. In particular, ageing and excess body weight and being a current/ex-smoker and drinker were all associated with a higher prevalence of hypertension. All these have widely been reviewed previously (Ogah, Okpechi et al. 2012). The pattern of age-specific increase in hypertension prevalence is clearly marked within three age-brackets for both genders. I found a significant difference among the highest proportion of hypertensives aged 65 years and over (47.26%) compared to those aged 18-44 years (17.94%) or 45-years years (38.10%*), P*<0.001

Substantial inter-State and study sites variation in the burden of hypertension was found in this study. I reported that the pooled estimate for hypertension in rural areas is significantly higher (32.0% versus 26.84%) than that in urban areas (P<0.001). This difference could be related to the difference in mean-age and other factors. I noted previously that there was no significant difference in mean-age of participants in rural compared to urban settings (39.18 versus 35.57 years), P=0.520, however, disease awareness, differences in lifestyle, share of poverty (socioeconomic factors), investment in healthcare services and the huge oil and gas pollution profile in various rural host-communities could not be ruled out (Kandala, Tigbe et al. 2013). For instance, the level of environmental pollutants recorded in different rural areas of Niger Delta is more than 100-folds compared to international standard (United Nations Environment Programme 2011).

States like Akwa Ibom, Bayelsa and Cross River have implemented the free healthcare delivery system to supplement the national health policy targeting maternal and child health while majority of others still prioritise the reduction of childhood mortality and common infectious diseases like malaria and HIV/AIDS (Udoh, Mantell et al. 2009). The economic burden occasioned by out-of-pocket medical expenses and lack of directive on hypertension awareness, prevention and treatment may have also contributed to the likely difference (van de Vijver, Akinyi et al. 2013, Maredza and Chola 2016). Other factors on the rural-urban disparity could also be related to the reverse rural-urban migration reported when urban dwellers could not cope with the economic situation and vulnerability related to urban life, or when senior citizen retires from active service and prefers to return to natural resource-rich rural settlements (Banegas, Rodríguez-Artalejo et al. 1998, Mainous, King et al. 2004, Beauchemin 2011). These need to be investigated further particularly in the Niger Delta where rural oil and gas host communities are much attractive in terms of economic opportunities such as oil bunkering, quasi-refineries, unskilled jobs and royalties paid to residents by multinational co-operations (New Nigerian Foundation 2011).

Recent reviews in Nigeria are consistent with the urban-rural divide with the urban population having a higher prevalence of hypertension (Addo, Smeeth et al. 2007, Adeloye, Basquill et al. 2015). This is largely explained not only by urbanisation and adoption of western diet (particularly food rich in salt and saturated fat) as a result of nutritional transitions currently occurring in Nigeria and other lower-income countries but also access and availability of healthcare and socioeconomic factors (Orogun 2010). Sedentary lifestyle and engagement in jobs with minimal physical activities are also common occurrences among urban dwellers. However, it has been reported that rural oil and gas host-communities are also exposed to western lifestyle due to the influence of oil and gas workers in their neighbourhood place (Egwurugwu, Nwafor et al. 2013). Water and land pollution in these areas are also commonplace. While possible, the influence of occupational shift due to displacement (resulting from pollution) from farming and fishing to unskilled works in oil and gas facilities may have had a significant contribution to the burden. Moreover, even if the causes of geographic (State/Settings) variation are not fully clear, public health practitioners and policy makers can use this geographic information on chronic disease mapping for planning purposes, pollution abatement purpose and public health programs on lifestyles, but also in the decision-making process for the allocation of public resources to the most affected areas and specific population (Kandala, Tigbe et al. 2013).

5.1.7.1 Study Strengths and Limitations

The overall strengths and limitations of this meta-analysis warrant careful consideration. I conducted a comprehensive search of databases to ensure that all relevant articles were identified. I also reduced potential bias in the conduct of this review by having the authors independently scan through the search output and extract relevant data. This was in addition to a detailed quality assessment and publication bias, with eligible studies having no small study effects. In addition, I included only community-based studies which constitute the best way to determine the true prevalence of hypertension and systematically identified the possible sources of heterogeneity using meta-regression analysis.

Despite the strength of the review, some limitations in the present study deserve attention. First, the study design (cross-sectional studies) does not allow establishing temporality and causality of the observed associations. Secondly, although study participants blood pressure was estimated using standard blood pressure monitor, there may be a risk of potential bias due to the fact that lifestyle and sociodemographic variables collected were self-reported. I could not disregard the probability that health outcomes such as hypertension may influence reports of smoking, drinking habits and other lifestyle factors, and not vice versa (Tenkorang, Sedziafa et al. 2015). Thirdly, lack of information on pollution data may have limited any relationship that could have been drawn from the link between pollution in the rural areas and high prevalence of hypertension. Similarly, lack of information on physical activity, ethnicity, biomarkers, pollutants monitoring and characterisation may have limited our understanding of the influence of these to increased hypertension estimates and its aetiology.

5.1.8 Conclusion

In conclusion, our study provides contemporary estimates that reflect the significant burden of hypertension in Niger Delta. The review provided interesting learning in view of the significantly higher burden of hypertension recorded in the rural population compared to the urban residents.

This is disturbing given that it is even higher than most urban estimates both in and outside the Niger Delta. The burden of hypertension in the Niger Delta is very heterogeneous in terms of the overall estimates and risk factors, however, the influence of unmeasured factors such as diet types, **reverse migration** and other extrinsic factors particularly environmental pollution that has been implicated in huge socioeconomic inequality and other co-morbid conditions cannot be ruled out. While routine surveillance and management of hypertensive individuals and related public health prevention strategies remain an important public health priority, environmental pollutants data and exposure assessment studies are needed to better understand the physiological relationship between environmental pollution and hypertension in these settings.

5.2 Results for Stroke Survivor's Review

5.2.1 Database Search

The process of study selection is shown in Figure 14. Overall, the literature searches of databases yielded 1,877 articles. The titles and abstracts of these were screened for relevance and 1,718 were excluded as duplicates, non-relevant titles and abstracts. 159 articles were selected for critical reading. In all, 101 articles with a total of 7,909,976 participants from 34 LMICs were included. All the studies are represented in the in the world map (Figure 15).

5.2.2 Characteristics of the Included Studies

The characteristics of the included studies are also summarised in the tables (Appendix 12 to 17). The studies were published between 1970 and 2014, and sample size ranged from 500 to as much as 258,576. All the studies are community-based employing a door-to-door, multi-stage or simple random sampling technique. Each of the study covered at least one part of the WHO STEPS stroke protocol for case ascertainment (Ana, Sridhar et al. 2012).

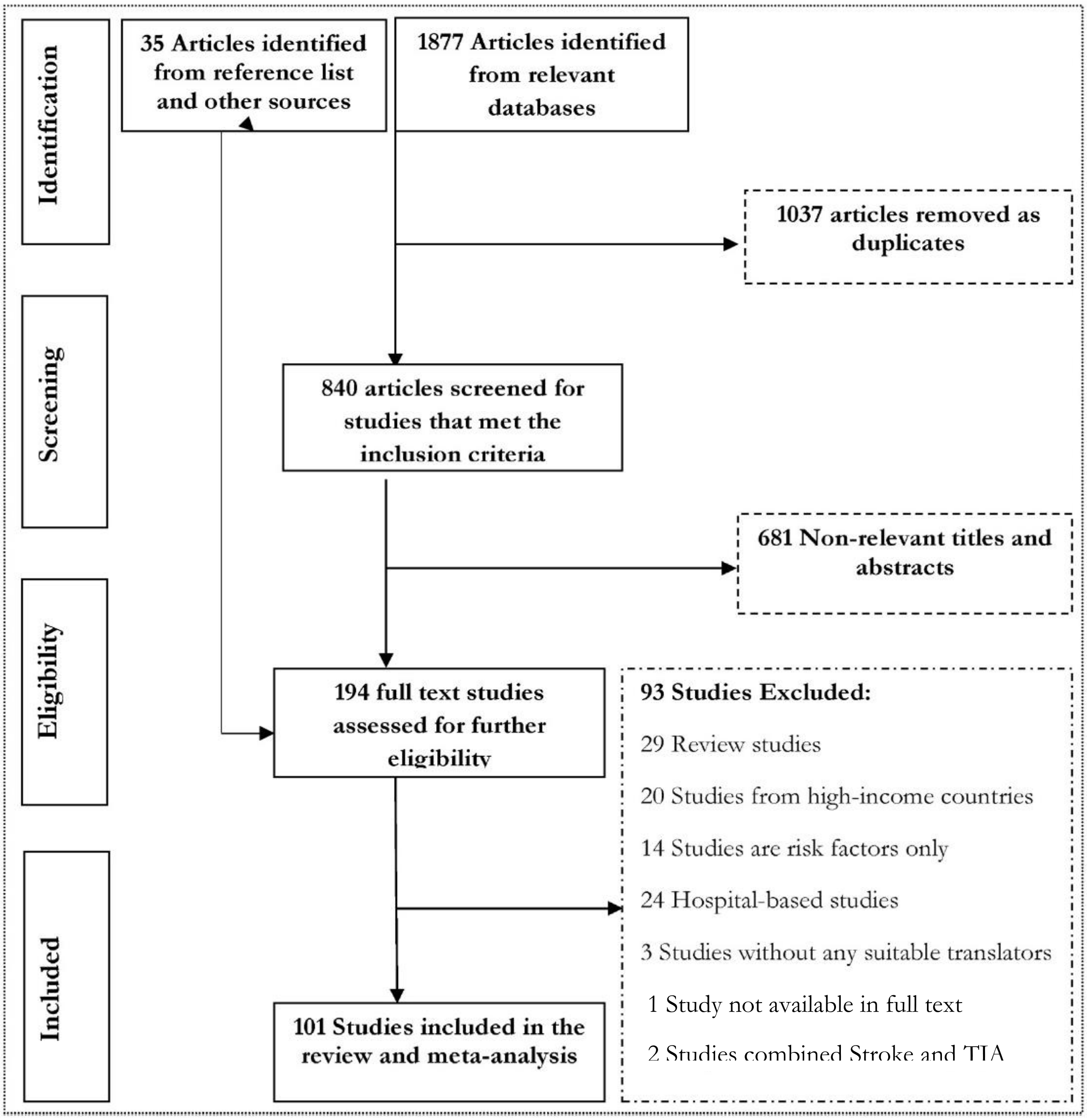


Figure 14: Flow Diagram for Study Selection

A total of 39 studies (38.6%) that employed cranial computed tomography (CT) or magnetic resonance imaging (MRI) were found. The studies have a low risk of bias in stroke diagnosis, while 62 (61.4%) studies were limited by availability of resources and neurological imaging, however, rigorous and detailed epidemiological exercise of self-reported diagnosis of stroke in these groups were validated through neurological examination by a specialist team. Most of the studies were conducted at a single site in the rural, urban settings or both. Only two studies were conducted in multiple sites in different countries (Van Minh, Ng et al. 2008, Ferri, Schoenborn et al. 2011). When reported, the mean age of participants ranged from 25 years to 78 years. The median percentage of male participants was 48% (range: 31% to 82%). The median percentage of participants with known hypertension was 36% (range: 6 to 71%).

5.2.3 Risk of Bias of Included Studies

Summary of the risk of bias assessment for each study is shown in Appendix 18. The risk of bias in the selection of participants is low in most studies (n=98, 97%) and moderate in three studies (3%). The risk of bias due to sample size or number of participants included in the studies was low in most studies (n=83, 83%), high in seventeen studies (17%) and unclear in one study. The risk of detection bias due to inadequate outcome assessment was low in about three-quarter of the studies (n=77, 76%) and high in the remaining studies (n=24, 24%).

5.2.4 Variations in Stroke prevalence by geographical regions

5.2.4.1 East Asia and Pacific

Prevalence of stroke 'survivors' and 95% CIs from individual studies with a pooled estimate are shown in figure 16. The reported stroke prevalence ranged from 4.27 (per 1000 population) to as much as 162 (per 1000 population). The pooled prevalence ('annualised year average') of stroke for all studies yielded an estimate of 19.9 (95% 14.7 to 25.9 per 1000 population). There was no strong evidence of a small study effect /publication bias (P = 0.058 for Egger's regression asymmetry test). The results of leave-one-study-out sensitivity analyses showed that no study had undue influence on pooled stroke prevalence.

5.2.4.2 Europe and Central Asia

Prevalence of stroke 'survivors' and 95% CIs from individual studies with a pooled estimate are shown in figure 16. The reported stroke prevalence ranged from 9 per 1000 population in Turkey to 33 per 1000 population in Romania. The pooled prevalence ('annualised year average') of stroke for all studies yielded an estimate of 19.5 (95% 3.2 to 49.1 per 1000 population)

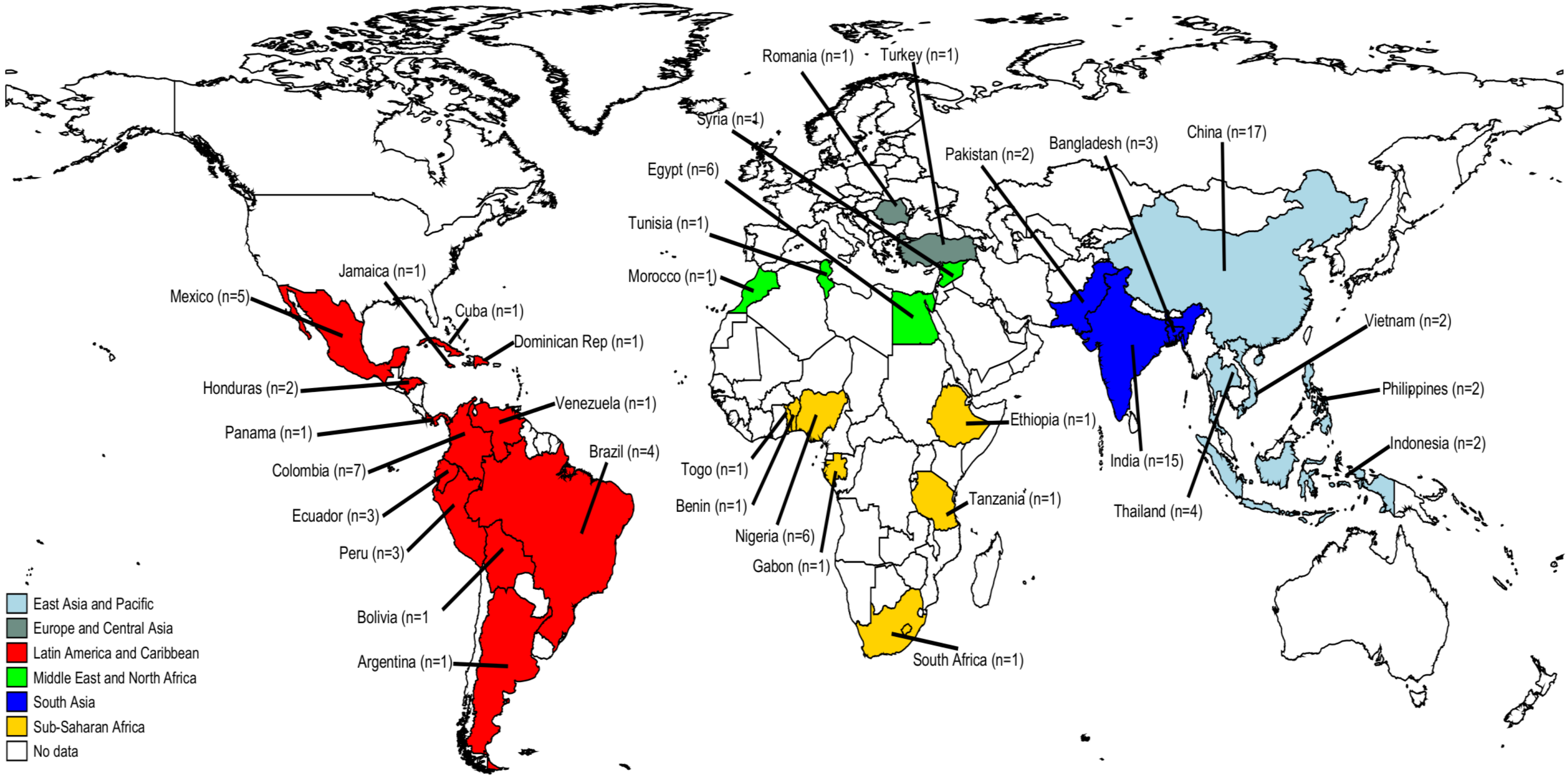


Figure 15: World map showing areas of community-based stroke survivor studies

5.2.4.3 Latin America and Caribbean

Prevalence of stroke 'survivors' and 95% CIs from individual studies with a pooled estimate are shown in figure 16. The reported stroke prevalence ranged from 1.5 (per 1000 population) to as much as 54.2 (per 1000 population). The pooled prevalence ('annualised year average') of stroke for all studies yielded an estimate of 21.2 (95% 13.7 to 30.3 per 1000 population). There was no strong evidence of a small study effect/publication bias (P = 0.053 for Egger's regression asymmetry test). The results of leave-one-study-out sensitivity analyses showed that no study had undue influence on pooled stroke prevalence.

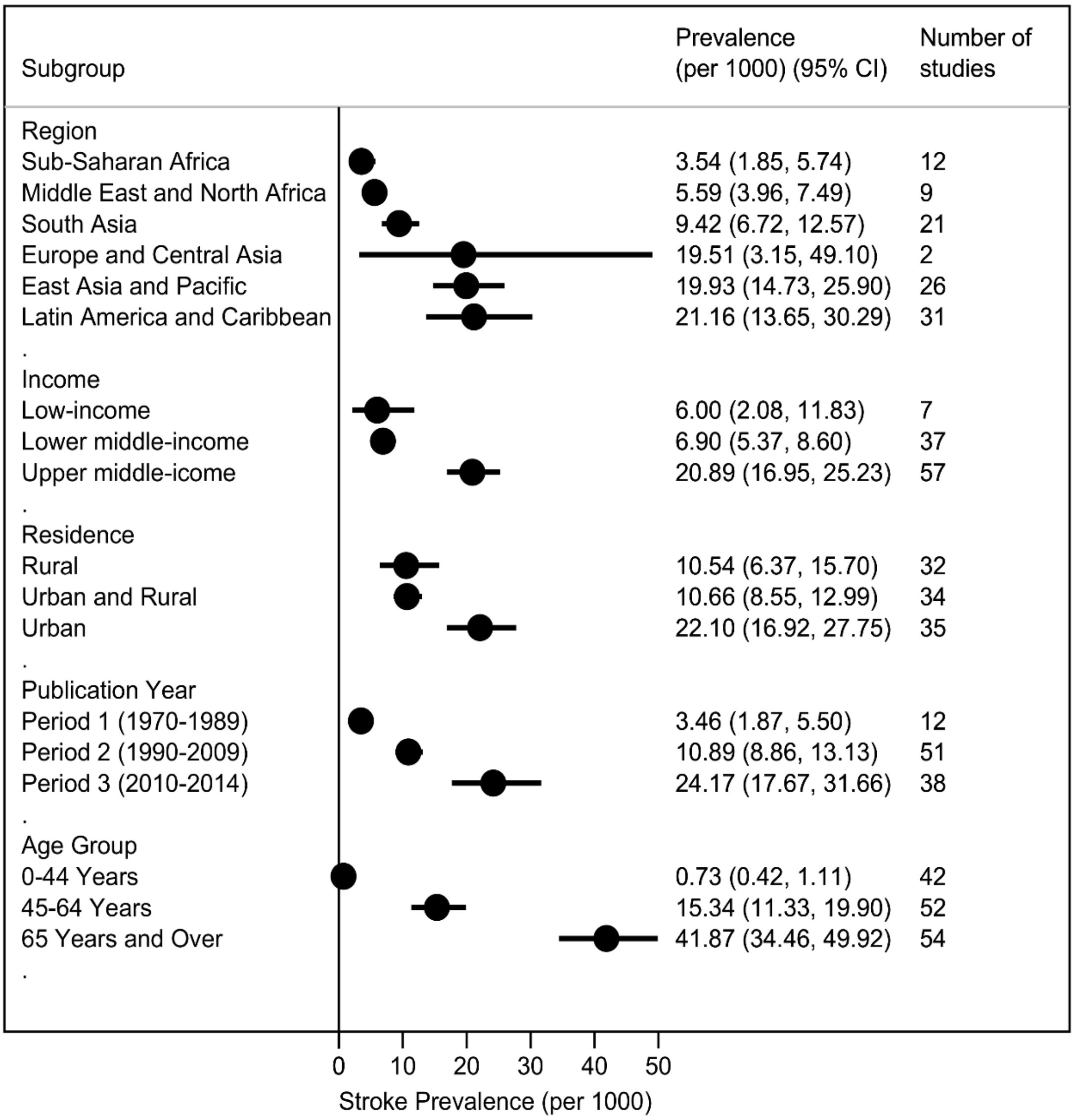


Figure 16: Pooled stroke prevalence by different subgroups

5.2.4.4 Middle East and North Africa

Prevalence of stroke 'survivors' and 95% CIs from individual studies with a pooled estimate are shown in figure 16. The reported stroke prevalence ranged from 1.20 (per 1000 population) to 10.8 (per 1000 population). The pooled prevalence ('annualised year average') of stroke for all studies yielded an estimate of 5·6 (95% 4.0 to 7.5 per 1000 population). There was no evidence of a small study effect/publication bias (P = 0.917 for Egger's regression asymmetry test). The results of leave-one-study-out sensitivity analyses showed that no study had undue influence on pooled stroke prevalence.

5.2.4.5 South Asia

Prevalence of stroke 'survivors' and 95% CIs from individual studies with a pooled estimate are shown in figure 16. The reported stroke prevalence ranged from 0.5 (per 1000 population) to as much as 191 (per 1000 population). The pooled prevalence ('annualised year average') of stroke for all studies yielded an estimate of 9.4 (95% 6.7 to 12.6 per 1000 population). There was no evidence of a small study effect/publication bias (P = 0.928 for Egger's regression asymmetry test). The results of leave-one-study-out sensitivity analyses showed that no study had undue influence on pooled stroke prevalence.

5.2.4.6 Sub-Saharan Africa

Prevalence of stroke 'survivors' and 95% CIs from individual studies with a pooled estimate are shown in figure 16. The reported stroke prevalence ranged from 0.15 (per 1000 population) to as much as 24.2 (per 1000 population). The pooled prevalence ('annualised year average') of stroke for all studies yielded an estimate of 3.5 (95% 1.9 to 5.7 per 1000 population). There was no evidence of a small study effect/publication bias (P = 0.945 for Egger's regression asymmetry test). The results of leave-one-study-out sensitivity analyses showed that no study had undue influence on pooled stroke prevalence.

5.2.4.7 Nigeria and Niger Delta region

Prevalence of stroke and 95% CIs from individual studies with a pooled estimate are shown in figure 17. The reported pooled stroke prevalence in Nigeria was 1.45 (per 1000 population), this ranged from 0.75 (per 1000 population) to as much as 2.41(per 1000 population). The study with the highest prevalence estimate (8.41/1000population) was conducted in a rural community in Niger Delta region of Nigeria while the lowest was conducted in the South-West (0.58/1000 population).

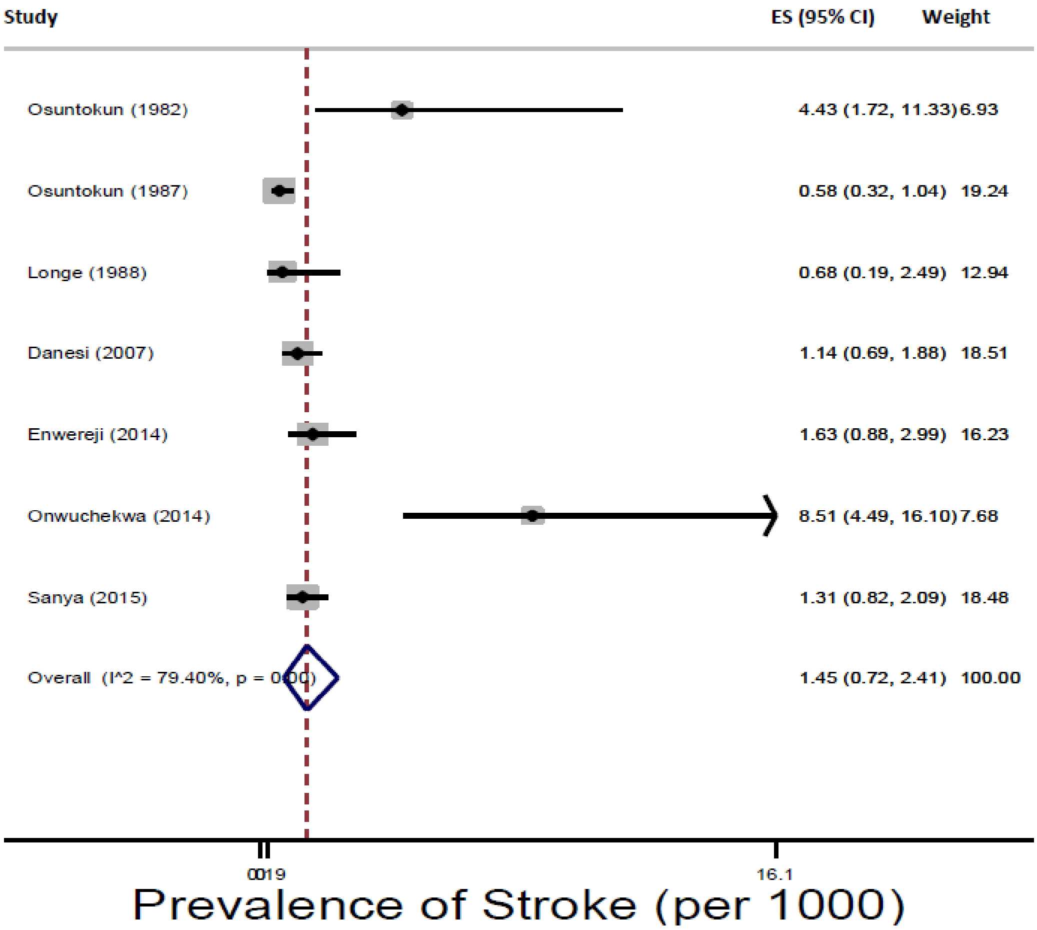


Figure 17: Forest plot for all the included studies in Nigeria

5.2.5 Variations in stroke prevalence by country's income categories

As shown in Figure 18, the pooled prevalence stroke 'survivors' was highest in upper-middle income countries (20.9, 95% CI 17.0 to 25.2 per 1000, 57 studies) followed by lower middle-income countries (6.9, 95% CI 5.4 to 8.6 per 1000, 37 studies) and closely by low-income countries (6.0, 95% CI 2.1 to 11.8 per 1000, 7 studies).

5.2.6 Secular Trend in the Prevalence of Stroke

Secular trend in stroke prevalence by different geographic region is shown in figure 19. I observed a continuous increase in the prevalence of stroke across all geographic regions. The increase is more pronounced in Latin America and Caribbean (trend = 0·157, p-value = 0.0001) followed East Asia and Pacific (trend = 0.125, p-value = 0.0001) and sub-Saharan Africa countries (trend = 0.113, p-value = 0·0001), such that prevalence of stroke have been increasing annually by 17.0%, 13.3% and 12.0% respectively.

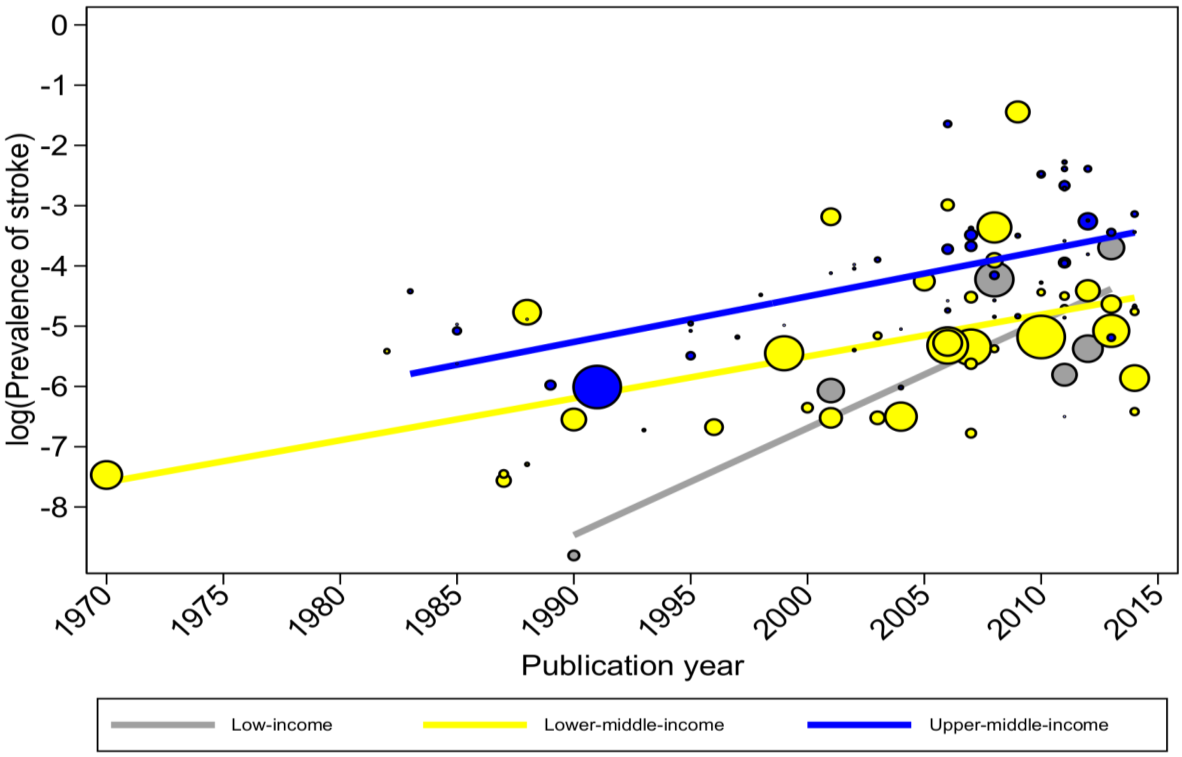
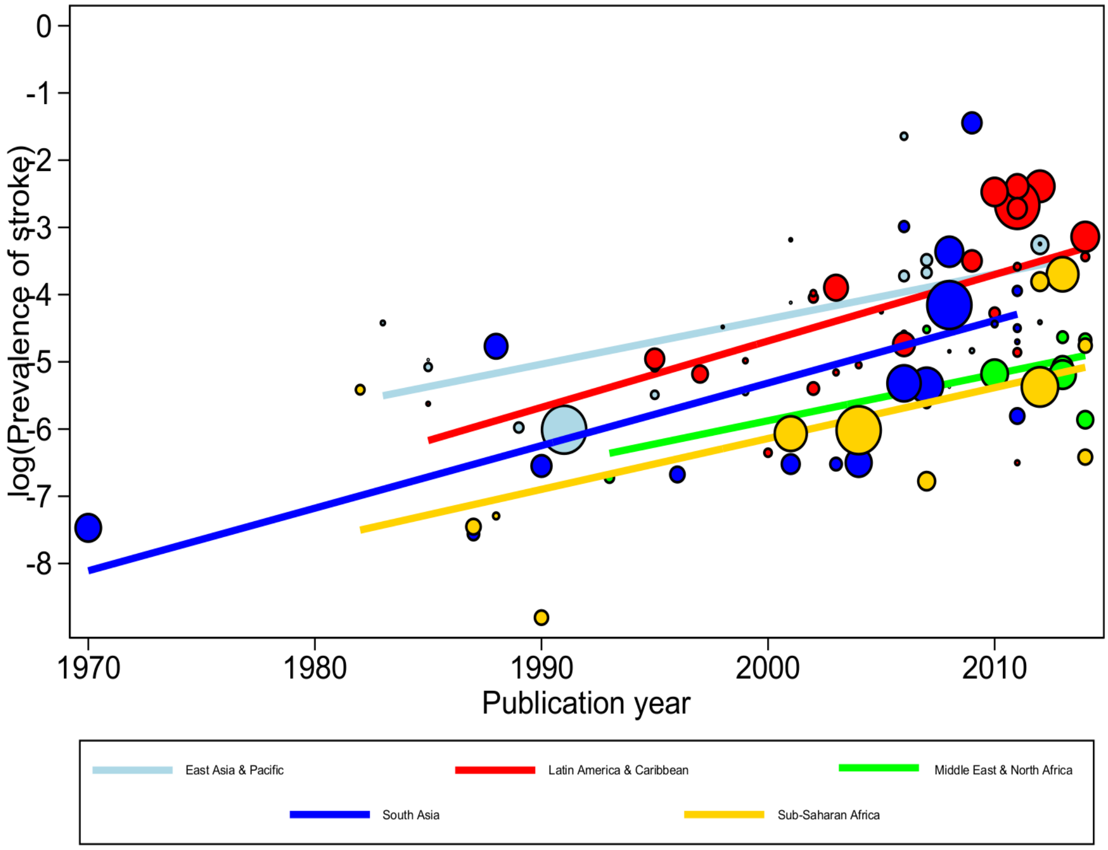


Figure 18: Secular Trends in Stroke Burden by Country's Income Category

As shown in figure 18, a continuous increase in the stroke prevalence across the countries' income categories was observed. Over the past three decades, the stroke prevalence has increased annually by 14.3% (trend = 0.134, p-value = 0.0001) in low-incomes countries, by 12% in upper-middle income countries (trend = 0.113, p-value = 0.0001) and by 5.8% in lower-middle income countries (trend = 0.057, p-value = 0.0001). Though the prevalence of stroke has been lowest in low-income countries, over time, it recorded the steepest increase and the rate of increase has already overtaken the lower-middle and upper-middle-income countries.



As

Figure 19: Secular trends in stroke burden by different geographic

5.2.7 Factors Modifying Prevalence of Stroke Estimates

The result of study-level factors associated with the prevalence of stroke is shown in table 4. In the adjusted analyses, study's geographic region, income category, publication year, sample size, participants' mean age, and percentage male were statistically significantly associated with stroke prevalence estimates. Prevalence estimates from East Asia and Pacific and Latin America and Caribbean were six times higher than those from sub-Saharan Africa.

Table 4: Results of Meta-Regression Analyses

	Unadjusted (Univariable)			Adjusted (Multivariable)*	
Variable	**OR (95% CI)**	**P-value**	**R2**	**OR (95% CI)**	**P-value**
Region			17.1		
East Asia & Pacific	5.95 (2.43 to 14.59)	0.0001		2.03 (0.37 to 11.11)	0.395
Europe & central Asia	7.01 (1.00 to 48.73)	0.049		1.19 (0.17 to 8.42)	0.858
Latin America & Caribbean	6.11 (2.54 to 14.69)	0.000		1.83 (0.37 to 9.12)	0.442
Middle East & North Africa	2.05 (0.67 to 6.32)	0.207		1.29 (0.18 to 9.40)	0.791
South Asia	2.39 (0.94 to 6.05)	0.066		5.21 (0.86 to 31.36)	0.069
Sub-Saharan Africa	1 (reference)			1 (reference)	
Country income			16.4	ni	
Low	1 (reference)			1 (reference)	
Low-middle	1.25 (0.43 to 3.59)	0.677		3.19 (0.54 to 18.83)	0·187
Upper-middle	3.94 (1.14 to 10.98)	0.009		3.12 (0.49 to 19.92)	0.213
Study design			0.0	ni	
Cohort	1 (reference)				
Cross-sectional	0.94 (0.31 to 2.80)	0.910			
Setting			2.9	ni	
Rural	1 (reference)				
Urban	2.13 (1.09 to 4.18)	0.028			
Rural & urban	1.34 (0.68 to 2.94)	0.393			
Publication year	1.08 (1.06 to 1.11)	0.0001	28.0	1.04 (0.92 to 1.16)	0.523
Sample size (log)	0.65 (0.57 to 0.75)	0.0001	28.6	0.96 (0.61 to 1.50)	0.839
Mean age (per 10 year)	1.84 (1.46 to 2.32)	0.0001	49.2	1.62 (1.06 to 2.47)	0.027
Percentage male (per 10%)	0.32 (0.22 to 0.47)	0.0001	30.4	0.77 (0.37 to 1.61)	0.462
Hypertensive (per 10%)	1.29 (0.98 to 1.68)	0·.064	11·.3	ni	
Smokers (per 10%)	1.52 (0.87 to 2·.68)	0.131	9.7	ni	

ni: not included, OR: Odds ratio; CI: Confidence Interval *Explained variance (52.5%)

Similarly, stroke prevalence from upper-middle income countries was as four times as high as those from low-income countries. Stroke prevalence from urban areas was twice as high as those from rural areas. For every 10 years increase in participants' mean age, the stroke prevalence increases by 84% (OR = 1.84, 95% CI 1.46 to 2.32) Appendix 19. For every 10% increase in the percentage of male participants included in the study, the stroke prevalence decreases by 68% (OR = 0.32, 95% CI 0.22 to 0.47) (Appendix 20). Variations in the mean age of the participants explained almost half of the between-studies variation in stroke prevalence estimates (49%). Year of publication, percentage male, and sample size each explained almost one-third in the between-studies variation in stroke prevalence estimates. However, in the adjusted analysis, when all study-level factors that were significant in unadjusted analyses were controlled for statistically, only mean age of the participants remained statistically significant with the prevalence of stroke estimates (OR- 1.62, 95% CI 1.06 to 2.47).

5.2.8 Discussion

5.2.8.1 Main findings

Stroke prevalence varied significantly across geographical regions in different time period. Low-income countries, particularly in sub-Saharan African have a low prevalence of stroke. This may have been due to the high fatality rates from stroke owing to less investment in health care, increased poverty and co-morbidities like HIV/AIDS and Tuberculosis (Wahab 2008). The early stage of epidemiological transition characterised by hypertensive heart disease and a huge proportion of haemorrhagic stroke disease are now occurring in these countries (Cappuccio 2004). Pooled estimate of stroke in upper-middle-income countries is about 3-fold higher as against lower-middle-income or low-income countries. These differences are not surprising, however, the increasing levels of affluence and urbanization (Copstein, Fernandes et al. 2013) and the rise in life expectancy (Copstein, Fernandes et al. 2013) and associated risk factors (Lloyd-Sherlock 2010, Ferri, Schoenborn et al. 2011) particularly hypertension provide a plausible explanation. In fact, there is a large body of epidemiological evidence on the high prevalence of undetected or poorly managed hypertension in LMICs, which is likely to play a major role in the huge prevalence of stroke in these settings (Ferri, Schoenborn et al. 2011).

A continuous increase in the stroke prevalence across the three countries' income categories was observed. Over the past three decades, the stroke prevalence has increased annually by 14.3% (trend = 0.134, p-value = 0.0001) in low-incomes countries, 12% in upper-middle income countries (trend = 0.113, p-value = 0.0001) and by 5.8% in lower-middle income countries (trend = 0.057, p-value = 0.0001). Although the prevalence of stroke has been highest in upper-middle income countries, low-income countries record the steepest increase in stroke prevalence and projected to overtake both lower-middle and upper-middle- income countries. The changing prevalence of stroke is quite revealing and suggests a major epidemiological and demographic shift. Other common themes found within the periods indicate a low prevalent rate from 1970-1989, however, there are few exceptions where the rate had increased significantly and reached a plateau from 1983 and 1988 (Li, Schoenberg et al. 1985, Bharucha, Bharucha et al. 1988, Sojinu, Wang et al. 2010). Between 1990 and 2007, data from China (He, Jiang et al. 2006), Columbia (Pradilla, Vesga et al. 2002, Pradilla, Vesga et al. 2003) and Romania (Florescu, Margulescu et al. 2007) showed a net increase in prevalence. This increases several folds from 2010 to 2014 particularly in China (Dong Y 2010, Sojinu, Wang et al. 2010, Wang, Huang et al. 2012), Brazil (Abe, Lotufo et al. 2011, Copstein, Fernandes et al. 2013, Fernandes, Benseñor et al. 2014) and Cuba (Moreno 2010), suggesting a combination of rapid socioeconomic changes including increase in ageing population, urbanisation, and lifestyle factors. Latin America faces major demographic changes; the most important being urbanisation (almost 90% of the population now live in urban areas) and ageing; that is, the ratio of productive adults to elderly individuals is steadily shrinking (Mukherjee and Patil 2011, Avezum, Costa-Filho et al. 2015). In Brazil, for instance, socio-economic developments that have occurred over the past decades is well-known. Other factors may include access to vascular prevention strategies, exposure to risk factors and inequality to basic medical care particularly in the rural communities (Fernandes, Benseñor et al. 2014).

This review apart from the evidentiary underpinning of the significantly high prevalence of stroke in LMICs revealed some important issues including the preponderance of traditional risk factors. For every 10 years increase in participants' mean age, the stroke prevalence increases by 62%. The pattern of age-specific increase in stroke prevalence is clearly marked within three age brackets for both genders with available data**.** In our review (result not shown) Latin America and Caribbean region has the highest proportion of elderly (≥65 years) participants living in urban areas. This corroborated the recent evidence of an epidemiological transition in Latin America toward older urban-dwelling adults (Avezum, Costa-Filho et al. 2015). The higher proportion of stroke in upper-middle-income countries and urban settings compared to low-income countries and rural environments as shown in the present study and in previous reviews (Ana, Sridhar et al. 2012, Adeloye and Basquill 2014, Avezum, Costa-Filho et al. 2015) are in line with convergence of increasing income level, urbanisation and cardiovascular disease predictors.

Our finding of a steep increase in stroke survivor prevalence in LMICs despite increased reported case-fatality appears that there is consistent evidence of increased vulnerability extending to a high number of younger adults with a higher chance of surviving the acute phase of stroke with residual disability and with much better outcomes compared to older patients leading to increased survivor rates. This means that quality incidence data if available, could present an important and additional etiological information as well as public health warning signs resulting from a corresponding increase in new cases.

5.2.8.2 Comparisons with Previous Studies

The most recent reviews on stroke epidemiology were limited to 7 incidence studies in 9 LMICs (Sajjad, Chowdhury et al. 2013). Previous reviews had little representation of LMICs (Feigin, Lawes et al. 2003), others were based on regional (Saposnik and Del Brutto 2003, Burke and Venketasubramanian 2006, Lavados, Hennis et al. 2007, Pandian and Sudhan 2013, Adeloye 2014), country (Wahab 2008, Tse, Fang et al. 2012, Xu, Ma et al. 2013) or population-specific analysis (Wahab 2008, Tse, Fang et al. 2012, Xu, Ma et al. 2013). There are also global reviews of stroke with few studies in LMICs (Feigin, Lawes et al. 2003, Feigin, Forouzanfar et al. 2014). Given the limited number of studies, geographical spreads and omission of important development indicators, it appears that these reports may not necessarily reflect the true prevalence estimate of stroke in LMICs in the current epidemiological and demographic transitions. For instance, Feign and co-authors (2014), in a recent report on the global burden of stroke reported a prevalence estimates of 393.4/100,000 population in 2010 (Feigin, Forouzanfar et al. 2014). The result was comparable to the current estimate, which further underpins a near representation of the size of the problem in LMICs. However, the minor differences may probably be due to the study periods, age groups and fewer data points (the report provided data for only 34 population-based studies for LMICs). In addition, the result of stroke prevalence in Africa reported a continent-wide pooled estimate without due consideration of human development index and gross national income per capita estimates (Adeloye and Basquill 2014, Owolabi, Akarolo-Anthony et al. 2015).

5.2.8.3 Implications for Policy in LMICs

To date, the health priorities of many LMICs particularly in sub-Saharan Africa and south Asian countries remain infectious diseases mainly HIV/AIDS, malaria and tuberculosis (Beaglehole, Bonita et al. 2011, Chan, Davies Adeloye et al. 2012, Bishwajit, Ide et al. 2014). This is in addition to high poverty, malnutrition, illiteracy, unsafe drinking water and social discrimination (Lopez, Mathers et al. 2006). The economic impact of increased stroke in our study would mean growing underinvestment and GDP losses reflecting increased loss in productivity and reduced labour efficiency in LMICs. The cost for stroke was estimated to be as high as $34 billion annually in the United States (Mozaffarian, Benjamin et al. 2015), and about £8.9billion in the UK (Saka, McGuire et al. 2009). Studies on the cost of stroke in LMICs are few and far between, in Togo for instance, the estimated direct cost per person stood at 936 Euros in only 17 days, about 170 times more than the average annual health expenditure of a Togolese (Guinhouya, Tall et al. 2010). This does not include informal and indirect costs. With the looming public health burden, such financial outlay in stroke alone would foreclose the consideration of other urgent priority public health issues in LMICs.

Consistent evidence from our study and elsewhere found that hypertension is the main risk factor for all stroke in LMICs and this is more prominent among the young adults who present with stroke unaware of their high blood pressure status (Feigin, Forouzanfar et al. 2014). With the steepest increase in the prevalence of stroke taking place in LMICs particularly in low-income countries, options for urgent and improved surveillance and cost-effective prevention of major risk factors such as hypertension remain an important public health priority. As a result of the double burden of communicable and non-communicable diseases in LMICs (Remais, Zeng et al. 2012), it appears the estimates found in this study will continue on an upward trend with huge fatality due to policy alignment focusing on the prevention and control of infectious diseases including maternal, perinatal and nutrition related conditions.

5.2.8.4 Implication for Policy in Nigeria and Niger Delta Region

The prevalence of stroke survivor in Nigeria reported in this study is 1.45 (0.78-2.41) per 1000 population, this estimate is significantly lower than the average in sub-Saharan Africa and in the low income or the lower-middle income countries where more than 80% of the countries in Africa belong. However, pooled analysis of the studies conducted in Nigeria found that the individual study for rural Niger Delta estimate was even higher than the pooled estimate in sub-

Saharan African and the Middle Eastern and North African region (Figure 17). This estimate is also more than the pooled estimates for both low income and lower-middle income countries.

The implication of this finding is twofold. First are the additional socioeconomic burden and financial exposure especially given that the higher rate was limited to the rural environment. The second one is the state of health care and access in these setting. Over the years, rural health care in Nigeria has not received adequate policy recognition. This is more worrisome when public health priority has continued to target infectious and vaccine preventable diseases. Increased effort directed towards halting maternal and child mortality has continued to received global attention, however, the omission of non-communicable diseases like hypertension has continued to drive other cardiovascular and cerebrovascular conditions. This twin problem or double burden in the face of poor and non-existent health service and targeting in rural communities portend great danger in the health of the rural population in Nigeria.

Influence of some extrinsic factors such as environmental pollution (not evaluated in this review) could not be ruled out due to evidence from previous findings which has shown a positive association with stroke (Shah Lee et al. 2015). There is urgent need to test this hypothesis in the light of differential exposure to oil and gas pollution in the Niger Delta in Nigeria. This will help in proper policy focusing in the context of disease surveillance, management and care in the Niger Delta and Nigeria as a whole.

5.2.8.5 Study Limitations and Strengths

While informative, the results of this meta-analysis should be interpreted with caution. First, in large continental regions such as sub-Saharan Africa and Europe and Central Asia, there were insufficient studies to entirely represent the regions. In addition, I found significant difference related to study-level participants' characteristics, publication year, and study sample size. Nevertheless, the results of tests for publication bias provided evidence that it was unlikely that I may have missed studies that could have altered the meta-analyses results. The diagnosis of stroke in LMICs remains a huge challenge, hence, ascertainment of cases was not well defined across some studies and this has been reported previously (Bennett 2011). I focused on prevalence estimate and secular trends alone in this review and did not provide data on stroke-related disability or case-fatality. Although such data are important for health-care planning and management, it is scarce particularly in LMICs compared to high-income countries. In addition, the few available data are highly heterogeneous and may be unreliable due to conflicting information on causes of death, overlapping disabilities caused by disorders that accompany stroke in many older patients and the fact that majority of stroke do not access the health service due to prohibitive out-of-pocket expenses, distance to urban hospital and lack of stroke functioning units in rural health care settings (Feigin, Lawes et al. 2003, Kengne and Anderson 2006). Some hospital surveys in South Asia and sub-Saharan Africa have shown that CT scan for instance, were only conducted on less than half of patients presenting with stroke, and this is mainly among those that can afford it (Kengne and Anderson 2006). Nonetheless, I allowed studies showing quality methodological rigour including detailed epidemiological exercise in our final analysis.

The lower prevalence of stroke in sub-Saharan African region does not call for relief when compared to other region. We are unable to provide data on stroke case- fatality in this study due to lack of data and confusion surrounding the actual cause of death. It could be that due to poor healthcare services, the estimate of stroke deaths may be higher compared to other regions. In the meantime, the limited data on stroke incidence in LMICs which suggest absence and/or inadequacy of stroke registration infrastructure would encourage reliance on prevalence estimate of stroke in the community as the best epidemiological indicator in the circumstance.

Despite these limitations, the study's strengths are important. Our study presents the most comprehensive and up-to-date review of stroke prevalence in LMICs. Moreover, the introduction of World Bank regions and income groups in our analytical model provided an interesting dimension to warrant valid comparative estimate appropriate for public health policy interventions on the prevalence of stroke within these jurisdictions. I conducted a meta-analysis as a preferable option for data synthesis since qualitative or narrative synthesis can lead to misleading conclusions that should not be generalized beyond the scope of the analysis (Ioannidis, Patsopoulos et al. 2008). Comprehensive searches of databases were also conducted to ensure that all relevant publications were identified. I also reduced potential bias in the conduct of this review by having the authors independently scan through the search output and extract the data. In addition, I included only community-based studies and provided estimates on stroke prevalence trends. These provided additional information for local feedback on the health system and public health demands.

5.2.9 Conclusions

Our study findings provide contemporary estimates that reflect the significant prevalence of stroke in LMICs. The socio-economic implication of stroke in LMICs is very high in terms of magnitude and secular trend. Though upper-middle income countries account for the largest prevalence of stroke, low-income countries have experienced the steepest increase in stroke prevalence over the last three decades and are projected to overtake both lower-middle and upper-middle- income countries.

Studies which estimated the prevalence of stroke survivor in Nigeria showed that stroke is now a public health issue not only in Nigeria which needed urgent intervention. This is in view of the low life expectancy and unknown case fatalities. Of much concern is the fact that estimates from the Niger Delta is significantly higher than that found in any other African countries. Additional and indeed urgent epidemiological study should be conducted to better understand the spread in the whole country, particularly in the Niger Delta. Such studies could consider environmental factors like pollution and geographical location as important exposure and/or modifying factors. Given the widely reported environmental pollution associated with oil and gas production in the Niger Delta, such study may benefit public health researchers and indeed the health department to understand if a positive relation between environmental pollution and stroke exist and the appropriate intervention necessary.

We are unable to provided data on case-fatality in this region and elsewhere in LMICs due to poor health registration infrastructure in sub-Saharan Africa and other regions in LMICs. Therefore, policy shift need to concentrate in adopting community stroke-registries and death-certificate coding that is consistent across the regions. This would make comparability of stroke burden in LMICs robust and strong.

Overall, findings of this review study will be useful for the proper design of stroke screening (including high blood pressure and other predictors), treatment, rehabilitation, and related public health prevention strategies. Particular attention should be given to the large prevalence of undetected or uncontrolled high blood pressure (Ferri, Schoenborn et al. 2011, Adeloye and Basquill 2014, Adeloye, Basquill et al. 2015), which is likely to play a major role in the observed secular trends in stroke prevalence across low-resource settings.

Summary

This chapter presented the systematic review and meta-analysis of not only the prevalence of hypertension in the Niger Delta but also the changing prevalence of stroke in LMICs. The review and meta-analysis highlighted very important gaps in hypertension/stroke prevalence in Niger Delta where only one community-based study for stroke currently exists. Key findings of the two reviews include;

For Hypertension prevalence estimates

i. The prevalence estimate of hypertension in the Niger Delta is very high

ii. The pooled estimate is higher when compared to the previous estimates of 18.4% (Ogah, Okpechi et al. 2012) and 28.9% (Adeloye, Basquill et al. 2015) for the whole country in the years 2012 and 2015 respectively.

iii. There is reverse epidemiology of hypertension in the Niger Delta such that the prevalence estimates of rural areas is significantly higher than the urban areas (32.0% versus 26.84%)

iv. Participant's residential location, socioeconomic and lifestyle factors are important risk factors associated with hypertension prevalence in Niger Delta.

For the prevalence of Stroke

i. Stroke differ significantly in both magnitude and secular trend in LMICs

ii. The highest annual increase of 14.3% occurred in low-income countries

iii. Pooled estimate in Nigeria is very high compared to the estimate for sub-Saharan Africa

iv. The study conducted in the rural Niger Delta is significantly higher compared to those conducted elsewhere in Nigeria and by extension the pooled estimate for sub-Sahara Africa

v. Undetected or uncontrolled HBP, participant's age, study period and socioeconomic characteristics remains important factors modifying the prevalence of stroke

In the next chapter, the background of the study area will be presented.

SECTION THREE

- **BACKGROUND TO THE STUDY COUNTRY**
- **METHOD AND METHODOLOGICAL ISSUES**

  (DATA COLLECTION AND ANALYSIS)

CHAPTER SIX

6.0 BACKGROUND TO THE STUDY COUNTRY

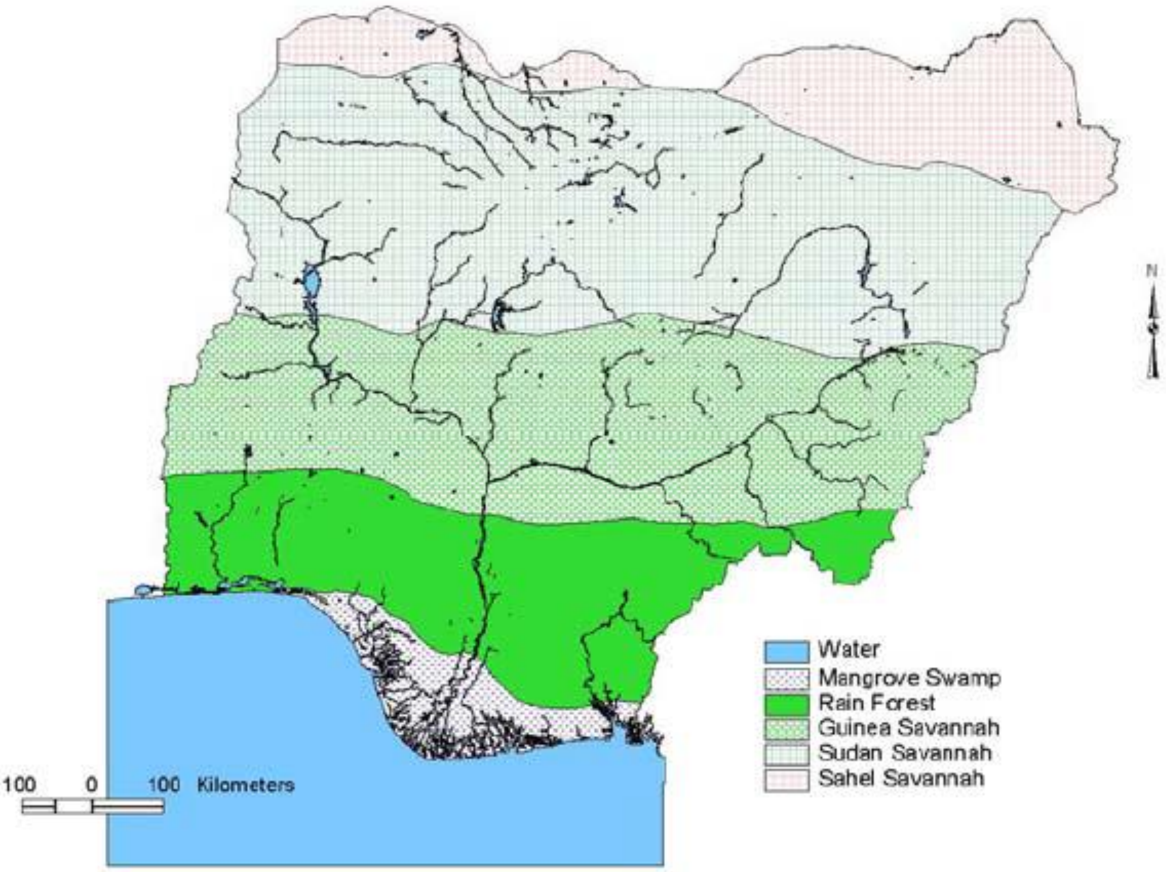
INTRODUCTION

This chapter establishes the context for the two epidemiological surveys of the thesis. It does this by first providing a detailed background on socioeconomic and demographic construct including health profiles and disease trends in the study country Nigeria in general and Niger Delta in particular. Subsequent sections will discuss the oil and gas production and industrial development including environmental pollution resulting from oil production and gas flaring activities. The last section discusses the environmental and socioeconomic impact as well as the adverse health consequences of oil and gas pollution on the host communities where it is arguably having the most devastating impact.

6.1 Nigeria Geography and Ecology

Nigeria is one the constitutional republics in West Africa. It is surrounded by Benin in the west, Cameroon and Chad in the east and Niger Republic in the northern part. The country covers a total land area of 923,768 square kilometres of land in West Africa (Coleman 1965, National Population Commission 2014). Nigeria is the fourteenth largest country in Africa geographically. In the southern part, the Nigeria coast lies on the Gulf of Guinea in the Atlantic Ocean. The coastline stretches approximately 850KM from Lagos in the west to the Rio del Rey in Cameroon. The country has two main rivers; Niger and Benue which converge and empty into the southern Niger Delta and together they form the shape of a Y or fan (Fasona and Omojola 2005, National Population Commission 2014). The country coastline in the south gave rise to a highly varied and rich coastal environment which constitutes the Niger Delta region of Nigeria.

Nigeria's ecology varies from tropical forest in the southern part to the dry savanna in the far north and extending into the Sahara desert with sand dune fields, but also arid mountains and plateaus (National Population Commission 2014). The tropical climate is characterised by two important seasons the rain-bearing south-westerly winds which dominate the rainy seasons between March to October and the cold, dry, and dusty north easterly winds commonly referred to as the harmattan which dominates the dry seasons between November to February (Fasona and Omojola 2005). The mean historical rainfall and temperature in Nigeria (Figure 20) oscillates between 25° and 40°C, and rainfall ranges from 2,650 millimetres in the southern part to less than 600 millimetres in some parts of the north, and mainly on the fringes of the Sahara Desert (Spurgeon, Wasilewski et al. 2009, National Population Commission 2014).

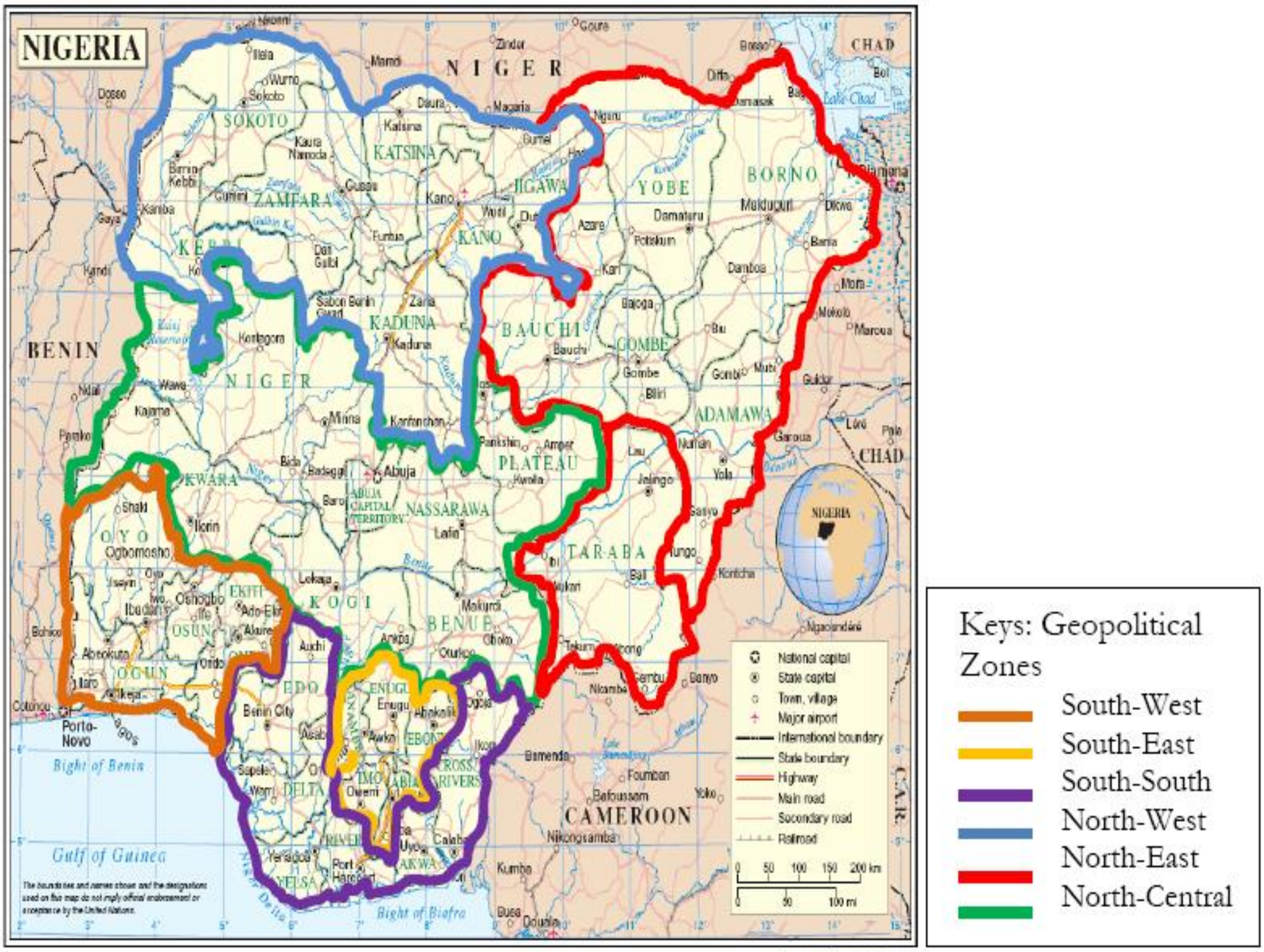


(Fasona and Omojola 2005)

Figure 20: Nigeria's Ecological Map

As a federal constitutional republic, the country is made up of three tiers of government: the federal government the state governments made up of 36 states and the Federal Capital Territory

(FCT), Abuja, and 774 local government authorities (LGAs). The states are divided into six geo-political zones as shown in Figure 21. These include; North-Central, North-East, North-West, South-East, South-South, and South-West. The Niger Delta region is located in the south-south and partly the south-eastern part of Nigeria (Odoemene 2011).



(NASRDA)[10]
Figure 21: Map of Nigeria Showing the Six geopolitical Zones

[10] The National Space Research and Development Agency (NASRDA) is a research institutions under the Federal Ministry of Science and Technology, Nigeria (http://www.nasrda.gov.ng)

6.2 Demography and economy

Nigerian population stood at 177.5M in 2014 according to World Bank report with annual growth rate of 2.8%. This estimate represents an increase of 37.1million (26.4%) from the 2006 national population census figure of 140.4 Million (National Population Commission 2014). According to the national census, Nigeria remains the most populous country in Africa and is approximately one-sixth of the African population and by extension, one fifth of the Sub-Saharan African population and seventh most populous country in the world with about 2.5% of the shared world total population (National Population Commission 2014). The country's median age is 17.8 years while life expectancy averages 53 years for both sexes (WHO 2016). Even though fertility rate is on the decline, current projection from the United Nations (UN) revealed that the country's population will increase to 210 million people in 2025, and 289 million in 2050 and the bulk of the increases will be in the working-age population (DESA 2015). The age-sex specific structure of the population is shown in the population pyramid in figure 22.

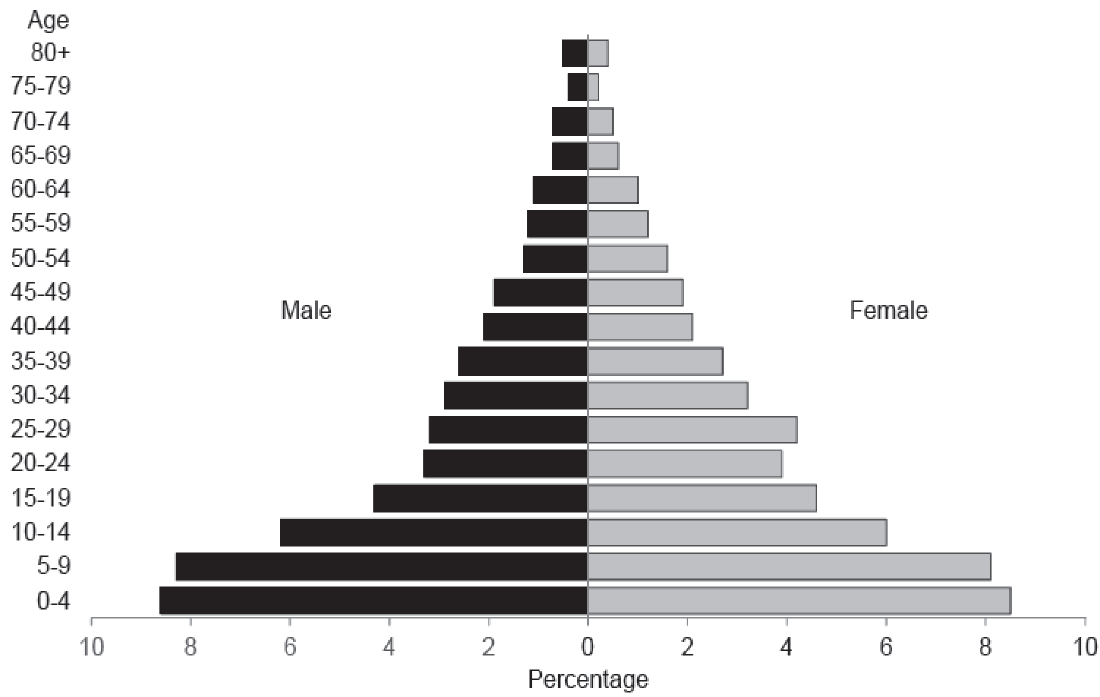
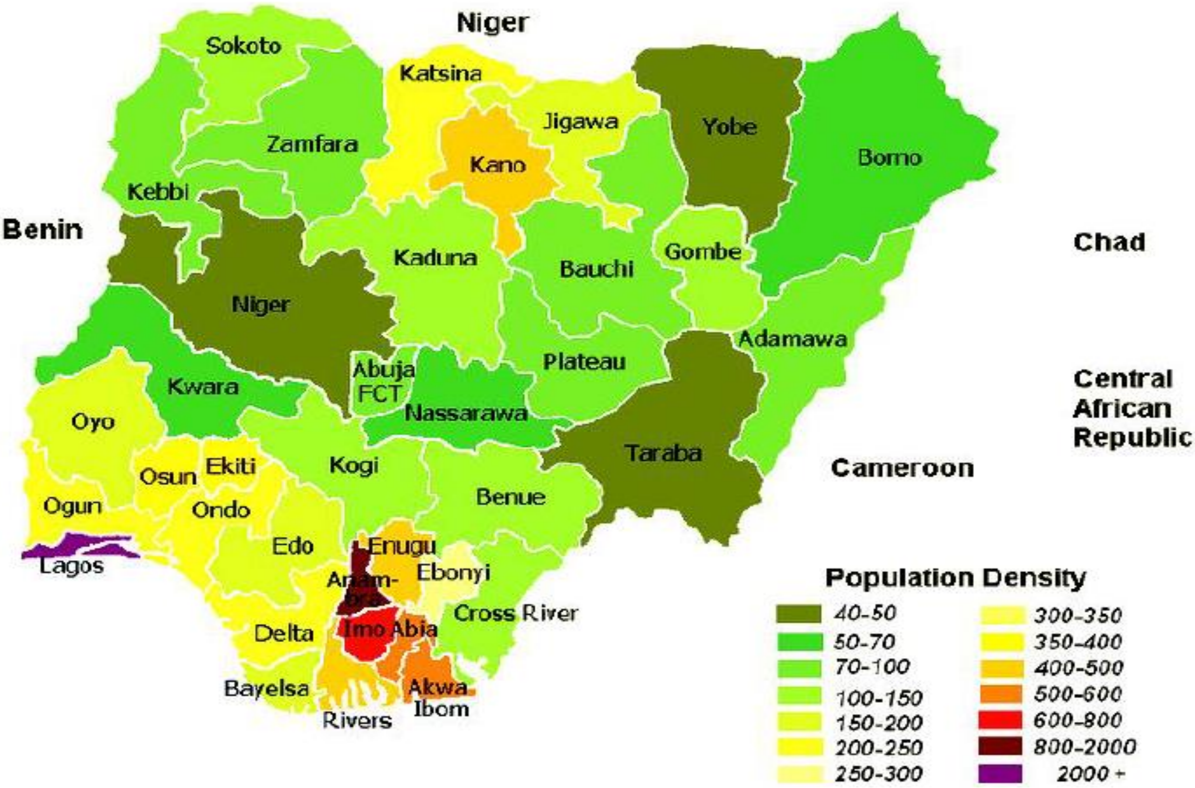


Figure 22: Nigeria's Age-sex specific population pyramid

The broad base of the pyramid indicates that about 50% the population are under the age of 18, while the proportion of individuals aged 65 years and over is about 4 percent, a scenario typical of countries with high fertility rates (Moore 2003).

Nigeria has the highest number of cities in Africa (those with over one million population (Ekpenyong and Akpan 2013). Currently, the population density is about 194.9 people per square kilometre of land area (National Population Commission 2014). There are about 24 cities in the 36 states of Nigeria (Figure 23) with a combined population of over 100 million. As at 2014, approximately 91,834,051 (51%) Nigerians are urban dwellers with annual population growth rate of 4.5% in 2014. This estimate exceeds that of sub-Saharan Africa by more than 10 percentage points (National Population Commission 2014). This also portends huge socioeconomic and health challenge in the next two decades (National Population Commission 2014).



(National Population Commission 2014)

Figure 23: Map of Nigeria showing the 36 States and the Population Densities

The country has a unique cultural diversity with about 389 ethnic groups. Hausa, Ibo and Yoruba are the major groups and constitute over 40 percent of the total population. In fact, 80% of the population are made up of about 10 ethnic groups (National Population Commission 2014).

Nigeria's GDP measured at 1990 constant basic prices indicated a growth rate of 7.8 percent in 2010. However, this figure dropped significantly in the preceding years and rises to 6.3 in 2014 (Figure 24). The reduced growth in GDP relative to 2010 was attributed to the contraction in oil's contribution to the GDP. Nigeria is a mixed economy emerging market and has been grouped as a lower middle-income country (LMIC) according to World Bank human development index and income group (African Development Bank 2013). Nigeria has huge natural resources including vast reserves of natural gas, tin, iron ore, coal, and limestone. The industrial and services sectors contribute about 80% of the GDP (Central Bank of Nigeria 2015). Interestingly, Nigeria accounts for about 14 percent of sub-Saharan Africa's GDP, yet grapple with high poverty rate with over half of the country's population living on less than US$1 per day (Mohan 1996).

Figure 24: Changes in Nigeria's Gross Domestic Product from 2006 -2014

According to World Bank, about 80 million Nigerians are living in poverty with 54 percent of them living in rural areas compared with 46 percent in towns and cities (World Bank 2014). Nigeria has exceptionally high and significant levels of inequality. UNDP reported a huge uneven distribution of nation wealth and found that about 20% of the population owned 65% of the national wealth (UNDP 2009). Regional inequality in wealth has also been documented by with the southern regions and states being wealthier and more urbanised compared to the north on average (UNDP 2009). Specifically, more than ten poorest states are all in the north, with a poverty rate of more than 60%. This compares to nine of the ten richest states found in the south. However, in the south, the south-south region which includes all the Niger Delta states has the highest prevalence of poverty compared to south-west and south-east (National Population Commission 2014).

6.3 Health and Socioeconomic Indicators

The Nigerian health sectors are characterised by poor quality and inefficiency in the provision of health services (Polsa, Spens et al. 2011). This has led to poor health outcomes, including large-scale inequality in health status among individuals and families, and across local government areas, states and regions. Inequality in access to care, resources and structural problems still pervade the entire landscape (Asuzu 2005, Welcome 2011). The Nigerian health system performance has been undermined by a lack of adequate investment in health and care (Ejughemre 2014). In the past decades, the total expenditure on health as a percentage of gross domestic product (GDP) in Nigeria has stagnated at 2% (Obadan 2001). This compares to Uganda which allocates 8.5% within the same period and despite its high HIV/AIDs burden, Uganda still rank 149/191 ahead of Nigeria 187/191 in health system performance (WHO 2000) (WHO, 2000). Current health and socioeconomic indicators in Nigeria are detailed in table 5.

Table 5: Demographic, Health and Socioeconomic Indicators

Indicators	Year	Estimate	Source
Demographic Indicators			
Total population	2014	178,516,904	Word Bank 2016
Total Rural Population	2014	94,717,499	Word Bank 2016
Population living in urban areas (%)	2013	46	Word Bank 2016
Rural population (% of total population) (2014)	2014	53.1	Word Bank 2016
Population aged under 15 (%)	2013	44	WHO 2015
Population aged over 60	2013	5	WHO 2015
Population aged 30 – 70 years (%)	2014	27.7	WHO 2015
Population annual growth rate (%)	2014	2.8	Word Bank 2016
Life expectancy at birth (years), Male/Female	2015	53	Word Bank 2016
Crude birth rate (births per 1,000 population)	2013	41.2	WHO 2015
Crude death rate (deaths per 1,000 population)	2013	13.2	WHO 2015
Percentage of population urbanised	2014	49.6	World Bank 2016
Average annual growth rate of urban population (%)	2014	4.5	World Bank 2016
Socioeconomic Indicators			
Gross National Income per capita (US$)	2014	2970	World Bank 2016
GDP per capita (US$)	2014	3005	World Bank 2016
GDP per capita average annual growth rate (%)	2014	6.3	World Bank 2016
Percentage share of household income, lowest 20%	2010	5.6	World Bank 2016
Total population of rural poor	2014	50,010,839	World Bank 2016
Rural poverty ratio at national poverty lines (%)	2010	52.8	World Bank 2016
Adult Literacy rate (% of people ages 15 and above)	2008	51.1	World Bank 2016
Chronic Non-Communicable Diseases Indicators			
Total NCD deaths (per 1,000 population)	2012	260	WHO 2015
Total NCD deaths (Percentage of all deaths)	2012	24	WHO 2015
NCD deaths between ages 30-70 (% of all NCD deaths)	2008	27.7	WHO 2015
All NCDs (Age-standardised death rate per 100,000)	2008	805.4	WHO 2015
Cancers (Age-standardised death rate per 100,000)	2008	94.1	WHO 2015
Chronic respiratory diseases (Age std. death rate per 1000)	2008	95.3	WHO 2015

Hypertension (Prevalence %)	2008	34.8	WHO 2015
Overweight (Prevalence %)	2008	26.8	WHO 2015
Obesity (Prevalence %)	2008	6.5	WHO 2015
Death from Stroke (%)	2012	3.4	WHO 2015
Healthcare Indicators			
Health System Performance ranking	2000	187	WHO 2000
Total health expenditure (% of GDP)	2014	0.9	WHO 2015
Physicians per 1,000 population	2010	0.4	WHO 2015
Nurses and midwives per 10,000 population	2009	16.1	WHO 2015
Percentage of rural population with access to water	2015	68.5	WHO 2015
Prevalence of HIV for 15-49 years	2014	3.2	WHO 2015

(WHO 2000, WHO 2015, WHO 2016)

6.4 Background to the Petroleum Sector in Nigeria

6.4.1 Pre and Post-Oil and Gas Boom

Nigeria is number one petroleum producer and exporter in Africa and 12th in the whole world. It has one of the highest proven reserves of natural gas according to the department of petroleum resources (DPR) and World Bank globally (British Petroleum 2014). The Petroleum industry plays a large role in the Nigerian economy, accounting about 40% of GDP and more than 75% of Federal Government total revenue (UNDP 2009). In 2000, 99.6 percent of the country's export income came from oil (the proportion has been above 90 percent since the mid-1970s). Significant oil production and export started after Nigeria independence in 1960 with the exploratory right for onshore and offshore areas given to major international oil companies including Mobil, Agip, Safrap (now Elf), Tenneco (now Texaco) and Amoseas (now Chevron), British petroleum and Royal Dutch shell. As at 1970, Nigeria's crude production output has risen to a peak of 2.4 million barrel per day (BPD) making her the 7^{th} largest oil producing nation worldwide (Frynas 2000).

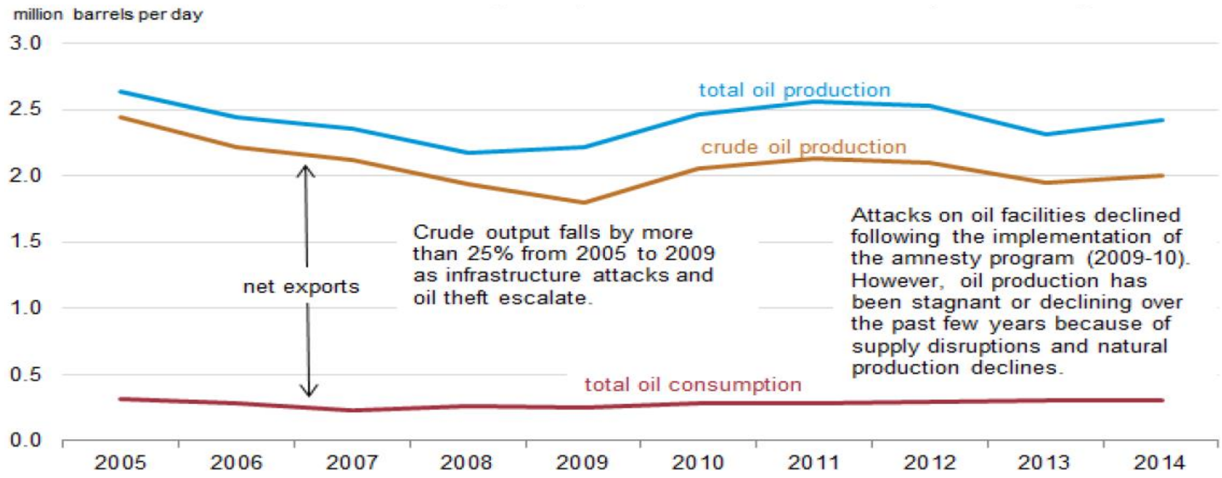
Initially, Nigerian government's interest in the oil industry was limited to policy, regulation and collection of royalties, lease rentals and taxes from the oil companies (Khan 1994). This was made possible through the Petroleum Act in 1969, which vested the ownership and control of all petroleum resources in the hand of the Federal Government (Pearson 1970). However, following the increasing dominance of the economy by petroleum sector due to increased foreign exchanges earnings, the once important agricultural sector was abandoned. To increase production output and more discoveries, exclusive exploration right was introduced to encourage other multinational oil companies (Nwokeji 2007). Subsequently, Nigeria joined the Organization of Petroleum Exporting Countries (OPEC) in 1971. In furtherance to OPEC's resolution urging member states to acquire controlling interest in concessions held by foreign companies, Nigerian government established the Nigerian National Oil Corporation (NNOC) later in the year, NNOC later became NNPC with a controlling interest in many Joint venture contracts (JVCs) with major international oil companies (Nwokeji 2007).

According to the ministry of Petroleum Resources and DPR Niger Delta region has an extensive network of over 159 oil fields, 1481 oil-producing wells currently in operation both offshore and onshore. The region also boasts of 120 flow stations, including over 1500 km of trunk lines and some 45,000 km of oil and gas lines or pipelines (DPR, 2010).

(Kadafa (2012)

Figure 25: Niger Delta Showing the Distribution of Onshore and Offshore Oilfields

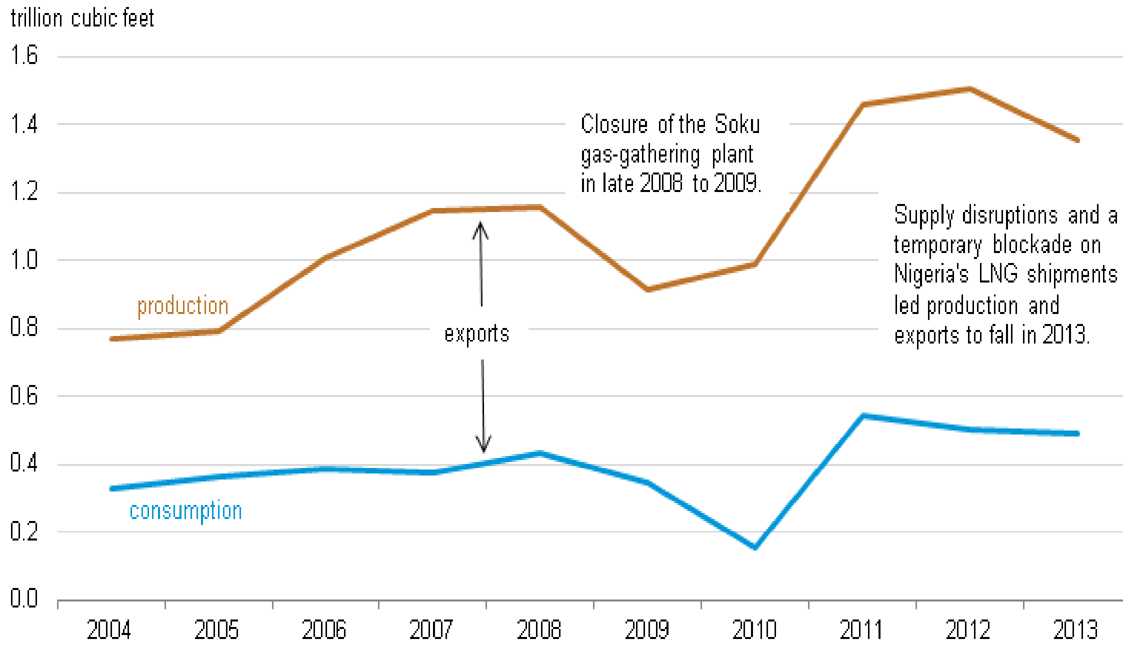
Apart from crude oil, the Niger-Delta is also endowed with the tenth largest proven natural gas reserves (DPR, 2010). In the last years, the country's average proven reserve stood at 182 Trillion cubic feet of gas (EIA) with annual production capacity of about 2,000 Billion standard cubic feet (BCF). Recent world energy review reported that Nigeria exported about 800 BCF of LNG in 2013 (British Petroleum 2014). This amount accounted for about 7% of liquefied natural gas traded worldwide and ranking Nigeria among the world's top five LNG exporters (Figure 26).



(US Energy Infomation Administration 2015)

Figure 26: Petroleum and other Liquids Production and Consumption in Nigeria

The expansion of the petroleum industry also recorded significant investment in the downstream sector including the building of functional oil refinery. As at 1985 the country has four refineries operating a full capacity with a total installed capacity of 445,000 BPD and these refineries are linked with a network of pipelines and depots. Natural gas production for local consumption and export has also seen increased investment and patronages resulting in increased export and foreign exchange earnings (Figure 27). Apart from oil refining major power generation and supply companies, oil and gas service companies, petrochemical and allied companies and many other industries that leverage on the petroleum sectors are important features of the petroleum sector in Nigeria.



(US Energy Infomation Administration 2015)

Figure 27: Natural Gas Production and Consumption

6.5 Niger Delta Regional Profile

6.5.1 Geography

The study was conducted in the Niger Delta region of Nigeria. Niger Delta region is situated in the southern part of Nigeria. The region represents 12% of Nigeria total surface area estimated to be 112,110 km. It extends over about 70,000 km² of land area and makes up 7.5% of Nigeria's total land mass (UNDP 2006). The region has the world's third largest wetland. This combined with the most extensive freshwater swamp forest and rich biological diversity (UNDP 2006). Niger Delta is made up of 9 states out of 36 states in Nigeria as shown in figure 28. These states include; Rivers, Bayelsa, Cross River, Edo, Delta and Akwa Ibom states in the South-South. Others are Imo and Abia states (part of the South East) and Ondo states in the South-West geopolitical zone of the country (Figure 28). The region is also made up of 185 local government areas (LGAs) out of 774 in Nigeria (Odoemene 2011).

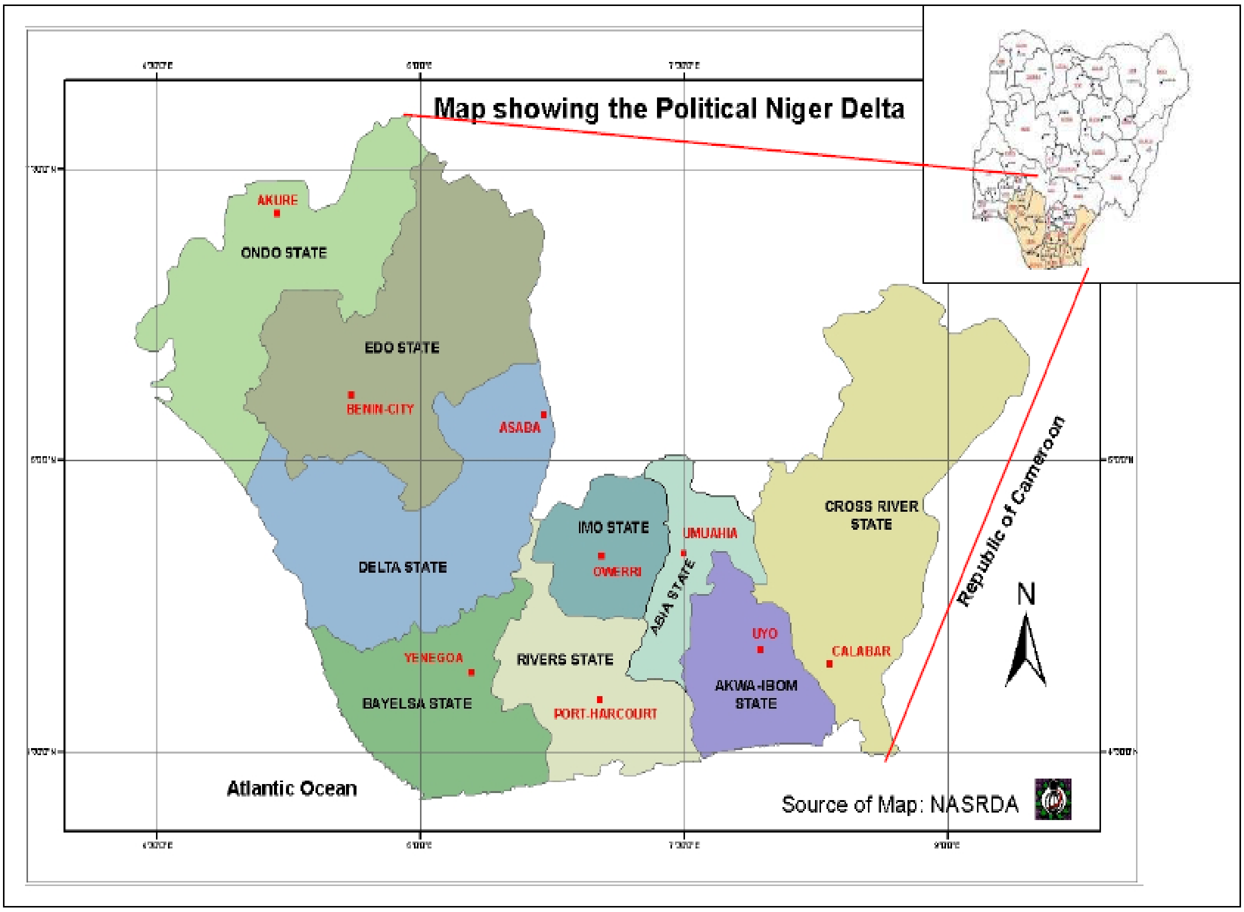


Figure 28: Map of Niger Delta Region in Nigeria

6.5.2 The People

Niger Delta is a multi-ethnic, with Ijaw, Ogoni, Itsekiri, Urhobo, Kalabari, Ibibio and Igbo being the majority (Odoemene 2011). Ogoni is well-known internationally mainly because of media focus and its agitation for resource control and autonomy. Niger Delta has a steady and rapid population growth (Table 6) accounting for 22% of the current Nigeria total population (National Population Commission 2014). Niger Delta had a total population of 31.2 million by 2006 and is projected to reach 45.7 million in 2020 according to Nigerian population census commission projection (National Population Commission 2007). The population density is also among the highest in the world with about 320 people per kilometre squared.

Table 6: Population projections of Niger Delta (2005-2020)

State	2005	2010	2015	2020
Abia	3,230,000	3,763,000	4,383,000	5,106,000
A/lbom	3,343,000	3,895,000	4,537,000	5,285,000
Bayelsa	1710,000	1,992,000	2,320,000	2,703,000
C/River	2,736,000	3,187,000	3,712,000	4,325,000
Delta	3,594,000	4,186,000	4,877,000	5,681,000
Edo	3,018,000	3,516,000	4,096,000	4,871,000
Imo	3,342,000	3,894,000	4,535,000	5,283,000
Ondo	3,025,000	3,524,000	4,105,000	4,782,000
Rivers	4,858,000	5,659,000	6,592,000	7,679,000
Total	28,856,000	33,616,000	39,157,000	45,715,000

(UNDP 2006)

6.5.3 Size Distribution of Settlements

Human settlements found in the Niger Delta are significantly different compared to other regions in Nigeria. Most of the settlements found in the region have less than 1,000 people. This was followed by those with 1,000 to 5,000 people and is all in the rural areas. Only 95 of these out of 13,329 are classed as urban with 20,000 people or more (table 7). Evidence found that the high numbers of smaller settlements are due to the nature of the environment, ethnic identity, occupation-related and the land tenure system which encourages small land holding and ownership which often times are dispersed in pockets of isolated dryland around fishing areas (UNDP 2006).

6.5.4 Regional Economy

The region's estimated human development index (HDI) score (a measure of well-being encompassing the longevity of life, knowledge and a decent standard of living) of 0.564 is slightly above the national average of 0.471 (with 1 being the highest score), however, it ranks lower in comparative terms with other countries or regions with similar oil and gas resources (UNDP 2006).

Table 7: Size Distribution of Settlements in the Niger Delta

Niger Delta States	Less than 1000 People	1000-5000 people	5000-20000 people	20000 people and above
Abia	393	494	52	11
Akwa Ibom	1236	1098	46	7
Bayelsa	290	317	85	4
Cross River	117	500	56	8
Delta	1016	307	104	22
Edo	903	264	70	11
Imo	788	925	81	2
Ondo	1463	278	57	16
Rivers	428	598	213	17
Niger Delta Total	**7686**	**4781**	**764**	**98**

There is endemic poverty (measured by income and food) in Niger Delta with regional average as high as 68.3%. However, a few individual (such as high-level politicians and those engaged in the illegal oil business) are stupendously rich widening the already bloated income inequality. The rate of unemployment has continued to increase as well. Compared to the national average of 21.4%, the region has a higher 27.3% unemployment rate in 2010. According to UNDP report, the socioeconomic and development indicators in the Niger Delta region point to inadequate, unavailable and of poor quality particularly in the rural communities (UNDP 2006). Despite decades of oil and gas exploration activities and contribution of the region to the national GDP

(40%), there is historical neglect of the region by the federal government and this poses a huge barrier to attaining significant health and socio-economic transformation.

6.6 Oil and Gas and Associated Pollution

Niger Delta region remains the economic nerve of Nigeria where the estimated 38 billion barrels of crude oil and 182 trillion cubic feet (TCF) natural gas reserves reside. Since Nigeria's discovery of oil and gas, its estimated reserve has continued to increase as more discoveries are made within the region (DPR, 2010). The abundant oil and gas deposits in Nigeria (Niger Delta region) are responsible for the strategic importance of the region and the country in the current global economic realities. This is also responsible for the current level of urbanisation, industrialisation and the large influx of people from other parts of the globe, making the country the fastest growing economy in Africa (UNDP 2006).

There has been a continuous strive by the Nigerian government to increase its crude oil production quota targeted at increasing revenue to accelerate investment in critical infrastructure. This effort over the years has led to a dramatic increase in environmental oil pollution in rural and urban areas in Niger Delta, thus suggesting a non-linear relationship between environmental cost and socioeconomic as well as health benefits to the host communities (Kadafa 2012). According to a UNDP report, there has been a total of 6,817 oil spills incidents which account for a loss of between 9-13 million barrels (1.5 million tonnes) of oil spilt in the Niger Delta over the past 50 years (UNDP 2006). This amount is 50 times the estimated spill volume in the Exxon Valdez spill which occurred in 1989 in Alaska (DPR 2010).

Most of these incidents were not reported, however, official record from DPR showed a steady increase from 1998-2007 (Table 8). Ageing oil and gas infrastructure (oil and gas pipelines and valves), operational failure due to poor maintenance culture and human error, and sabotage

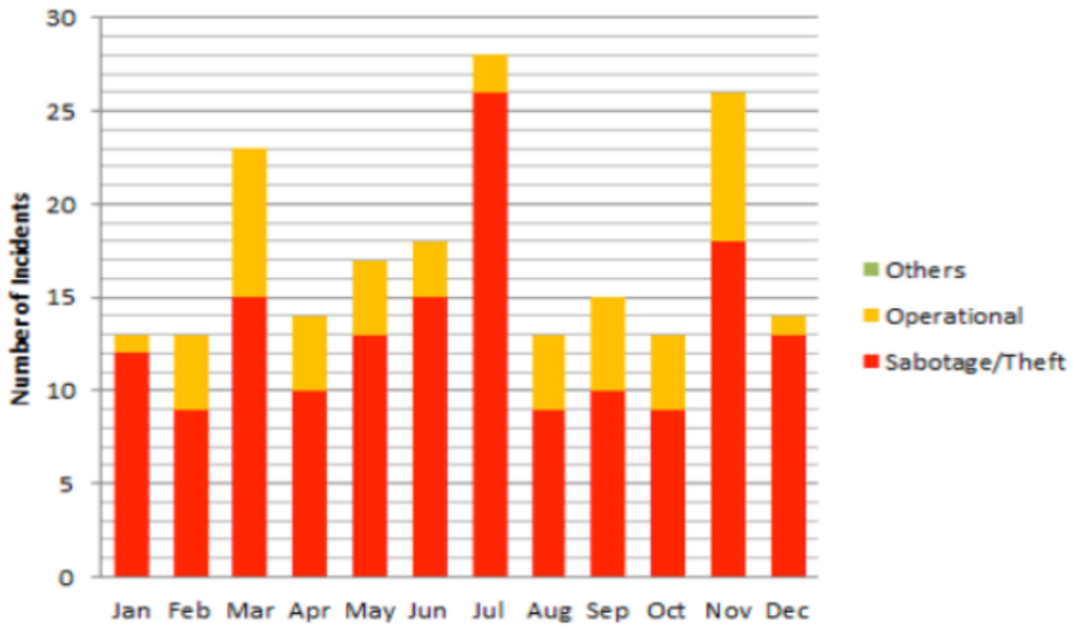
/theft through oil bunkering and for illegal refinery are the major avenues that led to oil spills and pollution consequently.

Table 8: Oil spill occurrences and causes in Niger Delta (1998-2007)

Year	Equipment failure	Human Error	Sabotage	Total Oil spills recorded
1998	28	12	65	105
1999	19	28	55	102
2000	34	39	40	113
2001	46	15	64	125
2002	39	20	67	126
2003	41	53	63	157
2004	38	32	96	166
2005	49	27	127	203
2006	37	39	187	263
2007	31	29	209	269
Total	**362**	**294**	**973**	**1629**
Percentage	**22.2**	**18.1**	**59.7**	**100**

(DPR 2010)

The majority of these spills are reported from facilities owned by major oil companies operating in the region. They include Shell Petroleum Development Company (SPDC), TotalFinaElf, Agip, Exxon Mobil, Chevron, Texaco and Addax petroleum. Available record from the department of petroleum resources revealed that SPDC alone has reported an average of 221 oil spills per year in its operational area involving 7,350 barrels annually (Oremade, 1986; Okoko and Ibaba, 1999; Osuji, 2001, 2002). Figure 29 revealed the reported spill incidents involving SPDC in 2014.



(Shell Petroleum Development Company 20016)

Figure 29: Oil Spill Incidents Reported By SPDC In 2014

A significant amount of natural gas produced in Nigeria is flared or burned off. This is because most of the oil fields lack the necessary infrastructure needed to capture the natural gas produced with crude oil, known as associated gas. A recent estimate found that more than 40% of the 2000bcf annual production capacity is burnt during production operation, more than is flared anywhere else in the world (Ahmad, 1994). Natural gas flared in Nigeria accounted for about 10% of the total amount flared globally. This estimate equals about 25% of the UK's total natural gas consumption and was equivalent to 40% of the entire African continent's gas consumption in 2001 and equivalent to the total annual power generation in sub-Saharan Africa (DPR 2010).

A report from FEPA estimated that there are about 100 gas flaring sites in Niger-Delta some of which have been burning ceaselessly for 40 years (Kadafa 2012, Tawari and Abowei 2012). The quantity of gas flared in Nigeria has continued to decrease in recent years, from 540 BCF[12] in

[12] Billion cubic feet

2010 to 428 BCF in 2013 due to investment in liquefied natural gas production. However, the associated impacts of gas flaring persist (Tawari and Abowei 2012).

(Kadafa 2012)

Figure 30: Illegal Oil Refining and Smuggling Operations in Niger Delta

Gas flaring, according to experts, not only wastes valuable resources but is also a major contributor to ambient air PM in the Niger-Delta and Nigeria as a whole. Other sources of environmental pollution directly or indirectly linked to oil and gas industry include refining operations, emissions from petrochemical plants, power plants and industrial machines that rely on refined petroleum products for its operation. Traffic-related or emissions occurring as a result of power generating sets have a significant contribution to environmental pollution (Tawari and Abowei 2012, Kadafa 2012).

6.7 Oil and Gas Host Communities

There about 800 oil and gas producing communities which cut across Niger Delta region. Apart from oil wells located offshore, these communities are abundantly endowed with oil and gas found onshore. They are oil-rich yet grapples with the shackles of disease morbidity and mortality and other poor socioeconomic indicators akin to the 'Dutch Disease' or 'Resource Curse' malaise visible in it's low-ranking in human development index (UNDP 2006, Otaha 2012). Apart from oil production and spillages, gas production, flaring and venting (Figure 31 and Table 9) are commonplace in the host communities.

The rural topography is mainly characterised by rivers, lakes, creeks, lagoons and swamps of small dry lands of varying dimensions. The land surface can be grouped into three main sub-divisions from north to south: the freshwater zone, mangrove swamps and the coastal sand ridge zone. The rural communities in Niger Delta fall into two main categories. These include the land based and water based communities. The land-based communities are majorly located on the northern end of the Delta while the water-based inhabitants are located in the southern parts. The riverine area covers about 40 percent of the state, while drier uplands occupy the remainder. The rural population of Niger Delta have unique settlement compared to other regions. They live in predominantly small and scattered hamlets in dispersed villages and clans. A typical fishing clan/village has about 500 people most of whom are farmers or fisherfolk. Though there are larger settlements which are usually separated from other clusters of rural residences and are mostly located along the roads, which radiate from a 'core' where markets, local churches and schools centres are situated. Most rural settlement in the Niger Delta lacks essential social amenities such as access roads, functional medical facilities and good drinking water. About 20-24 % of the rural inhabitant has access to safe drinking water. The lack of potable water in rural areas has been responsible for increased water-borne diseases due to poor sanitation and oil pollution (Nwidu, Oveh et al. 2008).

The livelihoods of the rural community are based on agriculture and fishing. Rubber, cocoa and palm oil plantation were all abandoned and cleared due to the oil boom. Agriculture is the main employer of labour in the rural communities, however, in some areas fishing could be the main occupation. This oftentimes plays a major role in determining settlement patterns, in particular, the location of fishing communities along the estuaries (UNDP 2006). Banana and plantain are major food crops grown in the local communities mainly due to the nature of the soil and climatic conditions. In addition, tubers and root crops are also found in relative quantities. Due to small farm holding, mixed croppings at the subsistent level are commonplace.

Artisanal or local fishing activities have been the major fishing type in many rural communities. Though commercial trawlers are also found, local fishing is responsible for the highest amount of fish supplied locally and in urban areas in the Niger Delta region due to a huge involvement of many local inhabitants who engage in the fishing occupation for their livelihood.

Table 9: Gas Production, Utilisation and Flared in Niger Delta from 2000-2011

Year	Production (Mm^3)	Utilisation (Mm^3)	Flared (Mm^3)
2000	47537.0	21945.0	25592.0
2001	57530.0	29639.7	27890.3
2002	101976.1	26203.4	75772.7
2003	53379.0	30583.0	22796.0
2004	69748.0	45156.0	24592.0
2005	58247.0	34818.0	23429.0
2006	57753.7	39374.8	18376.9
2007	65936.5	43188.4	22748.1
2008	66640.8	48796.0	17844.8
2009	41534.2	28076.5	13457.2
2010	58006.0	44506.6	13499.3
2011	55099.1	38898.2	16200.5

(Ite and Ibok 2013)

(Kadafa 2012)

Figure 31:Agip Gas Flares at Ebocha in Niger Delta

Rural transportation in the region is a significant source of misery, requiring people to trek long and excruciating distances with their produce (Figure 32). This is due to the high cost of motorcycle transport which is a popular means of transport. Apart from few inter and intrastate road network which connects urban areas, water transportation is a significant means of transport by the local communities. Hand-paddled dug-out canoes are very common means of transportation, and for fishing activities and for movement of farm produce over short distances.

(NDDC 1997)

Figure 32: Common means of Transport in the Rural Communities

6.8 The Socioeconomic and Health Burden

Oil producing communities in Niger Delta region of Nigeria has continued to experience unending consequences of oil exploitation without a future (Osuji et al., 2004). The region has become synonymous with oil pollution with environmental degradation more than any region with similar oil and gas resources (United Nations Environment Programme 2011)This is in addition to the considerable socioeconomic and public health burden (Ana, Sridhar et al. 2009, Ana, Sridhar et al. 2010, UNEP 2011, Otaha 2012)

According to the World Health Organization, social determinants of health represent the circumstances in which people are born, grow up, work and age, and all integrated systems put in place to deal with diseases and improve living standard (Satcher 2010). Oil exploration and production operations in rural Niger Delta have been associated with various socio-economic and cultural changes (Ugochukwu and Ertel 2008). The changes include land and water-use pattern. For instance, fluctuation in fishing, hunting, logging activities and agricultural activities through the introduction of new access routes, unplanned settlements and exploitation of natural resources and disease pattern were common. The socioeconomic issues associated with these include population dynamics due to labour mobility and income loss (UNDP 2006). Although underemployment and unemployment are rife in the Niger Delta as a whole, oil and gas activities have brought appreciable and attractive wages for full-time employment or specialised contractual services. These opportunities cannot be compared to the number that has been driven out of agricultural and fishing occupation particularly the elderly and those without basic education.

Farmland and source of drinking water are also destroyed (Nduka, Orisakwe et al. 2008, Ordinioha and Brisibe 2013). Evidence of these is common in rural communities of Niger Delta (Figure 33). Acid rain due to toxic properties of pollutants such as SO_2 and rapid corrosion and leakage of corrugated roofing sheets (galvanized iron sheet) witnessed in the oil–producing communities is very common (Nduka, Orisakwe et al. 2008, Obia 2009, Ekpoh and Obia 2010, Nkwocha and Pat-Mbano 2010, Obia, Okon et al. 2011).

The host communities with its peculiarities and vulnerabilities have continued to suffer more from oil spills. This explains the reason why the international non-governmental organisation (INGO), Nigerian society, including the Government and the organised civil society have reacted to the incessant oil spillages, gas flaring and the general environmental degradation with fear and desperation. Oil and gas pollution directly affects the farmers in the host communities through loss resulting from decline and contamination of fish population and low crop yield as well as reduced sales (Lawanson, Imevbore et al. 1983, UNDP 2006, Odjugo and Osemwenkhae 2009)

(Kadafa, 2012)

Figure 33: Livelihood destruction by pollution in the host Communities

The direct effect lies on the socioeconomic outcomes including individual or household income loss, food insecurity and increased vulnerability for other stakeholders in the value chain such as marketers, traders, consumers and food processors (Ordinioha and Sawyer 2008). Apart from the socioeconomic and cultural challenge posed by oil and gas pollution, the communities or population who reside or work in close proximity to the pollution source are directly or indirectly affected health-wise. Significant evidence of health impact (acute and chronic) has been found to be associated with pollution in the exposed communities (Ordinioha 2010, Nriagu 2011, Ordinioha 2013). For instance, UNEP report (2011) and study evidence from Ordinioha and co-worker (2013) found that exposure to the mists and fumes generated by a crude oil spill is associated with acute health effects, albeit mild and transient (UNEP 2011, Ordinioha and

Brisibe 2013). Severe and long-term exposures have also been linked to acute renal failure (Otaigbe and Adesina 2005), and cardiovascular and neurological disorders such as hypertension and stroke in the polluted communities (Ordinioha 2010, Onwuchekwa, Mezie-Okoye et al. 2012, Onwuchekwa, Tobin-West et al. 2014)

6.9 Study Communities

The epidemiological survey reported in this thesis was carried out among residents exposed to oil and gas pollution in a dominantly oil and gas polluted community (Ebubu), and non-exposed residents from another community (Usokun) without any oil and gas exploration or related activities (Figure 34). The two communities have the same socioeconomic and cultural features in Eleme and Degema local Government area in Rivers State. However, they differ remarkably in terms of environmental pollution and exposure level largely due to oil exploration and gas flaring and allied industrial activities. The communities are about 60KM apart with an estimated population of 30,580 (National Population Commission 2007). Livelihoods in this rural community are fairly narrow and unsustainable due mainly to environmental constraints brought about by a direct and indirect impact of oil production. The communities are below poverty line, hence the human development dilemma raises the fundamental question on why abundant human and natural resources have had so little impact on poverty level in these communities (UNDP 2006).

6.9.1 Ebubu Community

Ebubu is a densely populated rural farming settlement with sparse social infrastructure. It is about 15.5KM from Port Harcourt city. The community has huge functional oilfields and gas flaring sites in addition to a network of oil pipelines. It is a highly polluted community with a history of oil and gas exploration activities by Shell Petroleum Development Company[1] and other oil companies.

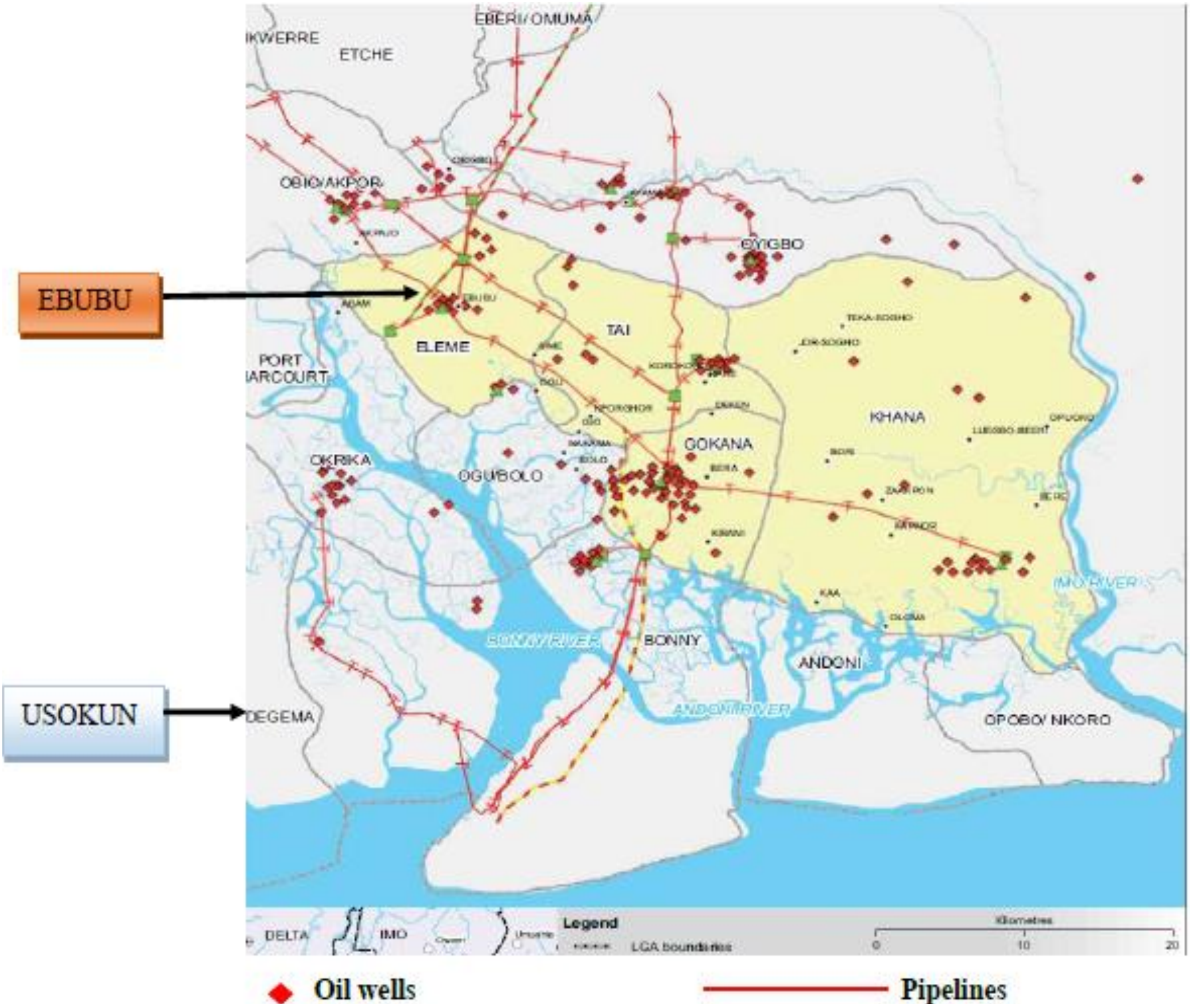


Figure 34: Location of the Study Communities and Oil exploration Sites

Oil and gas operations in Ebubu in Eleme LGA dated back in the 50s and the first shipment of 22,000 barrels of crude oil exported from Nigeria to Europe in 1958 was obtained from well locations in the community. A major crude oil spillage occurred at one of the villages (Ejamah) a few years ago which attracted national and international attention(United Nations Environment Programme 2011) Ebubu borders other communities that house many industries, oil refineries, petrochemical plants and many active oil and gas production facilities. Air pollution is very high in this area.

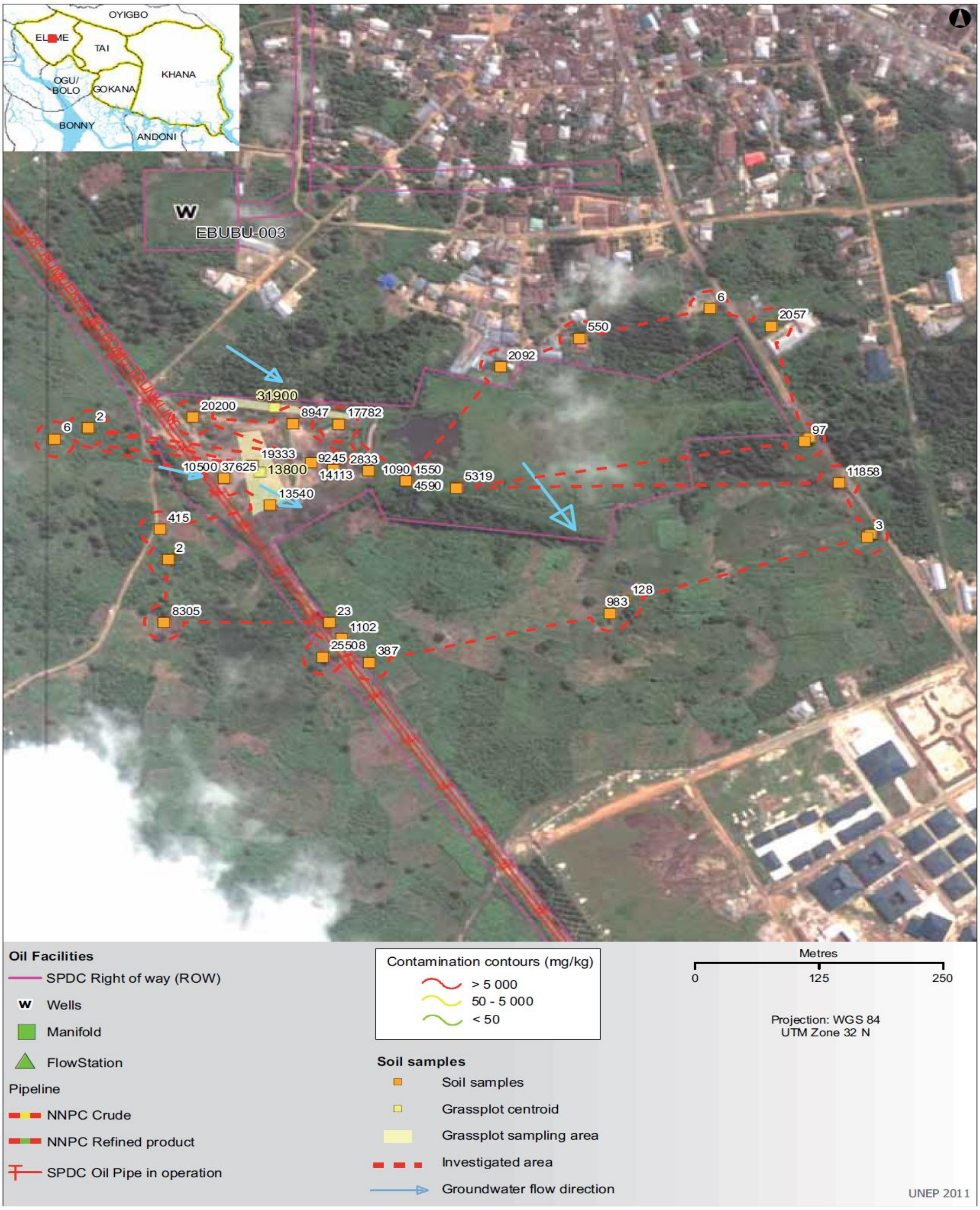
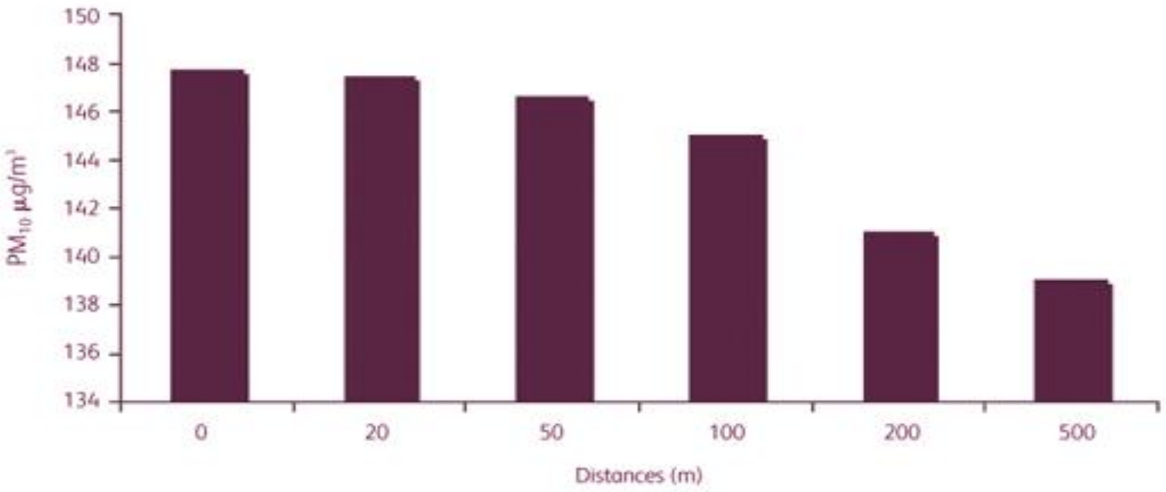


Figure 35: Spatial analysis of the polluted Community (Ebubu)

Recent ambient PM_{10} and $PM_{2.5}$ concentration are about 10-fold above the WHO recommended guidelines (Ana 2011). The concentration of particulate pollution emanating from the point sources or emission sources with respect to the average distances to the community dwelling has also been evaluated previously (Efe 2008). The result shows that at as the distance from the dwellings to the emission source deceases so also the concentration of particulate matter increases proportionally (Figure 35).



(Efe 2008)

Figure 36: PM concentration from the emission source and distance from the dwellings

According to UNEP report, over 2 million barrels of spill has been recorded in the community leading to the huge destruction of the both the aquatic and terrestrial environment. Till date, there has not been any clean up or remediation since the first incident despite UNEP recommendation (United Nations Environment Programme 2011). The oil spill in the environment has polluted water sources such as the Ochani stream in Ejama village. Available information found that the stream used to be the main source of drinking water and the focal point of most commercial and cultural activities in the community (Adoki 2013).

Just like other host communities, there is high unemployment and increased poverty, food insecurity and high crime rate. Household relocation is very common. Rural livelihood in Ebubu is generally destroyed all of which are associated with oil and gas exploration and production.

There is a general health and income inequality as the community heads and few privileged individual access the most benefits that come from the oil companies. The general health of the residents is poor. There is a newly built primary health care centre, however, essential drugs are rarely available and out-of-pocket cost remains prohibitive. This led to high patronages of the traditional medicine retailers or dispensers.

6.9.2 Usokun Community

Usokun is a pristine rural settlement in the southern part of River state. It is about 50KM from Port Harcourt city. It is an island situated deep inside the coastal rainforest, circled by Sambreiro River, an outlet of the Niger River. It is a non-oil and gas producing community and free from industrial activities. This community constitutes the control population. The community has only one access road connecting it to the urban areas. Many of the surrounding waters are brackish, and so is much of the ground water in the swamp areas. Transportation is mainly by paddled boat (mainly wooden board locally constructed) and is almost exclusively via the waterways. Motorcycles and bicycles are also common. Motorised canoe and speed boats fitted with outboard engines are the main means of public transport and commuting across urban areas.

Socioeconomic characteristics of the residents showed Usokun rural community is inhabited by people whose predominant occupation are fishing and farming. Those who engage in crop or vegetable farming also engage in fishing at least at subsistent level. The average annual income of a farmer or fish-worker in Usokun is about approximately US$300 per annum (UNDP 2006). A typical family dwelling is made of mud and thatched roof made from locally sourced materials (Figure 35). Fish and other seafood such as clams, oysters and periwinkles are a major part of their diet. It is estimated that about 4,000 fishermen and farmers are involved in fishing and crop farming in this community.

Figure 37: Typical household in Usokun Community

Earlier reports and investigations showed that about 60% of these were in the age range of 25 to 60 with an average of 20 years of fishing experience. While formal education is rare with the older fishermen, the younger ones were found on the average to have spent between 6-8 years or an equivalent to primary school level. Few graduates or educated young men either remain at their home bases working in the nearest local council or move to the city centres and the oil industry locations for paid employment.

There is a very high rate of smoking and consumption of alcohol or locally made drink (Ogogoro) which contains more than 40% of alcohol. This lifestyle is unique to Niger Delta people or those living in the rural riverine areas due to the influence of oil company workers, weather condition and for cultural reasons. Health facilities in Usokun are almost not available as there is only a very small health centre that serves the community with non-resident health officer (Community health officer or nurse). The closest primary health centre is about 45 minutes' walk from the community centre. However, the services of local medicine dealers, traditional healers and a few private clinics and maternity homes run by traditional birth attendants are very pronounced.

Summary

This chapter has presented a detailed background and insight into the Nigerian profile in general, the petroleum sector and the Niger Delta in particular. Details of the fieldwork location including the geographic and socioeconomic features of the communities were also presented to provide adequate knowledge of the study population.

Key issues identified include;

- The complex geographic and demographic features of Nigerian nation in general and the Niger Delta in particular
- The natural resources endowment and the contribution of the petroleum sector to the country's economic development.
- The oil and gas pollution, the causes and contribution of relevant stakeholders
- The state of the rural communities in Niger Delta vis-à-vis, the influence and contribution of oil and gas production and exploitation.
- The socioeconomic and environmental challenges and exposures faced by the rural population of the Niger Delta
- The state of health services and social development

In the next chapter, I will present a detailed study method and methodological issues related to the epidemiological survey.

CHAPTER SEVEN

7.0 METHODS AND METHODOLOGICAL ISSUES

INTRODUCTION

This chapter provides a description of the general study methods and methodological issues adopted in the epidemiological survey reported in the thesis. This starts with the quantitative survey method, study design used, ethical issues and institutional approvals. The chapter looks at the study tools used to collect the relevant data and all the variables used in estimating the prevalence of hypertension and stroke survivor.

The chapter also describes detailed activities and processes carried out for data collection and processing. Of huge importance are the procedures for community entry, meeting the participants and communicating the study aim. In the last part of this chapter, data management and analysis procedures carried out to produce the study results were presented in depth.

7.1 Quantitative Survey Method

As explained in Chapter 2, the study's conceptual framework mapped various indicators or risk factors linking pollutant exposure to our outcomes of interest (Hypertension and stroke). Relevant risk factors or modifiers such as lifestyles and socioeconomic factors were identified, defined and measured. Therefore, the research conducted in this thesis adopted a quantitative survey approach in data collection and analysis

7.1.1 Survey Design

In the conduct of this study, I adopted a cross-sectional study design such that our outcome of interest and hypothesis could be evaluated and tested using relevant statistical model. The choice of the study design was influenced by the exploratory nature of the study which aims to estimate the prevalence of hypertension and stroke in addition to their risk factors through description of participant's socioeconomic, health-related and lifestyle characteristics, and evaluating these characteristics with respect to any prevailing relationships among these individuals within different socioeconomic situation. A cross-sectional design study is an observational scientific technique that involves the analysis of data collected from a population, or a representative subset, at one specific point in time. The design could be used to demonstrate the relationship or association 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). The design will allow the picture to be seen clearly and variations better understood in these communities. In other words, the design remains the most appropriate approach that will provide a quick snapshot of the prevalence of hypertension and stroke and any existing variation within a limited time and resources.

As stated previously, the focus of the study is the rural population in the Niger Delta. I have pointed out that there is a huge inequality in access to healthcare measured in terms of health services utilisation in the rural areas compared to urban settings in sub-Saharan Africa including Nigeria (World Economic Forum, 2011). Evidence revealed a disproportionate concentration of health and welfare facilities in both urban and semi-urban areas in Nigeria, despite the fact that rural dwellers are living in poorer circumstance and have greater vulnerability to health risk (Ulasi, Ijoma et al. 2010, Isezuo, Sabir et al. 2011). Of particular interest are the Niger Delta rural communities which are more vulnerable due to increased exposure to environmental pollution. In general, rural inhabitants are socially and geographically excluded from health service utilisation due to the fact that they live in areas where adequate health services are not available. In addition, they are also excluded from accessing services in urban areas due to both individual and household meagre resources. This situation has made it methodologically inappropriate to adopt study design that would rely on urban population or hospital-based data to evaluate the exact prevalence of hypertension and stroke in the rural population.

While cross-sectional study is generally fast and less time consuming compared to case-control and cohort study design, its desirability is most appropriate in the light of time constraints and financial requirement for a PhD project (Burns and Grove 2008). While cross-sectional design could not be used to test for causality or cause-and-effect relationships (Rothman *et al.*, 2008) it could be used as a strong basis for hypothesis generation and implementation of immediate public health intervention and resource allocation(Burns and Grove 2008). Additionally, generalising the finding from sample to the population could be enhanced by adopting good sampling strategy used in this current study.

An alternative design approach is the longitudinal study design, in which the subjects are followed over time with a repeated or continuous monitoring of the disease condition or risk factors, or both (Barrett-Connor, Ayanian et al. 2011). The essence of monitoring of the subjects over time is to track changes or examine associations between exposure to known or suspected causes of disease and subsequent morbidity or mortality. The study design could also be implemented to follow subjects exposed to oil and gas pollution and other modifying factors over a long period of time. This may last up to many years. Unlike the cross sectional design, the longitudinal design is able to detect developments or sequence of events in the characteristics of the target population at both the group and the individual level. In addition, the design is more likely to suggest cause-and-effect relationship by virtue of its scope.

However, implementing a longitudinal study design in the current study is not feasible due to the restricted period and strict budget for this PhD. In addition, there are other challenges and drawbacks which make it inappropriate for this study. These include; its expensive and labour-intensive nature, time-consuming (due to a long period of follow-up) and the fact that a large number of people must be followed up for long periods before sufficient cases accrue to give statistically meaningful results (Goldstein and Goldstein 1981). Furthermore, the design is quite susceptible to many other threats to validity commonly associated with quasi-experimental study design such as selection, attrition, instrumentation, and regression to the mean (Shadish, Cook et al. 2002).

7.1.2 Study Settings

The study settings represent ideal rural environment and were selected based on the background information already detailed in the profiles of the area. Although the settings have comparable socioeconomic and cultural features of the rural environment in Rivers State, they differ remarkably in terms of environmental pollution and exposure level largely due to oil exploration and gas flaring and allied industrial activities (United Nations Environment Programme 2011). Another important reason for the choice of the area is due to ease of access, peaceful atmosphere and previous assessment report from the UNEP (United Nations Environment Programme 2011). Compared to most oil and gas host communities in the Niger Delta, the location of the study areas encourages land transportation, hence, there is no recourse to water transport to get around. The area is also located within a safe distance from the city of Port Harcourt, so it is possible for the research team to visit the community without having to worry about flooding, rainfall and adequate commercial boats which at times are the major issues that affect people's movement in this region. In addition to the location and access, the settings are relatively peaceful. Most oil and gas producing rural communities in Niger Delta are known hot-spots for social vices including criminal activities, oil theft, pipeline vandalism, smuggling, drug-related incident, kidnapping and hostage takings. Others include armed conflict, robbery and intractable communal conflicts particularly ethnic, or between oil-bearing communities and state and/or petrol-businesses (Akpan and Akpabio 2009, Osagie, Fred et al. 2010, Ifedi and Anyu 2011). These social vices and community disorder are the fallout of environmental neglect and injustices on the part of the stakeholder mainly the oil and gas companies, the political elites and the Nigerian government's reluctance to enforce relevant petroleum and environmental laws (Odoemene 2011). In addition to the peaceful atmosphere, the UNEP report in Ogoniland (a sub-region in Niger Delta comprising of four local government councils) provided substantial documented evidence of the impact of oil and gas to the environment. However, the UNEP investigation did not provide any information on both hypertension and stroke and their risk factors which this study will address.

7.1.3 Study Participants

The study populations are adult men and women aged 18-80 years who are long-term (≥10 years) residents in the two study communities. I concentrated on adults' population because of the epidemiological evidence of increased risk of hypertension and stroke in the polluted environment among this group of people. Ageing on its own is a major independent risk factor for hypertension and stroke (McEniery, Wilkinson et al. 2007, Kuklina, Tong et al. 2012), this is because it weakens the blood vessels (heart and brain) and may lead to a reduction of its function (Pinto 2007). Hence, its is our understanding that exposure to environmental pollution may worsen the situation and increase the anticipated outcomes. The exposed population were recruited from the highly polluted community (Ebubu) and the comparison sample group (control population) were recruited from Usokun community where there is no oil and gas production and related activities.

7.1.4 Study Collaboration

This study was designed with the understanding that relevant collaborators will be involved for hitch-free delivery of the survey. The nature of collaboration in many studies like this is variable, however, I noted that responsible collaboration must be driven by openness, early and ongoing communication and must be championed by named individuals that represent the parties involved. To get the right collaborator, I first searched on the relevant journal for recent study within the field of hypertension and stroke conducted in the Niger Delta in recent time. I found two studies and contacted Prof. Arthur C. Onwuchekwa (Department of Internal Medicine, University of Port Harcourt, Port Harcourt, Nigeria) who was the principal investigator and the first and corresponding author. I received a positive response from him to be involved in the study. In our subsequent discussion, an open and detailed study nature was presented. After further communication, a collaboration agreement was sealed subsequently. At the end, the collaboration was between the team from the Health Science Division of the University of Warwick and the team from the department of Preventive and Social Medicine (PSM) University of Port Harcourt, Port Harcourt, Nigeria. The supervisors of this current project in WMS and the head of the department of PSM from the University of Port Harcourt signed the collaboration agreement (Appendix 21).

7.1.5 Sample Selection

I attempted to select a subset of individual to estimate the characteristics of our study population since it was difficult to directly observe every single person in the study area. Though there are many types of sampling techniques available, I choose a simple random approach and convenience sampling methodology (O'Leary 2013). The choice was guided by our study purpose which is to obtain a sample data in order to make an inference that can be generalised to the entire population or Niger Delta region. The estimated sample size and its calculation are described later in the chapter. In the simple random approach, participants were recruited through a door-to-door visit to randomly selected household and through invitations to attend data collection sessions at the designated health centres. The door-to-door simple random sampling involved visits to even number households in the census enumeration areas (using updated census sample frame) in the whole communities. To make up the non-respondent and shortfalls from the total sample size, I allowed a convenient sampling approach where additional participants were selected on a volunteer basis in a non-probability manner. While each participant has an equal chance of being selected, I avoided incurring additional financial cost and security risk of repeat visits to the households visited earlier. The convenient sampling was conducted in designated areas (such as town halls and primary health centres).

7.2 Ethical Issues and Institutional Approvals

7.2.1 Ethical Approval

As with all studies involving human subjects, ethical approval for the current study was obtained from the Biomedical and Scientific Research Ethics Sub-committee (BSREC), University of Warwick, United Kingdom. This is the institution where the PhD degree programme is registered and where the study concept and part of the design were developed. The procedure for ethical permission involved a rigorous process including the evaluation of the study proposal and adequate insurance cover given the fact that the study will be conducted outside the United Kingdom.

Ethical approval was also obtained from Research Ethics Committee of the University of Port Harcourt, Nigeria. The committee is the local ethics body whose jurisdiction covers the study areas under the National Health Research Ethics Committee (NHREC), Nigeria. This local ethical approval was facilitated through the study collaborator (Department of Preventive and Social Medicine, University of Port Harcourt) which also acted as a local host institution in Nigeria. As part of the approval process, I submitted a more detailed study proposal including survey protocol for review. In both cases, informed consent documents and participants information sheets that were used in the fieldwork were approved. The ethical approval letters from both institutions are presented shown in appendix 22 and 23.

7.2.2 State Primary Healthcare Management Board Approval

As part of the institutional requirement, approval was also sought from the state ministry of health which oversees all the state primary health care facilities in the state. Therefore a written application for study permission with detailed study proposal (including the study benefits to the state) was sort from the state primary health care management board whose mandate is the running of primary health care services and programmes in the state and management of all the primary health care facilities. The approval was granted by the Executive secretary of the board before official contact could be made with the facilities contact person and before a scheduled entry to the study communities (Appendix 24).

7.2.3 Traditional Institution and Council of Elder's Authorisation

Authorisation to conduct the study in selected communities (and villages) was also given by the respective traditional institution and council of elders. The authorisation and approval were communicated in a meeting scheduled in the palaces of the community paramount rulers. In keeping with the tradition of the community, our study collaborators some of whom were known to the community leaders led the way for approval meeting. After I have presented the detail of the study and the huge benefits to the community including free consultations and drugs, oral approval was granted after a brief closed-door deliberation by the community leaders and the paramount rulers.

7.2.4 Primary Health Care Facilities Staff Consent

I obtained informed consent from all staff at all the primary health care centres where some participants were invited for further assessment and consultation. Although the health care management board gave approval for the study, I needed the consent of the facilities staff to ensure confidentiality and non-obstructive workflow. Link study assistants were also stationed at the facilities to signpost participants who were invited for assessment. Although relevant announcement for the study was made in the communities, participants still visited the facilities to obtain clearer information concerning the study.

7.2.5 Study Participant's Consent

Consents were requested from all the study participants. These are signed informed consent. Others without valid signature were required to thumbprint before participation in the study.

For stroke patients or participants with disability, consent where offered by close relatives or guardians. A detailed explanation of the study on the information sheet is given to the participants before consents are requested. In that way, participants had the opportunity to opt out of participation if necessary. However, no participants chose to opt out of participation in the research given the benefit of the study to both individual participants and their families.

7.3 Data Collection Materials

7.3.1 Data Collection Tools

Study tools and equipment for collection of participant's data were appropriate with a high degree of accuracy and reliability. Participants' data were collected by means of study questionnaire and measurement equipment. The equipment in this study was suitable, properly used and maintained following manufacturers and standard guidance to achieve accurate and reproducible results. WHO-STEPS standardised questionnaire and Stroke-Specific Questionnaire Tool were used to ensure that each respondent receives the same stimuli through the previously piloted wording and order of questions. The questionnaire provided a prescribed explanation (label) for each question to ensure consistency from interviewers in each case and from respondents if clarification arises. The structure, patterns and format of the questions ensure rapid completion of the questionnaire and keeps respondent(s) interested throughout the interviewing process.

7.3.2 The General Study Questionnaire Tool

The field survey interview and assessment utilised the general WHO–STEPS adapted questionnaire (World Health Organization 2005). The questionnaire contains 60 items made up of items from WHO-STEP and additional items related to hypertension and stroke. The items were organised into 3 sections (Appendix 25). The sections covered questions related to core socio-demographic, health-related and behavioural information. The questionnaire has 2 additional sections (from WHO-STEP) for anthropometric and blood pressure measurement details containing 7 measured values accordingly. The summary of the general questionnaire is provided in table 10. The general questionnaire tools and equipment generated information regarding hypertension, stroke diagnosis, mental disorders, chronic conditions/physical health, anthropometry, demographics, infectious disease (such as mosquito-borne infection) and battery of cardiovascular and cerebrovascular risk factors.

Table 10: Summary of the General Study Questionnaire

Section	Contents	Question number
Socio-demographic information	Age, sex, gender, ethnicity, education level, occupation type, income earning, source of water supply, cooking energy, electricity supply, number of rooms, landed properties, household appliances etc.	1-21
Health-related information	Family history of risk factors/disease, current and past medical conditions and/or diagnosis, regular medication	22-40
Core behavioural information	Smoking, alcohol consumption, fatty food consumption and physical activity	41-60

7.3.3 Stroke-Specific Questionnaire Tool

The study used the stroke-specific questionnaire in the assessment and diagnosis of stroke in the study population. The stroke-specific screening tool was adopted from a modified World Health Organization protocol for epidemiologic studies of neurological disorders in developing countries (Osuntokun, Schoenberg et al. 1982). The questionnaire included the initial screening questions in the general questionnaire and additional stroke-specific questions to validate the diagnosis (Appendix 26). The questionnaire has been validated and used in two published studies (Danesi, Okubadejo et al. 2007, Onwuchekwa, Tobin-West et al. 2014). The sensitivity and specificity of the stroke screening instrument have been reported to be 96% and 86% respectively (Meneghini, Rocca et al. 1991). The stroke-specific tool contains 14 relevant questions woven around neurological-related manifestation or signs of stroke. These signs are grouped to confirm neurological deficit types such as disturbances and consciousness, including semi-consciousness e.g., not fully aroused, and coma, response to pain only or no response at all (World Health Organization 2005), weakness/paresis (motor deficits of the upper or lower limbs) and speech disturbances such as aphasia or dysarthria (World Health Organization 2005).

The study goal is to estimate the prevalence of stroke in the study community. Since I was not interested in stroke sub-type, I adopted the validated tool which met our study budget and logistics. I relied on available evidence which found that most of the history of stroke patients is usually clear-cut, and the likelihood of a computed tomographic (CT) scan showing anything other than an infarction or a haemorrhage is under 5% (Allen 1983). Clinical evidence has also shown that diagnosis of ischaemic stroke (the most common stroke in developing country like Nigeria) using CT may or may not show a definite infarct and that a normal scan does not rule out a stroke (Yew and Cheng 2009). In addition, the proportion of visible infarcts also depends on the timing of scanning, for instance, within the first few hours, few infarcts can be seen. It should be noted that less than 50% of infarcts never become visible on CT, especially among patients with mild strokes (Sacco, Kasner et al. 2013). Therefore, the diagnoses of stroke were made reasonably accurately on clinical grounds alone by the study specialists employed for the purpose. Even if there is sufficient budget for CT scan, this may not have added significant information in what is known given the location of the participants, the time the event may have occurred (weeks and months or even years) and the distance to stroke specialist units in the urban areas.

7.4 Main Outcome Measures (Outcome Variable)

7.4.1 Hypertension

Two standard methods were used for the diagnosis of hypertension in the study population. In the first method, blood pressure readings that met World Health Organization/ International Society of Hypertension (WHO-ISH) cut-off points for both systolic and diastolic blood pressure measures (systolic pressure ≥140 mm Hg and/or diastolic pressure ≥90 mm Hg) were used (World Health Organization and International Society of Hypertension Writing Group 2003). Participants' blood pressures were measured using an automated upper arm digital blood pressure monitor (Omron M6 HEM-7001-E, Birmingham, UK). This device has previously been validated (Altunkan, Ilman et al. 2007, Altunkan, Ilman et al. 2008) and has been used in previously published studies (Iliescu, Beghin et al. 2008, Uhlig, Balk et al. 2012). An earlier report by O'Brien and colleague (2003) revealed that digital BP monitor not only improves reliability but also eliminates inter-rater variability. Display of the output in digital format has a huge advantage as errors due to human judgements often occurs using analogue instruments (O'Brien et al., 2003).This device is accompanied with different cuff sizes (Figure 36).

The second standard method for the diagnosis of hypertension used in the study was participants' previous confirmation of hypertension. This could be a self-reported diagnosis of hypertension and was verified by physical evidence of hypertension medication (antihypertensive drugs) or medical report of the previous diagnosis of hypertension by a physician. Six relevant questions in the study questionnaire were used to obtain this important detail from participants. These include;

i. Has your blood pressure ever been measured?

Figure 38: Omron M6 HEM-7001-E Digital Blood Pressure Monitor

ii. Has your blood pressure ever been measured?

iii. When was the last time your blood pressure was taken?

iv. Have you ever been told that you had high blood pressure/hypertension?

v. Did your doctor prescribe any blood pressure medicines?

vi. Has any member of your family had high blood pressure?

vii. During the past two weeks, have you been treated for high blood pressure with drugs (medication) prescribed by a doctor or other health worker?

7.4.2 Stroke

Following a review of the responses from the general study questionnaire tool, I used a stroke-specific questionnaire to further confirm the diagnosis of stroke and any known risk factors among study participants screened positive to any of the 4-stroke related questions in the general study questionnaire. The questions are evidence–based signs associated with stroke diagnosis according to WHO definition of stroke (Sacco, Kasner et al. 2013). The stroke-related questions include:

I. Have you ever noticed that your face or mouth was shifted to one side (paralysed) for more than 24 h?
II. Have you ever had loss of sensation or abnormal sensation affecting your arms and legs, lasting for more than 24 h?
III. Have you ever had paralysis of one side of your body (arm or leg) lasting for more than 24 h?
IV. Have ever been diagnosed with stroke or currently taking any stroke medication?

The diagnosis of stroke outcome follows the specialist assessment of participants who responded positively to the above question(s). The diagnosis of whether or not a stroke has occurred is straightforward if there is a clear history of sudden onset of focal brain dysfunction, or if the symptoms were first noticed on waking, especially if the patient is aged over 50 and has vascular risk factors or neurological disorders and /or in addition to physical manifestation consistent with stroke (Sacco, Kasner et al. 2013). Evidence found that the differential diagnosis of acute stroke may include ruling out head injury, malaria, tuberculous meningitis, subdural haematoma, cerebral cysticercosis, encephalitis, brain abscess, brain tumour, and parasitic infestation due to similar presentation, however, I relied on laboratory information or report to rule out presence of infections (Poungvarin 1998).

All participants responding positively to the stroke-specific questionnaire administered in the second stage were invited to the health centre to undergo a general laboratory test (for infections using blood samples) and specific physical and neurological examination such that any abnormalities of function may lead to localization of the lesion and possible diagnosis (Masdeu and Biller 2011). Relevant physical examination performed included eye, neck, reflexes, body temperature, heart and lungs and bowel examination (Sacco, Kasner et al. 2013). The diagnoses of stroke were made exclusively on clinical grounds without CT or MRI. These are made in two ways viz;

I. Based on the previous diagnosis by specialist with evidence of confirmed medical reports read and agreed by study neurologists
II. Study neurologists found presenting sequelae consistent with a stroke.

7.4.3 Confounding Variables (Risk Factors)

7.4.3.1 Socioeconomic or Demographic Factors

Socioeconomic or demographic factors considered in this study include;

a. Participant's Age: This is obtained from the participant or their relatives or the age recorded on any official documentation such as hospital report or birth certificate.
b. Participant's gender: Participants are defined as either male or female.
c. The level of education attainment: This is the total number of years spent in formal education in a school. The response is provided by the participants themselves or their close relatives and is classed: no education (≤6 years), primary (7-11 years) and secondary or high education for those who spent 12 years or more in a formal education.
d. Marital status: Participants were asked if ever married (married and divorced, widowed, married but separated) or not married or single.
e. Occupational status: Participants were asked to provide their current employment status (Whether employed or not employed)
f. Income earning: Daily, weekly or monthly earning of participants were used to estimate the average earning for the past year. Although there is no validated data for individual income and expenditure in Nigeria and Niger Delta, I used some individual assets measure to validate income earning. Such assets like car, television, refrigerator,

telephone, mains water supply, cooking fuel types were used. I did not employ the principal component analysis (Vyas and Kumaranayake 2006) to group individual wealth or socioeconomic circumstance because most studies in the Niger Delta including National demographic survey has classed this rural population as living below poverty (National Population Commission 2008). Although, very few individuals may have been above the national threshold, I accurately used individual past year income earning to validate their financial disposition (Okoji 2002, Ordinioha 2008, Onwuchekwa, Mezie-Okoye et al. 2012).

7.4.4 Health Related-Information Variables

Individual health and health-related information were also collected and include:

a. Acute and chronic health condition: self-reported diabetes, heart disease, malaria and other common infections were documented. For diagnosed condition such as diabetes, participants responded "Yes" to the question; have you ever been told by a doctor that you have diabetes?"
b. Family history of hypertension and/or stroke: Participants were asked about any family history of hypertension or stroke. These include first degree relatives such as father, mother, brother and sister diagnosed with hypertension and/or stroke.
c. Sleep deprivation: Participant's sleep qualities were obtained. Self-reported quantities of sleep or average night-time sleep duration in the previous week were provided. The quantity of sleep was calculated from the difference between rising time and bedtime. Open-ended responses ranged between 3 and 14 hours. Participants were categorised as <5 hours, 5–7 hours, and >7 hours for comparability with previous studies (Stranges, Dorn et al. 2008, Miller, Wright et al. 2014). I grouped low sleep deprivation as those with more than or equal to 7 hours of sleep duration, mild sleep deprivation as those with

about 5-6 hours and moderate-to-severe are those with less than 5 hours of night-time sleep.

d. Knowledge of hypertension: Participants were tested on the knowledge and awareness of hypertension using 15 questions concerning awareness of previous diagnosis and blood pressure readings and risk factors of hypertension and/or stroke. For instance, participants were asked whether hypertension is a silent killer or life-threatening condition. All the questions have been validated in previous surveys (Familoni, Ogun et al. 2004, Katibi, Olarinoye et al. 2010). All the questions contain Yes/No answer. To avoid guessing the right answer, I also included "I do not know" response as well. I rated participants knowledge and grouped them into three classes viz; Low (≤6 correct answers), Moderate-to-High (7-9 correct answers) and High (≥10-15 correct answers)

7.4.5 Lifestyle Variables

Study participants provided information concerning their lifestyle choices or risk behaviours. These include physical exercise, a diet rich in fat or salt (or personal use of salt in diet), tobacco smoking and alcohol consumption. Information provided by close relatives was used for participants who were severely disabled. To reduce information bias, I encouraged both close relatives and the older participants to provide the required information. These responses were given reliability rating based on consistency and recall. I selected the information that has a higher rating. However, I selected the participant's information if his information and that of his close relative has the same response rating. The lifestyle variables collected include;

a. Smoking: This includes current or previous tobacco smoking experience (history of tobacco smoking). I classified this as non-smoker (for those without smoking history). Alternatively, I used "ever smoker" for either current or previous smokers.

b. Drinking status/Alcohol consumption: I provided details of the number of units of alcohol ingested per week for men and women. I used the standard definition of unit of alcohol (10ml or 8g of pure alcohol), which is the amount of pure alcohol in a 25ml single measure of spirit (ABV40%), a third of a pint of beer (ABV 5-6%) or half glass of red wine with ABV of 12% (Miller 2012, Department of Health 2016, ScHARR 2016). To work out safe limits, we used 21 units/week for men and 14 units/week for women (Miller 2012). I classed drinking status as non-drinkers (Those that do not drink), low drinkers (<14 units/week for women and <21 units/week for men) and moderate-to-heavy drinkers (≥14 units/week for women and ≥21 units/week for men).

c. Fatty food consumption: Participants were asked to provide details of their fat intake from information adapted from 72hours diet recall report carried out previously (Schröder, Covas et al. 2001, Oguntona and Akinyele 2002, Ogechi, Akhakhia et al. 2007). To reduce high discrepancies, I used low (for low consumption of saturated fats and fatty diets) and moderate-to-high fatty diet (For moderate or high consumption of saturated fat or fatty rich in fatty diet).

d. Salt intake: 24 h urine collection is widely regarded as the gold standard method for assessment of intake, and is often used as the measure by which to compare and validate other methods of sodium intake assessment (Elliott, Stamler et al. 1996, McLean 2014). However, it suffers a lot of drawbacks. Specifically, the 24-hour urinary collection is burdensome, expensive, time-consuming, and is limited by under-collection and lack of suitable methodology to accurately identify incomplete samples (McLean 2014). I relied on 24hrs salt intake recalls in food rich in salt or self-reported habitual use of table salt 'addition of table salts directly in normal meals' (Charlton, Steyn et al. 2008). This is due to study evidence that self-reported habitual use of table salt is strongly associated with actual salt intake (Mittelmark and Sternberg 1985). This consideration has been used in previous studies conducted in Nigeria and elsewhere (Mittelmark and Sternberg 1985, Olubodun, Akingbade et al. 1997). Although our result may indicate the discretionary use of salt measure, such estimate may correlate with the total dietary salt intake among the study population (Charlton, Steyn et al. 2008). Salt intake in the population was classed as 'low' if participants avoid food or deliberately reduces salt addition in food, and moderate-to-high if table salt is directly added to food or reported increase preference to salty diet.

e. Physical activity: Information concerning each participant's physical activity measures was obtained from the study participants. Although I was unable to identify a validated physical activity questionnaire that fit into the rural environment and population of Niger Delta where no concept of leisure time physical activity was available and where trekking long distances, paddling of canoes for fishing and transportation, using simple farm tools like hoes for cultivation and carrying a load on the head formed a major part of daily activity. I, therefore, modified the validated International Physical Activity Questionnaire (Booth, Ainsworth et al. 2003), and categorised respondents as, sedentary, low activity and moderate-to-high activity on the basis of their responses as shown in table 11. This has been used in similar rural and sub-Saharan African population in South Africa (Thorogood, Connor et al. 2007).

7.4.6 Anthropometric Variables

I obtained anthropometric data which involves the systematic measurement of the physical properties of the human body and its parts. It is primarily the dimensional descriptors of body size and shape. The human body physical measured in this study include height, weight, waist and hip circumferences.

Table 11: Definitions of Physical Activity Categories

Activity class	Activity description	Frequency
Moderate-to-High Activity	Walks with heavy loads and/or cycles	• At least 2.5 hours a week OR • At least 30 minutes on each occasion, 4 times or more a week
	Does vigorous non-work activity, e.g. football	
	Has a job that involves standing and walking and either walks with loads and/or cycles or trek with or without loads	
	Farming (such as bush clearing, cultivating with hoe) or fishing operation or paddling of canoe	
Low Activity	Not sedentary but not active enough to fit the vigorous or moderate activity categories	
Sedentary	Had no job, or a job that only involves sitting and does no walking, cycling, or vigorous non-work activity.	

I also derived important measures of adiposity or abdominal such as Body Mass Index and Waist-to-Hip Ratio) in population-based studies.

a. Height (in cm): Participant's heights were measured using a portable Stadiometer (Leicester Portable Height Measure SECA Ltd., Birmingham, UK). This device has been used and validated in many studies (Millar, Perry et al. 2015, Noonan, Boddy et al. 2016). It has a ruler and a sliding horizontal acrylic headpiece and could be adjusted to rest on the top of the head (Figure 37).

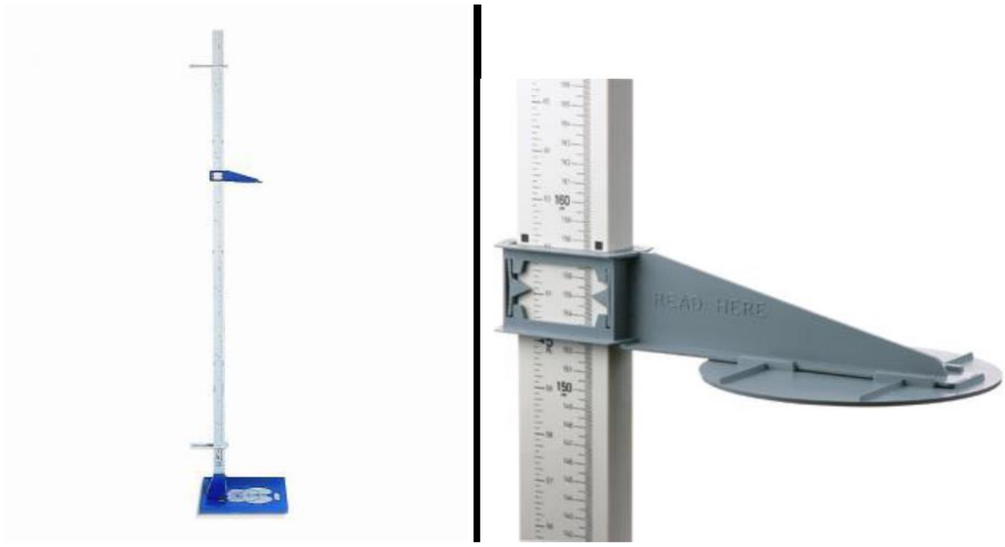


Figure 39: SECA Leicester Portable Height Measure

b. Weight (in kg): I measured participant's body weight in kilogramme (Kg) using portable weighing scale (SECA 877 Class Weighing Scale III, GmbH, Hamburg, Germany) shown in figure 38. The scale has been used in many studies published recently (Nkhoma, Duffy et al. 2013, Grydeland, Hansen et al. 2014, Cheikh Ismail, Bishop et al. 2016).

Figure 40: SECA 877 Class Weighing Scale III

c. Waist and Hip circumferences (in cm): Participant's waist and hip circumferences were measured in centimetres (cm) using a flexible, retractable and inelastic measuring tape (Seca 201, GmbH, Hamburg, Germany) shown in figure 39. The tape has been used in other studies (Navti, Ferrari et al. 2014, Jaeschke, Steinbrecher et al. 2015, Navti, Ferrari et al. 2015).

Figure 41: SECA 201 Circumference Measuring Tape

d. Body Mass Index (kg/m^2,): I obtained participants BMIs using their body height (in meters) and body weights (in kilogramme) to estimate body fat or adiposity. The BMI is defined as the body weight divided by the square of the body height and is universally expressed units of kg/m^2. BMI provides good indirect measures of relative adiposity or fatness and correlate well with more direct methods such as bioelectrical impedance, densitometry (underwater weighing), dual energy x-ray absorptiometry (DXA), total body potassium, and computed tomography (Garrow and Webster 1984, Gorber, Tremblay et al. 2007, Duren, Sherwood et al. 2008, Sun, Van Dam et al. 2010). Epidemiological evidence has shown that BMI is strongly correlated with various metabolic and disease outcome such as hypertension (Chobanian, Bakris et al. 2003). It is also less expensive, accessible, simple, safe, easily administered and most frequently used both in clinical and population-based studies to screen for underweight, overweight, and obese individuals (Ekpenyong, Ettebong et al. 2012).

e. Waist-to-Hip Ratio (WHR): I used the ratio of participant's waist and hip circumferences to determine individual with abdominal obesity. This is consistent with WHO recommendation which defined abdominal obesity as a waist-hip ratio above 0.90 for males and above 0.85 for females, or a body mass index (BMI) above 30.0 (Ana, Sridhar et al. 2012). In addition to WHR for abdominal obesity, I also defined central obesity as a waist circumference of more than 40 inches (101.6 centimetres) in men and of more than 35 inches (88.9 centimetres) in women (Ana, Sridhar et al. 2012).

7.4.7 Exposure (determinant variable)

The main determinant variable of interest in this study was oil pollution status of the place of residence of the participants. This was categorised into two, whether the participants were from the oil polluted area or not. The two areas have been described in detail previously (Chapter 3).

7.5 Study Sampling Procedure

7.5.1 Sample Size Calculation

A recent study in a rural community in the Niger Delta which recruited 1,078 eligible adult participants found that the age–adjusted prevalence of hypertension was 18.3% (Onwuchekwa, Mezie-Okoye et al. 2012). The study employed a simple random sampling targeting 1,527 adults aged 18 years and over. The sample size was based on the assumption of an average of 3 adults per each household. Therefore, I estimated that a sample size of 2,010 could be estimated from 700 hundred households in the study areas and that the number would be adequate for the 2 communities to detect the prevalence of hypertension with 90% power, 3% precision within 95% confidence level. This implies that a total of 2,010 eligible participants made up of 1005 men and 1005 women would be recruited in the study. In the end, I selected 2028 participants for the study. This number would be adequate for a valid sub-group analysis of the prevalence of hypertension and stroke, and their risk factors.

7.5.2 Participant's Selection

A maximum of three study participants was selected from each household in the census enumeration areas in the study communities. A total of 2,028 participants were selected from even number household using an updated census sample frame that has been used previously in the study communities.

7.5.3 Study Selection Criteria

7.5.3.1 Inclusion criteria

- Adult male or female aged 18-80 years
- Those who reside in Ebubu or Usokun communities for at least 10 years
- Eligible adults who agree to participate and sign a consent form (signature or thumb print).

7.5.3.2 Exclusion criteria

- Those who refuse consent
- Pregnant women
- Temporary visitors
- Those who have not lived in the study area for at least 10 years

7.5.4 Research Assistants (RAs) Selection

I selected most of the RAs from the study communities. The choice of the RAs and fieldworkers from the community is to enthrone a sense of ownership and to fend off any external influence.

There are other advantages of selecting RAs from the study communities. Apart from strong knowledge of the local customs and traditions, the knowledge of the community layout and local languages, they helped to communicate or translate the study content appropriately to the intended participants. The success of this helped in no small measure in building trust and confidence in dealing with the participants and realising the study objectives. In addition to the security issues and with strong and organic connection with their kith and kin, these individuals no doubt provided privilege security tips/alerts and relevant clues that would otherwise lead to the risk and danger to the life of investigators.

I also involved the respective traditional rulers who recommended most of these RAs. I also made sure that each of the villages was represented among the RAs who took part in the study to avoid any internal squabbles and domination. This on its own improved my relationship and communication with the community leaders. I was able to report back (periodic feedback) to the respective traditional rulers who nominated most of the RAs to address any challenges such as late coming and other behaviours that are unwarranted. An equal mix of men, women and young adults were represented so that cultural and other social issues (particularly femininity-related issues) are not bridged.

7.5.5 Community Entry and Site Visits

I planned the initial community entry prior to the study commencement to get familiarised with the whole community, the villages and household layouts. This entry was approved by the respective community leaders and village heads who are already aware of the study. In collaboration with our study collaborators, we entered the community to gain access and meet informally with residents. This visit was coordinated by the community liaison officer in charge of the primary health facility located in the communities. Also in attendance are the community youth leader, the woman leader and the traditional rulers' two errand men.

This exploratory visit took place around 3 weeks before the actual study. The main purpose of the visit was to enquire as to whether the site will be accessible and feasible to be covered by me and the research assistants within the time frame, and to identify the location of important community landmarks such as market, community halls and place of worship where consultation and announcement (study publicity) could be made. I also established informal links with some local community-based groups such as local co-operative society, local farming and fishing group, motorcyclist union and community youth organisation. These groups are very powerful in the oil and gas host community as they are the platform under which they meet with the oil and gas companies operating in their communities.

During this exploratory visit, I attended three consultation meetings with relevant groups (stakeholders) and study RAs where all the fine details including logistics, security and local laws and customs were exhaustively discussed and agreed. These meetings provided the opportunity to disclose intended start date and other functions for the study success such as the hiring of chairs and setting up the study venues.

7.5.6 Training of Research Assistants

One week preceding the start of data collection, I trained 14 Research Assistants (RA), 5 from each community and 4 from outside the community for a 5-day period. Six (6) staffers of the primary health centre were also nominated by the health of officer in charge. All the trainees were trained in line with the WHO STEPS survey protocols (World Health Organization 2005). The training covered WHO standard techniques for body weight, height, and waist circumference and blood pressure measurements. Stroke-specific assessment protocols, physical and neurological assessment were also reviewed by study specialist. The training covered 6 main areas. These include the objectives of the study and all the assessments that were planned during the data collection period, the questionnaire content, instruction and administration, interviewing techniques and recording efficiency and confidentiality. The training manual was developed with input from our local collaborators who nominated study specialists.

On the first day of the training, I used a slide presentation and leaflets that summarised the key messages for the survey. Research assistants were familiarised with the survey materials and equipment (Figure 40).

Figure 42: Slide Presentation Session

They were trained on the basic functionalities and calibrations of the equipment including troubleshooting (understanding error message on weighing scales and blood pressure monitor). I also covered standardised procedures for taking participants weight, height, blood pressure and waist circumference. Interviewing techniques particularly sitting positions and physical contact with participants were practiced in greater detail.

On the second day of the training, I tested the RAs on key discussion and training on the first day. Questionnaire contents and survey materials were discussed and the process of administration and collection practised. Each section of the questionnaire with material components was explained and clarified. Misleading self-reported responses to personal details, body language and eye contacts were thoroughly discussed. Recording efficiency and confidentiality were also discussed and explained. RAs were also trained on error checks and storage of questionnaire including how to adopt a confidential tone of voice and sitting positions. Obtaining consent from participants was also discussed and understood.

Figure 43: Training Session for Research Assistants

On the third day, I reviewed the previous learnings and dwelled on the procedures for obtaining consent, anthropometric measurement and data recording were practised by each of trainee until they were confident (Figure 41). Each of the RAs carried out an average of 5 complete measurements. I evaluated the trainee competency after allowing each to try out the whole component using each other as a simulated participant

On the fourth days, learnings from the first and third day were reviewed. I also conducted an open feedback to address the RAs individual and collective concerns before handing each of them the study questionnaire and relevant leaflet to further familiarise with the content.

On the fifth day, I made a presentation to the two study specialists and allowed them to provide an overview of the neurological and physical assessments. I also brought in six RAs to act as simulated stroke patients. I observed them during the routine assessment exercises. At the end of each case, I asked relevant questions for checks and consistency.

7.5.7 Increased Study Awareness in the Community

Two community announcers or town criers were also recruited to make public announcements for the study. I developed the content of the public announcements with inputs from our local collaborator and primary health centre liaison officers. The announcers were invited at the traditional ruler's palace for briefings. The briefing included the purpose of the announcement, area of coverage, time and how repeats should be done. In case people needed more information concerning the study, a detailed reference of who to contact in the community or in each of the villages within the community was also agreed. A trial run was conducted in the palace and relevant feedback made.

This public information was also printed and pasted on the notice board at strategic places within the two communities. The places include; the primary health centres, the town hall and markets squares. The announcements were also made in the local markets, churches and on two important events that took place at the palaces during the survey period. Relevant contacts with named persons were all contained in the information leaflet.

7.5.8 Researcher's Safety and Security

I made sure that all my research teams were closely monitored by directly contacting each of them every 1 hour. In addition, I requested each of the respective community head to nominate one tour guide (a well-known and respected member of the community) who did not work directly or took part in the technical detail of the study but who provided assistance relating to local information and layout, including privileged security intelligence. I was also in constant touch with the respective community heads and youth leader during the study duration and notified each of them on completion. The contact details of the community heads and local health centres were also passed on to my supervisors who monitored the study progress from the UK. Movement from one community to another was also communicated to my supervisors. This enabled them track the study team and provided useful supervisory advice at all times.

7.6 Announcements and Meeting the Participants

7.6.1 Community Announcement

Two weeks before the survey in each of the community, two separate announcements were made a week before the start of the study. On the survey day, commencing in June 2014 two separate announcements were also made by the respective town criers in each village. One of the announcement was made very early in the morning and one was done late in the night. The announcements helped the participants to be prepared to welcome the study team.

7.6.2 Meeting the Participants

Meeting the participants starts from 7:00AM and ended at 2PM each day during over 6 days in a week Monday to Saturday except on Sundays. Meeting the participants and collection of data were conducted across 9 villages in two communities between June and September 2014. I conducted the study with my team of RAs working in 3 groups. In each household, we will first knock on the door and waited briefly for a response. After the response, I will introduce myself and my team and the purpose of the visit. If welcomed, I will step inside where a detailed explanation of the study will be provided. After the explanations, I will hand the eligible adults the information leaflet and consent form. I will first of all obtain consent from the participants before taking relevant data. In some household where the participants were not literate, I invite the local RAs to explain the content of the consent protocol very clearly in their local language. In all cases, I assured the participants that no consequences will result from a decision to withdraw consent. In most households where there were more than 3 eligible participants, I randomly select the first 3 that comes out or using the toss of a coin if all were present at the same time. However, in order not to create confusion or deny eligible participants the benefit and knowledge of their blood pressure reading, I made sure that all non-selected participants benefit from the measurement, but will not enter their data accordingly. Participants who consent to the study but without signature were presented with an ink pad to thumb-print the consent form according. Eligible adult participants with special needs were assisted by their relatives, and consent obtained before participation.

I interviewed each participant in private within his/her house and all discussions were in a low voice to maintain privacy. I made sure that waist measurements were sex-specific to avoid cultural breaches. To avoid this, combinations of male and female RAs are always with me or in another team. I conducted the study in the English language (or Pidgin English, a unique version of English language common in Nigeria), the official language in Nigeria. For participant's not comfortable reading English, back translation to local language was provided by the local RAs who are from the communities and who have very good understanding of English language (Figure 42).

Figure 44: Study Specialist with a participant while the RA offers back Translation

I was present on each occasion and took overall responsibility for all the information obtained from participants, including consent forms, study measurements and questionnaires. I also maintained contact with the community leaders and brief them on daily a basis to review any unusual development or any issues relating to security threat particularly for myself and my team. I provided each RA with two separate bags for the storage of the completed and uncompleted questionnaire booklets. At the end of each survey day, I assemble all the teams and collected the completed booklets, review the day's exercise and plan for the itinerary for the next day. All participants invited for further assessment (Stroke) at the primary health centre were assessed by neurological specialist invited for the purpose. I kept all the completed booklets in a locked private room.

7.7. Data Collection Procedure

7.7.1 Completing the Study Questionnaire

One general questionnaire was handed out to each eligible participant or their proxies in each household to complete after consent has been obtained. In the absence of any proxy, I collected the survey information from participants directly or using a local RAs in most cases to obtain the response to the questions. The first 3 sections of the questionnaire required direct answers while the last 2 sessions required anthropometric and blood pressure measurement which was carried out by RAs or myself. We spent between 20-30 minutes to complete each questionnaire (Figure 43). In the case where the participants do not understand verbal explanations or written information given in English, or if any of the participants has special communication needs, I normally rely on information provided by their close relatives present.

Figure 45: Research Assistant's Interview Session with a Study Participant

Participants screening positive for stroke according to the stroke-specific questions were documented in the special register. They were invited for stroke assessment at the primary health centre for further assessment using stroke-specific questionnaire. At the centre, all participants were screened again with a few items in the general questionnaire (sociodemographic detail and details related to previous stroke diagnosis if applicable) before using the stroke-specific questionnaire.

All participants who were screened positive for stroke in the second stage were further invited for physical and neurological examination at the centre. To be examined for stroke, all probable stroke patients consented for further physical and neurological examination. All the examinations were carried out by a specialist paid for the purpose. I also collaborated with the health officer in charge of the primary health centre for participant's medical records and blood test. The specialist combined the participant medical report history, laboratory results and the physical assessment to confirm stroke diagnosis.

7.7.2 Body Weight Measurement

As part of the anthropometric measurements, myself or the RAs measured each of the consented participant's weight and other details recorded accordingly. Briefly, I calibrated the weighing scale first and placed it on a smooth hard floor surface. I invited each participant on barefoot with very light clothing to mount on the scale. I always advised that heavy outer clothing such as jackets be removed. I also asked participants to remove any material in his or her pocket before reading is taken. In all occasion, I asked participants to stand at the centre of the scale for even weight distribution to both feet. This is because standing off-centre may affect the measurement. All participants' body weights were measured to the nearest 0.1 kilogrammes (kg). After the body weight measurements, I recorded and store the data safely.

7.7.3 Waist Circumference Measurement

Each of the consented participant's waist and hip circumferences was measured according to the WHO-STEPS protocol (World Health Organization 2005). Briefly, WC measurements were made around a participant's bare midriff. Participants were asked to exhale while standing bare-footed and with both feet touching and arms freely hanging. I used appropriate measuring tape (SECA 201) to take the measurements. Before taking the reading, I located the top of the hip bone (iliac crest) and placed the tape perpendicularly to the long axis of the body and horizontally to the floor and take the measurement just above the hip bone at the end of normal expiration. I applied apply sufficient tension to conform to the measurement surface but did not make compressions in the skin with the tape. After the WC measurements, I recorded the result accordingly and stored the data safely.

7.7.4 Height Measurement

I and the RAs conducted height measurements on each of the consented eligible participants accordingly (World Health Organization 2005). We used a Stadiometer placed on a smooth hard floor surface and behind a smooth and straight wall for the purpose. Briefly, the upper part of the measuring rod was positioned straight and vertical according to the manufacturers' instruction. Participants were asked to remove their shoes, heavy outer garments, and hair ornaments. We asked the participants to stand with his/her back to the height rule. We also made sure that each participant's feet are together and that the back of their head, back, buttocks, and heels were touching the upright measuring rod while looking straight ahead. We measured heights to the nearest centimetres (cm). After the measurements, I recorded and store the data safely. The Body Mass Index (BMI) was thereafter derived from the measured height and body weight using the formula BMI = body weight (kg)/height $(m)^2$ according to World Health Organisation (2006).

7.7.5 Blood Pressure Measurement

I and the RAs measured the blood pressure of study participants according to the guidelines of the International Society of Hypertension /World Health Organisation (World Health Organization and International Society of Hypertension Writing Group 2003). Briefly, participants were asked to sit up straight in a comfortable and relaxed position with both feet flat on the floor, right arm supported, the centre of the upper right arm at heart level, (approximately the 4th intercostal space) with the elbow slightly flexed, forearm with the palm facing upwards and supported on a flat surface (O'Brien, Waeber et al. 2001). The upper right arm was exposed by rolling up the sleeve or wearing top revealing the arm. Participants were asked to remove their Jackets, sweaters or tight shirt if a tight shirt sleeve has been rolled up. This was because it could occlude the blood flow in the arm and erroneously led to a low blood pressure reading (World Health Organization and International Society of Hypertension Writing Group 2003). We advised the participants to avoid stimulant drugs or foods and from smoking or ingesting caffeine during the 30 minutes prior to the measurement (Krause, Lovibond et al. 2011). We took three blood pressure readings from each participant after consent was obtained, allowing 2 minutes between measurements (Pierin, Ignez et al. 2008). The mean of the last two measurements was used as the final blood pressure (Chobanian, Bakris et al. 2003).

Participants with reading suggestive of hypertension were invited for another assessment after two days at the health centre where a diagnosis will be made by a study physician after further measurement.

In all cases, I used appropriate cuff size for each participant's blood pressure reading to avoid erroneously high or low reading if the cuff size is too short or too wide respectively (Pickering, Hall et al. 2005). I made sure that the cuff sizes complied with the dimension line with the National High Blood Pressure Education Program Working Group (2004) which recommended that a suitable cuff size must have an inflatable bladder width that is at least 40 percent of the arm circumference at the midpoint of the olecranon and acromion. All Participants blood was measured with upper arm digital blood pressure monitor (Omron M6 HEM-7001-E, Birmingham, UK) and results recorded and stored safely.

7.7.6 Referral Form and Debriefing

As part of the study incentives, all participants with a positive diagnosis for hypertension and stroke were referred by study physician/specialist for further medical assistance at the health center selected for the study. Those that required treatment were treated free of charge. Any participant whose blood pressure is ≥140/90 for SBP and DBP according to the Joint National Committee on hypertension - JNC-7 (World Health Organization and International Society of Hypertension Writing Group 2003) received free hypertension drugs that will last for 2 weeks or those who are not confident of the study physician competency were referred (using a specially designed referral form to any of the two primary health centre where free drugs have been kept for the purpose. In any case, a 2 weeks dose of hypertensive drug treatment was given. Apart from lifestyle modification advice, patients also benefited from the study physician's drug treatment advice and health check-up. For participants with stroke diagnosis, appropriate stroke drugs were given while some were referred to their respective health centres for treatment and follow-up.

Most of the drugs procured for the exercise are approved drugs for use in primary care in Nigeria. I offered all participants immediate debriefing on what happens next to the measurements and completed questionnaires. Non-hypertensives or those who were not diagnosed with stroke were commended and briefly advice on preventive lifestyle for hypertension and stroke. However, those who were diagnosed with hypertension or stroke were either referred or consulted appropriately free of charge.

7.8 Data Management Procedure

7.8.1 Handling and Storage

After collecting the required information, I personally take back the forms and questionnaire for safe keeping. I also give direction on how to navigate around any issue that arose in the course of the data collection. I was responsible for the whole study preparation/planning through to completion. My responsibility was not limited to data collection and storage; they also included training of research assistants, purchases, scheduling meetings, book-keeping, and editing and data entry.

All the data collected from participants including the questionnaire, consent forms results were stored securely in my secure accommodation while in Nigeria. These were securely sent to the health science department (University of Warwick) storage room under the care of my primary supervisor within two weeks of completing the study. The questionnaire and the anthropometrical measurement outputs were matched using the assigned participant's unique identification number. These were stored in the University of Warwick computer. Access to the data was restricted to me and my supervisors. The storage time will be in line with the university policy (minimum of 10 years). I took extra care and made sure that the collection, storage, disclosure and use of the data complied with all legislation relating to data protection act and in line with the Warwick University data management directives and guidelines.

To ensure that there is no confidentiality breach, I made sure that the identity of all participants that consented to the study was anonymized using a unique participant's identification number (PIN). This number was made up of four letters and four natural numbers. The first two letters represented the first two alphabets of any of the two study communities or study areas where the study took place. These include; Ebubu (EB) or Usokun (US). The third and fourth letters represented the first two alphabets of any of the villages in each study communities. The last four natural numbers represented an individual serial number which fell within 001–1100 for each of the communities. For instance;

E	**B**	**E**	**J**	**0**	**1**	**2**	**2**

This study **PIN** means that the participant serial number **EBEJ0122** is from Ejama village in Ebubu community in Eleme local government area. Only participants who were diagnosed with hypertension or stroke have their first name written on the questionnaire to match them during the further assessment, consultation and referral. However, even with the first name, these individuals could not be traced or identified using their first name alone without their surnames and clan.

7.8.2 Data Entry and Cleaning

Each questionnaire was inspected at the end of each session with the participants. The visual inspection was carried out by the non-recording RAs or by me on each occasion. Quality check for missing data was undertaken by me each day. At the end of each study day before collation and storage, I counted, recorded and visually inspected the entire questionnaire. I also ticked and cross-check this in line with the unfilled questionnaire handed out before the start of the study. Satisfied that all questionnaires were accounted for, the RAs and I signed our names.

I developed a study result database in an SPSS version 21. This was transferred to STATA 14 using STATA Transfer software for analysis. All the study identification numbers coded appropriately were used to enter the participant's relevant data in the database. No participants name identifier was entered. All the data were manually processed. After the entry of each case, I checked the data to identify entry errors. Following that, a random check of entered data was carried out for further confirmation. Apart from visual inspection, I ran initial stat check to identify any vacant space or where non-recognisable data were entered. These were promptly corrected before saving the data in three separate locations to avoid data loss or corruption of the data due to malfunctioning of the system.

7.9 Data Analysis

7.9.1 Descriptive Statistics

I used descriptive statistics to describe and summarise the data collected. This enabled me to present the data in a more meaningful way, which makes interpretation of the data very simple to understand. I did this using the measure of central tendency and variability which gives the overall description of the study population. I also used it estimate the prevalence of hypertension and stroke and to present the participants' sociodemographic, lifestyle, anthropometric and other factors in the study areas. The values were expressed as an absolute number with percentages and mean with standard deviation for categorical and continuous variables respectively.

7.9.2 Inferential Analysis

In the inferential analysis, I performed several analyses to enable me to estimate some study parameter(s) and to test important study hypotheses. I used the Chi-square test to compare the prevalence of hypertension and stroke in both polluted and non-polluted areas in line with my study hypothesis. I also used the chi-square test to examine the statistically significant difference in the prevalence of hypertension and stroke within categorical variables such as age group, gender, physical activity level, BMI, education levels and other categories used in the data collected.

I also performed both univariate and multivariate logistic regression to examine the associations between participants' socio-demographic and clinical characteristics with the risk of hypertension. Specifically, in multivariate analysis, I used multiple logistic regression analysis to investigate any association between the dependent variables (Hypertension) and polluted areas while adjusting for possible confounding factors such as age, sex, BMI, waist circumference, smoking and alcohol consumption. I considered variables for inclusion in the final multivariate model if they reached a moderate level of significance ($P < 0.25$) or from the conceptual framework underlined in previous studies (Mickey and Greenland 1987).

It is possible that the socioeconomic and demographic variables may alter not only an individual's overall predisposition towards hypertension but also the association between living in polluted area and risk of developing hypertension. For instance, the strength of the relationship between living in the polluted area and the likelihood of developing hypertension may be different for men and women. To explore this possibility, I added interaction terms between living in the polluted area and each of the determinants to the multivariate model.

7.9.3 Sensitivity and Model-Fit Analysis

How well a statistical model fits my data is important in making a correct conclusion about the study findings. Hence a measure of goodness-of-fit typically summarises any observed discrepancy between my observed and expected values. In addition, I took steps to reduce uncertainties and increase the robustness of my result through simple but understandable statistical approaches. Therefore, I used several regression diagnostics to assess the goodness-of-fit, predictive power and to choose the parsimonious model used in the analysis. These analyses include are described in the sub-sections below.

7.9.3.1 Receiver Operating Characteristics Analysis

I assessed the sensitivity and specificity of the model by conducting the receiver operating characteristic (ROC) curves which show the trade-off between sensitivity and specificity. Specifically, a ROC curve (c-statistics) analysis was used to determine the predictive powers of the final multivariate model. The receiver operating characteristic curve plots the sensitivity of the model against 1 minus specificity for different cut-off points of the predicted probability of having hypertension. The greater the area under the receiver operating characteristic curve (upper limit = 1), the better the model is at discriminating between hypertension cases.

7.9.3.2 Hosmer–Lemeshow Goodness-Of-Fit Test

I used this test to assess the goodness of fit for the logistic regression model. I used it to assess whether or not the observed event rates (risk of hypertension) match expected event rates in subgroups (that is in the polluted and non-polluted communities) of the model population.

7.9.3.3 Tolerance Test and Variance Inflation Factor

I assessed multicollinearity between the variables under consideration by examining tolerance (the variable's tolerance denoted by 1-R2) and the Variance Inflation Factor (VIF). A small tolerance value indicates that the variables under consideration are a perfect linear combination of the independent variables (socioeconomic and lifestyle and other variables).

The VIF (1/Tolerance) is always greater than or equal to 1. The Values of VIF that exceed 10 are an indication of multicollinearity.

7.9.3.4 Link Test

I conducted a link test analysis to check for the accuracy of the regression. The test is commonly used to check for model specification error. It will be noted that if the model is correctly specified, any additional variables will have little or no explanatory power.

7.10 Reporting Results of the Findings

I presented the results for the prevalence estimates as an absolute number with percentages and mean with SD for categorical and continuous variables, respectively. I also expressed result of the regression analysis as an odd ratio (ORs) with 95% confidence intervals (CIs). All statistical analyses were carried out using Stata version 14 for Windows (Stata Corp, College Station, TX). The significance tests were 2-tailed and statistical significance was defined at the alpha level of 0.05. The study is reported following the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement (Vandenbroucke, Von Elm et al. 2007).

Summary

This chapter presented a detailed study method and methodological issues arising before, during and after study data collection from participants. The chapter concluded with the description of data analysis procedures employed to generate the study results. In the next chapter, I will present the results of the study for both hypertension and stroke using the statistical approaches described in the study methods.

SECTION FOUR

- **RESULT: (HYPERTENSION & STROKE)**

CHAPTER EIGHT

8.0 STUDY RESULT: HYPERTENSION

INTRODUCTION

This chapter presents the result of study findings with respect to hypertension prevalence in the study communities. These results are derived from analyses of the participants' data collected during the fieldwork. The results provide details of all relevant statistical analysis including descriptive, inferential and model diagnostics. The chapter will first present the response rates for both individual participants and the households during the data collection exercise; this is followed by the participant's general characteristics including sociodemographic, lifestyle and hypertension prevalence estimates.

8.1 Study Response Rates

The household and participants' response rates for the study are shown in table 12. A total of 700 households were randomly selected from 40 sampling units. 450 of these were in the polluted and 250 were in the non-polluted communities. In these households, 590 were found to be occupied at the time of the visits by myself and other fieldworkers. Among the occupied households, only 582 were screened successfully, yielding a household response rate of 98.62% for both polluted (98.68%) and non-polluted (98.57%) communities, while a response rates in terms of randomly selected households were 83.14% for the two areas (83.33% for polluted vs 82.80% for non-polluted). In the screened households, a total of 1552 randomly selected participants aged 18-80 were identified as eligible for participation. All the participants except 8 consented to the study leading to 99.49% participant's response rate. Of those that declined to participate, two were afraid to be diagnosed with hypertension while the rest did not want to participate because of time and other personal commitments. Due to security challenges and high requirement for logistics, we are unable to reschedule revisits to make up the estimated sample size. Hence I included convenient sample of 476 selected from non-random participants who turned up at designated locations such as town halls, village squares and primary health centres. 185 of these participants were from oil-polluted while 291 of their counterparts were from the non-polluted community.

Table 12: Household and Participants' Response Rates for the Study

Notations	Study communities		Total
	Polluted	**Non-polluted**	
Eligible Households			
Households randomly selected	450	250	700
Household occupied	380	210	590
Household screened successfully	375	207	582
Response Rate (%)	98.68	98.57	98.62
Eligible Participants (18-80 Years)			
Randomly selected participants (Total)	854	706	1560
Randomly selected participants (Screened)	851	701	1552
Response Rate (%)	99.65	99.29	99.49
Non-randomly selected participants	185	291	476
Total	**1036**	**992**	**2028**

8.2 Study Participants' Characteristics

The results of the descriptive analyses of participants data for the 2 communities are shown in table 13. About half of the study participants were from the oil-producing communities with a greater percentage of women (60.0%). The overall participants' mean age was 44.32 (SD: 14.0), this differed between the polluted and non-polluted areas (44.72 vs. 43.93) albeit non-significantly, P = 0.09. In general, the proportion of participants in each age group increases with increasing age with the highest rate between 35-44 years (24.16%) before declining to the lowest among those 75 years and over (1.28%), reflecting the comparatively young adult age structure of the study population in the study communities in particular and Niger Delta and Nigeria in general which is partly as a result of high fertility and low life expectancy.

I noted that there are no significant differences in terms of educational attainments between the two communities. Most of the participants had secondary or higher education and spent at least 12 years in formal education (61.8%). The percentage of those currently working (81.7%) are generally high, and are significantly higher (P <0.005) in the polluted community (84.07%) compared to the non-polluted community (79.32%). The mean annual earnings of participants from the polluted community were significantly higher than those from the non-polluted area ($1.92K vs $1.3K, P=0.001). In particular, the percentage of participants earning ₦250k (in Nigeria currency, Naira) and over was about 2-fold higher in the polluted community than their counterparts, while those within ₦151-250k bracket were evenly distributed in the two communities. I found a significant difference in participants' BMI. For example, more than half of the participants were either overweight or obese (55.08%) and were mostly from the polluted area (62.26%), P=0.001. This is in contrast to 43.20 % of those with normal weight of which about 50.60% of them are from the non-polluted community.

I also found a high prevalence of unhealthy lifestyle factors in the two communities. A significantly higher percentage of participants in the non-polluted compared to polluted area reported moderate-to-high salt (74.90% vs. 46.81%), physical activity (67.34% vs. 63.42) and fat intake (59.78% vs. 44.21), (P =0.001). Others include moderate-to- heavy drinker (37.20 vs. 19.69%) and ever smokers (22.98% vs. 10.71), (P=0.001). There was also a higher preponderance of those reporting moderate-to-severe sleep deprivation among participants in polluted community compared to their counterparts in non-polluted area (27.99% vs. 12.92%), P=0.001. Although not reported due to their non-significant number, we also found small cases of malaria (9), cough (10) and asthma (5) among the study participants.

Table 13: Characteristics of the Study Population by Oil Pollution Status

Variable	Total (n=2028)	Polluted area (n=1036)	Non-polluted area (n=992)	P-value[a]
Mean age (SD)	44.3 (14.0)	44.72 (13.3)	43.93 (14.7)	0.09
Age group, n (%)				
18-24	146(7.20)	77(7.43)	69 (6.96)	
25-34	423(20.86)	177(17.08)	246(24.80)	
35-44	490(24.16)	252(24.32)	238(23.99)	
45-54	453(22.34)	272(26.3)	181(18.3)	
55-64	303(14.94)	175(16.9)	128(13)	
65-74	187(9.22)	77(7.4)	110(11.1)	
≥75	26(1.28)	6(0.6)	20 (2.0)	0.001
Gender, n (%)				
Male	871 (43.0)	417(40.0)	454 (46.0)	
Female	1157 (57.0)	619(60.0)	538(54.0)	0.001
Marital Status, n (%)				
Never married	544 (26.8)	235(22.7)	309(31.2)	
Ever married	1483 (73.2)	800(77.3)	683(68.9)	0.001
Education attainment, n (%)				
No education (<6 years)	362 (17.85)	221(21.33)	141(14.21)	
Primary (6-11 years)	411 (20.27)	178(17.18)	233(23.49)	
Secondary/higher (≥ 12 Years)	1255 (61.88)	637(61.49)	618(62.30)	0.001
Employment status, n (%)				
Unemployed	371 (18.29)	165(15.93)	206(20.77)	
Presently working	1657 (81.71)	871(84.07)	786(79.32)	0.005
Annual Income*, n (%)				
Less than ₦100000	222 (10.97)	108(10.43)	114(11.54)	
₦101000-₦150000	592(29.26)	242(23.38)	350(35.43)	
₦151000-₦250000	635 (31.39)	319(30.82)	316(31.98)	
₦251000 and over	574 (28.37)	336(35.36)	208(21.05)	0.001
Body Mass Index, n (%)				
Underweight	35 (1.73)	17(1.64)	18(1.81)	
Normal	876 (43.20)	374(36.10)	502(50.60)	
Overweight	786(38.76)	429(41.41)	357(35.99)	
Obese	331(16.32)	216(20.85)	115(11.59)	0.001
Weight-Hip-Ratio, n (%)				
Normal	682(33.63)	348(33.59)	334(33.67)	
Overweight	720(35.50)	324(31.27)	396(39.92)	
Obese	626(30.87)	364(35.14)	262(26.41)	0.001
Family history of HTN[d], n (%)				
No	1724(85.01)	847(81.76)	877(88.41)	

Yes	304(14.99)	189(18.24)	115(11.59)	0.001
Hypertension awareness, n (%)				
Low	1292(63.83)	724(70.16)	568(57.26)	
Moderate	483(23.86)	231(22.38)	252(25.40)	
High	249(12.30)	77(7.46)	172(17.34)	0.001
Smoking status, n (%)				
Non-smoker	1689 (83.28)	925(89.29)	764(77.02)	
Ever smoker	339 (16.72)	111(10.71)	228(22.98)	0.001
Drinking status, n (%)				
Non-drinker	799 (39.40)	523(50.48)	276(27.82)	
Mild drinker	656 (32.35)	309(29.83)	347(34.98)	
Moderate-to-heavy drinker	573 (28.25)	204(19.69)	369(37.20)	0.001
Sleep deprivation, n (%)				
No	1326 (65.42)	564(54.44)	762(76.89)	
Mild	283 (13.96)	182(17.57)	101(10.19)	
Moderate-to-severe	418 (20.62)	290(27.99)	128(12.92)	0.001
Physical activity, n (%)				
Sedentary	79 (3.90)	33(3.19)	46(4.64)	
Low intensity	624 (30.77)	346(33.40)	278(28.02)	
Moderate-to-high intensity	1325 (65.34)	657(63.42)	668(67.34)	0.001
Salt intake, n (%)				
Low	800 (39.45)	551(53.19)	249(25.10)	
Moderate-to-high	1228 (60.55)	485(46.81)	743(74.90)	0.001
Fat intake, n (%)				
Low	977 (48.18)	578(55.79)	399(40.22)	
Moderate-to-high	1051 (51.82)	458(44.21)	593(59.78)	0.001

Data are expressed as mean (standard deviation) or as percentages.
[a]P values for comparison between polluted and non-polluted areas.
[b]Defined as blood pressure ≥ 140/90 mmHg or on antihypertensive medication.
[c]Currency conversion: $1=₦162.55 (June 2, 2014)
[d]HTN- Hypertension

8.3 Prevalence of Hypertension

The prevalence of hypertension by study characteristics are presented in table 14. The result showed that a total of 758 participants out of the 2028 participants were hypertensives. This represents more than one-third of participants that were hypertensive (37.38%) in the two study areas. I found a significantly higher prevalence of hypertension among participants in the polluted community (43.34%) compared to those in the non-polluted community (31.15%), $P < 0.01$.

There is no gender difference for both hypertensives and normotensives. However, statically significant differences were observed within participant's age groups, education attainments, occupational and marital status. There was a significantly and graded increase in the prevalence of hypertension across age groups. For instance, participants aged 18-24 years had the lowest prevalence of hypertension (2.74%) and those aged 75 years and over had the had the highest prevalence of hypertension (88.46%) while the middle age group (44-54) had the prevalence of 49.01%.

With regards to socioeconomic indicators, table 14 showed that the prevalence of hypertension was highest among ever married participants (46.59%). These were made up of widows, currently married and those that were previously married but either divorced or separated. The prevalence of hypertension was significantly higher among those with no education or who spent less than 6 years in formal education (53.59%) compared to their counterparts that spent between 6-11 years (38.93%). In addition, participants with secondary level or higher education who spent 12 years and above recorded the least proportion of hypertension (32.19%), P=0.001 in the study areas. In terms of employment status, participants who were currently working had the highest proportion of hypertension compared to their counterparts who were unemployed (41.40 vs. 19.41), P=<0.001. I found a linear relationship between hypertension and participants' annual income. There was a significant and corresponding increase in the prevalence of hypertension as participant's annual income increases. Specifically, participants that earned ₦100K or less a year had a 22.07% prevalence of hypertension compared to those that earned ₦251k and over (45.12%), P=0.001

The prevalence of hypertension in the study population increases significantly with body fat distribution or adiposity using anthropometric indicators of body mass index and waist-hip-ratio.

The highest proportion of hypertensives were found among study participants categorised as obese and overweight compared to those with normal weight or underweight, P=0.001

Ever smokers (46.90%), moderate-to-heavy drinkers (50.44%), those with severe sleep deprivation which was less than 5 hours of undisturbed sleep (75.12%), physical inactivity or sedentary lifestyle (70.89%), moderate-to- high salty (41.04%) or fatty food (41.29%) and those with family history of hypertension (61.18%) recorded a significantly higher proportion of hypertension compared to their counterparts, P=0.001

Table 14: Hypertension prevalence by Study Characteristics

Variables	Total (N=2028)	Hypertensive (n=758)	Normotensive (n=1270)	P value
Oil Pollution status, n (%)				
Non-polluted	992(48.92)	309(31.15)	683(68.85)	
Polluted	1036(51.08)	449(43.34)	587(56.66)	0.001
Gender, n (%)				
Male	871(42.95)	319(36.62)	552(63.38)	
Female	1157(57.05)	439(37.94)	718(62.06)	0.54
Age group, n (%)				
18-24	146(7.20)	4(2.74)	142(97.26)	
25-34	423(20.86)	47(11.11)	376(88.89)	
35-44	490(24.16)	141(28.78)	349(71.22)	
45-54	453(22.34)	222(49.01)	231(50.99)	
55-64	303(14.94)	200(66.01)	103(33.99)	
65-74	187(9.22)	121(64.71)	66(35.29)	
≥75	26(1.28)	23(88.46)	3(11.54)	0.001
Annual Income, n (%)				
Less than ₦100000	222 (10.97)	108(10.54)	114(11.54)	
₦101000-₦1150000	592(29.26)	242(23.38)	350(35.43)	
₦151000-₦250000	635 (31.39)	319(30.82)	316(31.98)	
₦251000 and over	574 (28.37)	336(35.36)	208(28.37)	0.001
Marital Status, n (%)				
Never Married	544(26.84)	67(12.32)	477(87.68)	
Ever Married	1483(73.16)	691 (46.59)	792 (53.41)	0.001
Education attainment (%)				
No education (< 6years)	362(17.85)	194(53.59)	168(46.41)	
Primary (6-11 years)	411(20.27)	160(38.93)	251(61.07)	
Secondary/Higher (≥12 years)	1255(61.88)	404(32.19)	851(67.81)	0.001
Occupational Status, n (%)				

Unemployed	371(18.29)	72(19.41)	299(80.59)	
Presently Working	1657(81.71)	686(41.40)	971(58.60)	0.001
Body mass Index, n (%)				
Underweight	35(1.75)	6(17.14)	29(82.86)	
Normal	876(43.20)	269(30.71)	607(69.29)	
Overweight	786(38.76)	304(38.68)	482(61.32)	
Obese	331(16.32)	179(54.08)	152(45.92)	0.001
Waist-Hip-Ratio, n (%)				
Normal	682(33.63)	230(33.72)	452(66.28)	
Overweight	720(35.50)	251(34.86)	469(65.14)	
Obese	626(30.87)	277(44.25)	349(55,75)	0.001
Smoking, n (%)				
Non smoker	1689(83.28)	599(35.46)	1090(64.54)	
Ever smoker	339(16.72)	159(46.90)	180(53.10)	
Drinking Status, n (%)				
Non drinkers	799(39.40)	289(36.17)	510(63.83)	
Low drinkers	656(32.35)	180(27.44)	476(72.56)	
Moderate-to- Heavy drinker	573(28.25)	289(50.44)	284(49.56)	0.001
Sleep deprivation, n (%)				
NO sleep (≥7 hours)	1326(65.42)	295(22.25)	1031(77.75)	
Mild (5-6.99 hours)	283(13.96)	149(52.65)	134(47.35)	
Severe (≤5 hours)	418(20.62)	314(75.12)	104(24.88)	0.001
Physical Activity, n (%)				
Sedentary	79(3.90)	56(70.89)	23(29.11)	
Low intensity	624(30.77)	314(54.65)	283(45.35)	
Moderate-to-high intensity	1325(65.34)	361(27.25)	964(72.75)	0.001
Salty Food, n (%)				
Low intake	800(39.45)	254(31.75)	546(68.25)	
Moderate -to- high	1228(60.55)	504(41.04)	724(58.96)	
Family history of HTN*, n (%)				
No	1724(85.01)	572(33.18)	1152 (66.82)	
Yes	304(14.99)	186(61.18)	118(38.82)	0.001
Awareness of HTN* n (%)				
Low	1292(63.83)	432(32.74)	869(67.26)	
Moderate-to-high	483(23.86)	217(44.93)	266(55.07)	
High	249(12.30)	116(46.59)	133(53.41)	0.001
Fatty food Intake, n (%)				
Low	977(48.18)	324(33.16)	653(66.84)	
Moderate-to-high	1051(51.82)	434(41.29)	617(58.71)	0.001

HTN- Hypertension*

8.4 Systolic and Diastolic Blood Pressure

The mean systolic and diastolic blood pressures by study participant's characteristics are shown in table 15 and 16. Mean values for both systolic and diastolic blood pressure measurements for the study participants in the polluted areas were 134.03 mmHg and 80.53 mmHg respectively. This was significantly different from the non-polluted areas with values of 128.46 mmHg and 78.35 mmHg, P=0.001. Stratified analysis for polluted residents showed a significant difference across age groups and an increasing trend with increasing age ($p<0.001$).

Men residing in polluted areas had a statistically significant higher systolic BP than their females counterparts and by extension than those residing in the non-polluted areas (P=0.001). Similarly, the mean systolic and diastolic blood pressure of participants with no formal education and those within primary education were significantly higher in polluted areas compared to their counterparts in non-polluted areas (P=0.001). The same applies to obese and overweight participants, those who were currently working, those with a history of hypertension, and those with moderate awareness of hypertension (P=0.001).

From the histograms created, I found that the distributions are roughly symmetric and mound-shaped. However, systolic blood pressure for participants in the polluted areas skewed slightly to the right compared to those in the non-polluted areas which favoured skewness to the left to a lesser degree. The median participants' systolic BP in the two study areas were 127mmHg, this varies from 130mmHg among participants in the polluted area compared to 125mmHg among their counterparts in the non-polluted area. Similarly, the overall diastolic BP was 78mmHG. I also found that participant's living in the polluted area had a median diastolic BP of 80mmHg compared to 77mmHg among those in the non-polluted area. Since my samples size is adequate, I may proceed under the assumption that systolic blood pressures for exposed and non-exposed participants are approximately normally distributed. This assumption may also be true with diastolic blood pressure (Figure 44 and 45).

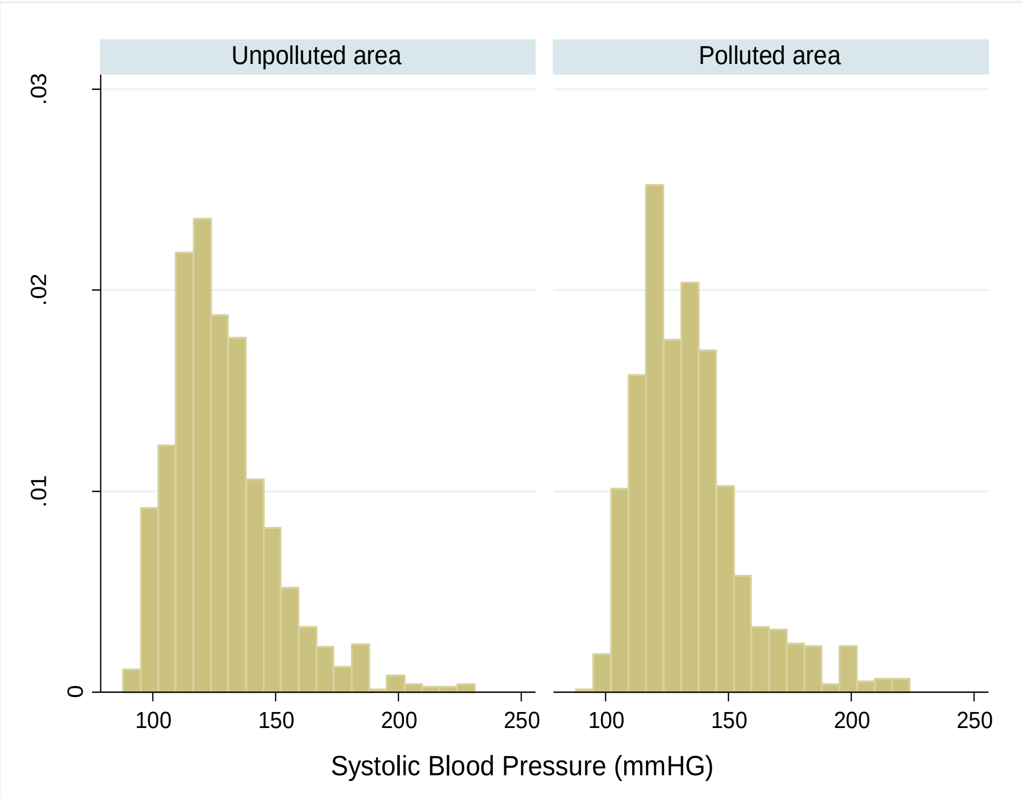


Figure 46: Comparison of Systolic Blood Pressure by Pollution Status

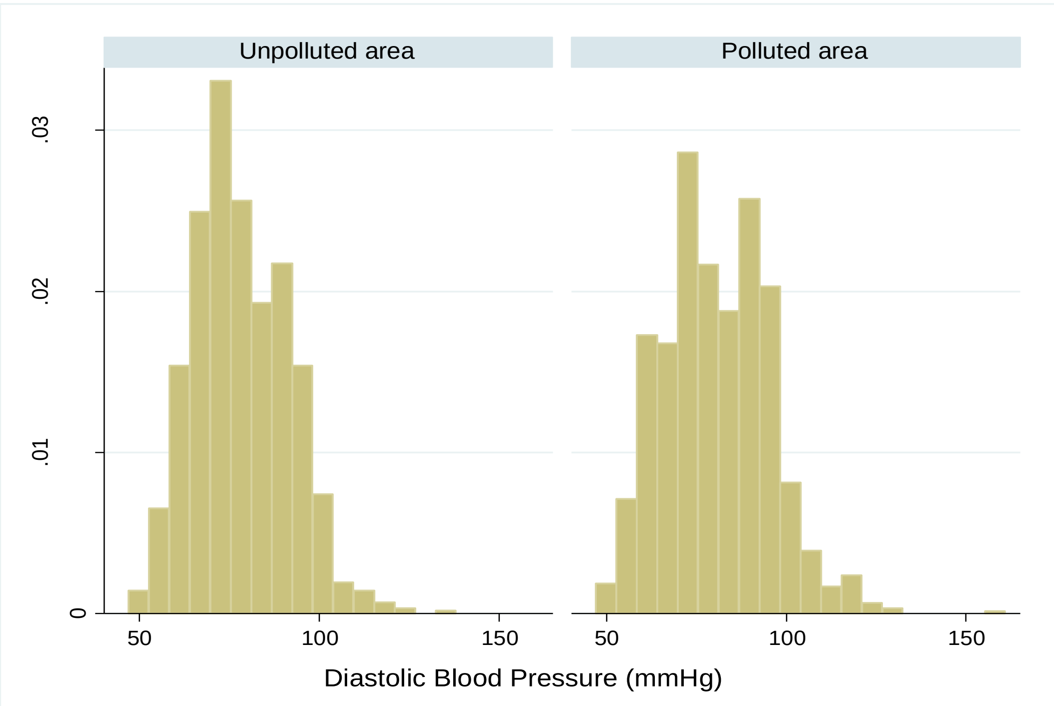


Figure 47: Comparison of Diastolic Blood Pressure by Pollution Status

Table 15: Mean Systolic Blood Pressure of the Study Population by Oil Pollution Status

Variables	Polluted			Non-polluted			
	N	Mean systolic	Standard deviation	N	Mean systolic	Standard deviation	P value
Systolic BP	1036	134.03	22.23	992	128.47	21.75	0.001
Age groups							
18-24	77	116.88	12.58	69	112.47	8.91	0.009
25-34	177	122.12	13.19	246	117.94	14.28	0.001
35-44	252	130.94	19.98	238	123.46	15.92	0.001
45-54	272	139.50	21.70	181	135.92	23.01	0.047
55-64	175	144.69	23.61	128	139.61	22.22	0.030
65-74	77	144.40	26.99	110	142.29	23.12	0.28
+75	6	143.58	17.77	20	157.61	33.92	0.83
Gender							
Male	417	134.35	21.17	454	129.60	21.17	0.001
Female	619	133.82	22.74	538	127.51	22.19	0.001
Marital Status							
Never Married	235	122.71	16.79	309	119.12	16.32	0.006
Ever Married	800	137.38	22.53	683	132.69	22.57	0.001
Education attainment							
No education (< 6years)	221	138.15	22.87	141	139.45	26.58	0.68
Primary (6-11 years)	178	138.87	23.71	233	128.56	21.43	0.001
Secondary/Higher (≥12 years)	637	131.25	21.13	618	125.92	19.81	0.001
Occupational status							
Unemployed	165	126.67	21.64	206	119.31	17.28	0.002
Presently Working	871	135.42	22.07	786	130.87	22.17	0.001
Annual Income							
Less than #100000	108	127.80	22.81	114	121.40	18.31	0.010
#101000-#149000	242	135.28	21.81	350	129.14	20.07	0.001
#150000-#250000	319	133.57	22.29	316	127.41	22.57	0.001
#251000 and over	366	135.46	22.06	208	133.17	23.78	0.124
Body Mass Index							
Underweight	17	115.41	8.27	18	121.36	20.32	0.87

Normal	374	130.61	20.85	502	126.4	21.01	0.002
Overweight	429	134.15	21.69	357	129.20	21.51	0.001
Obese	216	141.18	24.16	115	136.12	24.06	0.035
Waist Hip Ratio							
Normal	348	132.91	21.40	334	125.18	19.50	0.001
Overweight	324	133.80	23.35	396	128.32	21.81	0.001
Obese	354	135.31	21.97	262	132.88	23.60	0.009
Family History of HTN							
No	847	132.87	22.09	877	127.25	20.91	0.001
Yes	189	139.23	22.16	115	137.71	25.56	0.029
Hypertension Awareness							
Low	724	132.69	21.76	568	127.24	20/09	0.001
Moderate	231	136.90	23.30	252	128.56	22.29	0.001
High	77	137.56	22.14	172	132.39	25.55	0.063

Table 16: Mean Diastolic Blood Pressure of Study Participants by Oil Pollution Status

Variables	Polluted			Non-polluted			P-value
	N	Mean diastolic	Standard deviation	N	Mean diastolic	Standard deviation	
Diastolic BP	1036	80.53	14.85	992	78.35	13.05	0.001
Age							
18-24	77	68.08	10.61	69	67.48	8.20	0.35
25-34	177	73.21	12.66	246	72.69	9.72	0.31
35-44	252	79.17	14.01	235	75.60	10.69	0.001
45-54	272	83.28	13.43	181	81.86	13.03	0.032
55-64	175	87.49	13.58	128	85.72	12.42	0.123
65-74	77	85.32	17.22	110	87.43	13.95	0.821
+75	6	81.0	17.77	20	89.35	14.78	0.871
Gender							
Male	417	80.09	14.80	454	78.55	12.69	0.050
Female	619	80.83	14.90	538	78.18	13.36	0.001
Marital Status							
Never Married	235	71.50	12.82	309	72.33	11.13	0.79

Ever Married	800	83.20	14.37	683	81.07	12.95	0.001
Education attainment							
No education (< 6years)	221	82.88	14.99	141	84.60	13.99	0.86
Primary (6-11 years)	178	82.89	15.56	233	78.61	13.37	0.001
Secondary/Higher (≥12 years)	637	79.96	14.44	618	76.82	12.28	0.001
Occupational Status							
Unemployed	165	74.35	14.40	206	73.43	12.06	0.25
Presently Working	871	81.71	14.66	786	79.63	13.01	0.001
Annual Income							
Less than #100000	108	73.94	14.52	114	73.04	12.37	0.309
#101000-#149000	242	81.43	15.62	350	78.87	12.37	0.013
#150000-#250000	319	80.41	14.38	316	77.83	13.60	0.010
#251000 and over	366	81.98	14.38	208	81.41	12.74	0.318
Body Mass Index							
Underweight	17	72.32	10.28	18	74.69	13.63	0.71
Normal	374	78.17	15.01	502	77.09	13.18	0.128
Overweight	429	80.25	14.37	357	79.15	12.50	0.129
Obese	216	85.85	14.45	115	81.95	13.31	0.001
Waist- Hip-Ratio							
Normal	348	80.42	14.69	334	76.34	12.72	0.001
Overweight	324	79.40	15.25	396	78.52	12.58	0.198
Obese	364	81.65	14.61	262	80.66	13.80	0.193
Family History of HTN							
No	847	79.83	14.94	877	77.62	12.60	0.001
Yes	189	83.68	14.07	115	83.95	15.04	0.56
Hypertension Awareness							
Low	724	79.56	15.17	568	77.93	12.41	0.019
Moderate	231	83.31	14.33	252	78.58	13.63	0.001
High	77	81.0	12.22	172	79.39	14.20	0.194

8.5 Measure of Adiposity in the Study Participants

The physical characteristics of all the participants for this study (*n* = 2028) which includes those residing in the oil-polluted areas and those residing in the non-polluted areas at the time of the survey in 2014 were shown in table 17. Overall, the study participants mean weight and height were 67.16±11.24kg and 161.03±6.85cm respectively. All the anthropometric measures for all the participants were significantly higher among those in the polluted areas compared to their counterparts. Specifically, mean BMI for all the participants in the polluted area showed that they were overweight with a measure of 26.52 (95% CI, 26.27-26.78). However, their counterparts in the non-polluted areas have normal weight 25.23 (95% CI, 24.98-25.46).

Table 17: Anthropometric Characteristics of the study participants, by oil pollution status

Variables	Polluted			Non-polluted			
	Mean	Standard deviation	95% CI	Mean	Standard deviation	95% CI	P-value
Height	161.90	6.27	161.52-162.28	160.13	7.30	159.68-160.59	0.001
Weight	69.54	11.44	68.84-70.23	64.69	10.48	64.04-65.34	0.001
WC	78.17	12.18	77.42-78.91	75.87	10.83	75.19-76.54	0.001
Hip	87.60	13.97	86.74-88.45	85.61	11.92	84.87-86.35	0.001
BMI	26.52	4.19	26.27-26.78	25.23	3.78	24.98-25.46	0.001
WHR	0.90	0.14	0.90-091	0.89	0.13	0.88-0.90	0.066

The mean values of WC were 77.04±11.60cm for the overall sample, however, residents of polluted areas had a wider WC (78.17±12.18 cm) compared to those in non-polluted areas (75.87±10.83cm) $p < 0.001$. In addition, the mean hip circumference was 86.62±13.04cm. This gives the mean WHR of 0.90±0.14 for the whole participants. Figures 46-48 showed various degree of skewness in the histogram outputs and suggested approximately normal distributions for measures of obesity among participants in the two areas.

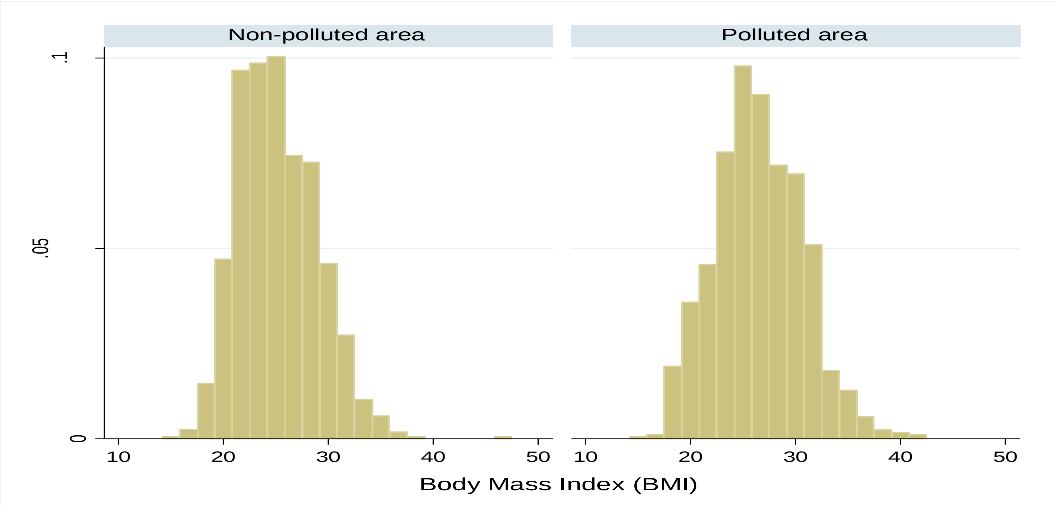


Figure 48: Comparison of Participants Body Mass Index by Pollution Status

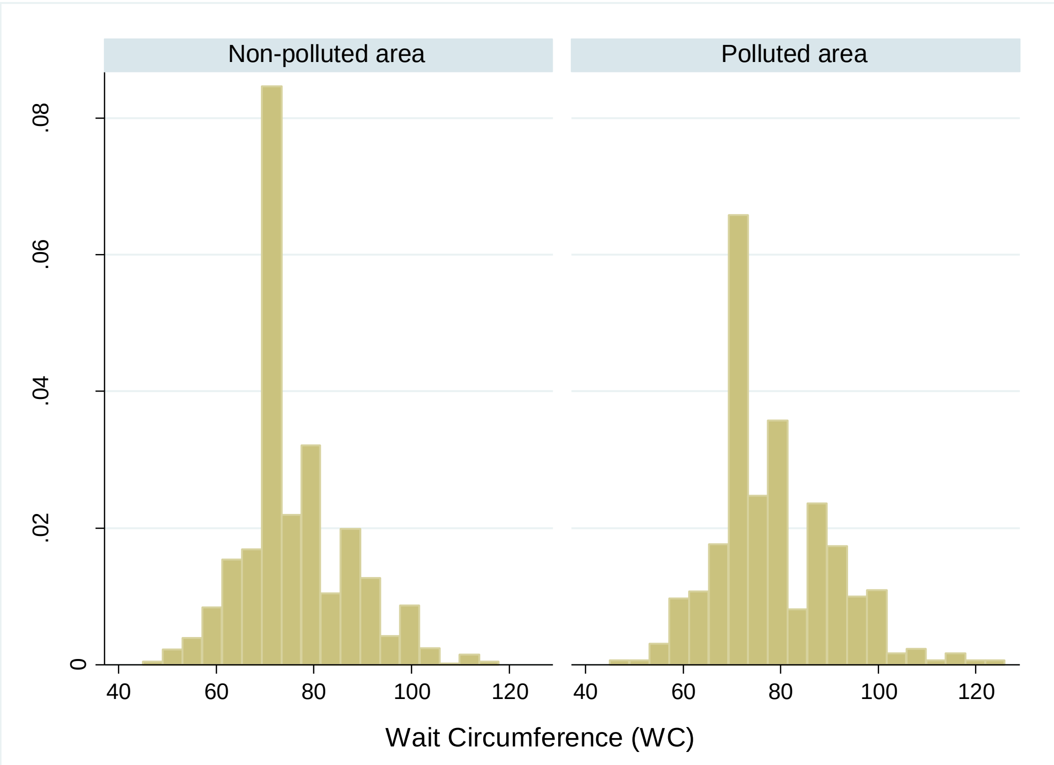


Figure 49: Comparison of Participants Waist Circumference by Pollution Status

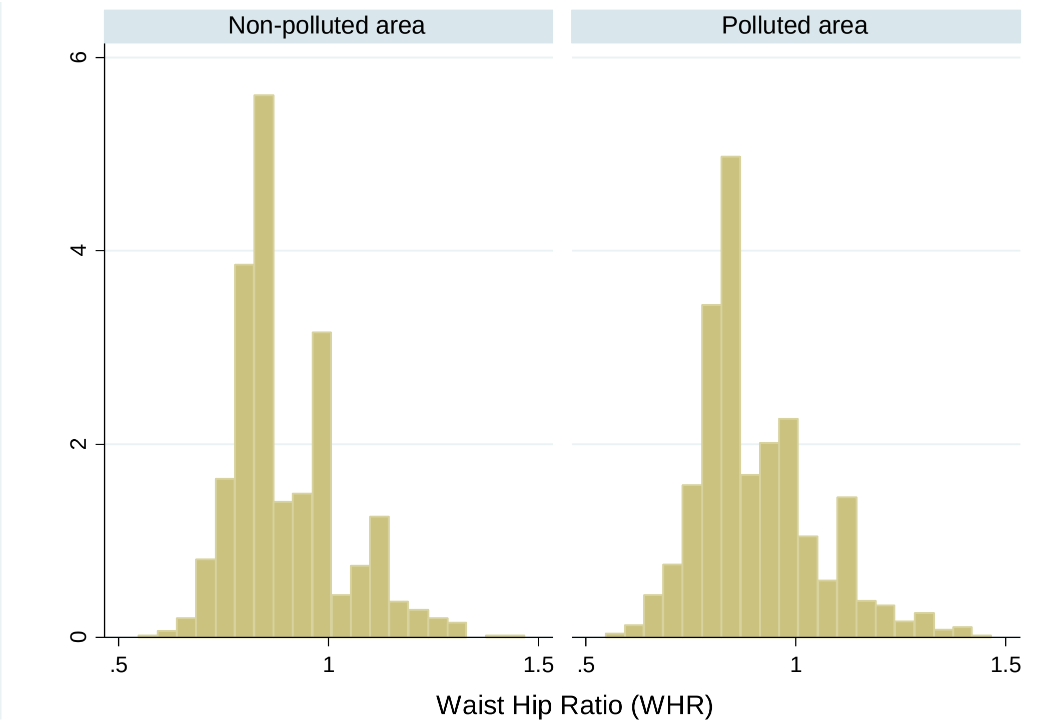


Figure 50: Comparison of Participants Waist-Hip-Ratio by Pollution Status

8.6 Univariate and Multivariate Logistic Regression Analyses

The results of univariate and multivariate logistics regression models are presented in table 18. In the univariate analysis, with the exception of the sex of the study participants, all the variables including pollution status were statistically significantly associated with hypertension. Specifically, the odds of hypertension was significantly higher among participants residing in polluted areas compared to their counterparts in non-polluted areas (OR = 1.69, 95% CI 1.41- 2.03), P= 0.001. It can also be observed that the odds of developing hypertension increased significantly with every 10 years of age among the study participants (OR=2.11, 95% CI, 1.36-3.27). In addition, the odds were highest among those aged 55-64, 65-74 and 75 and above with corresponding ORs 2.02, 1.91 and 7.97 respectively compared to those aged 45-54, P=0.001.

The odds of hypertension among participants with adiposity was also investigated using WHRs with different standard cut-offs for male and female participants. The result showed that the odd was significantly higher among obese participants (OR = 1.56 95% CI 1.24-1.95). With respect to lifestyle factors for hypertension, smoking (OR = 1.61 95% CI 1.27-2.03), moderate-to-high

Table 18: Unadjusted and Adjusted Odd Ratio of Hypertension for Selected Risk Factors

Variables	Unadjusted model		Adjusted model	
	Odds ratio (95% CI)	**p-value**	**Odds ratio (95% CI)**	**p-value**
Oil Pollution status				
Non-Polluted	1(reference		1(reference	
Polluted	1.69 (1.41-2.03)	0.001	4.85 (1.84–12.82)	0.001
Age Group				
18-24	0.073(0.01-0.08)	0.001	0.79(0.16-3.80)	0.077
25-34	0.13(0.09-0.19)	0.001	0.03(0.43-2.47)	0.943
35-44	0.42(0.32-0.55)	0.001	0.94(0.56-1.56)	0.816
45-54	1(reference)		1 (reference)	
55-64	2.02(1.50-2.73)	0.001	1.98(1.39-2.81)	0.001
65-74	1.91(1.34-2.71)	0.001	1.48(0.14-0.91)	0.066
≥75	7.98(2.36-26.94)	0.001	4.93(1.29-18.87)	0.020
Age (per 10 years increase)	2.11 (1.36-3.27)	0.001	2.08 (1.77 to 2.43)	0.01
Gender				
Female	1.06 (0.88-1.27)	0.544	**Not included**	
Male				
Family history of Hypertension				
No	1 (reference)		1 (reference)	
Yes	3.17 (2.46-4.08)	0.001	2.14 (1.75-3.32)	0.001
Marital status				
Never married	1 (reference)		1 (reference)	
Ever married	6.21 (4.72 - 8.18)	0.001	1.62 (1.12-2.35)	0.027
Education attainment				
No education (< 6 Years)	2.43 (1.92 - 3.09)	0.001	1.34 (0.82-0.96)	0.002

Primary (6-11 Years)	1.34 (1.06-1.69)	0.012	0.90 (0.67-1.23)	0.52
Secondary/Higher (≥ 12 Years)	1 (reference)		1 (reference)	
Employment status				
Unemployed	1			
Presently Working	2.93 (2.23-3.86)	0.001	1.43 (0.95-2.15)	0.09
Annual Income				
Less than ₦100000	1			
₦101000- ₦149000	1.02(1.49-3.05)	0.001	1.04(0.63-1.72)	0.851
₦150000- ₦250000	1.96(1.38-2.81)	0.001	1.08(0.66-1.77)	0.757
₦251000 and over	2.90(2.03-4.15)	0.001	1.03(0.62-1.72)	0.903
Body Mass Index				
Underweight	0.47 (0.19-1.14)	0.09	0.65 (0.22 -1.89)	0.43
Normal	1 (reference)		1 (reference)	
Overweight	1.42 (1.16-1.74)	0.001	1.33 (1.04 -1.69)	0.002
Obese	2.66(2.05-3.44)	0.001	1.49(1.06-2.11)	0.022
Waist-Hip-Ratio				
Normal	1 (reference)		1 (reference)	
Overweight	1.05(0.84-1.31)	0.654	1.04(0.78-1.39)	0.807
Obese	1.56(1.24-1.95)	0.001	1.14(0.84-1.58)	0.393
Smoking status				
Non-smoker	1 (reference)		1 (reference)	
Ever smoker	1.61 (1.27-2.03)	0.001	1.28 (0.92-1.77)	0.14
Drinking status				
Non-drinker	1 (reference)		1 (reference)	
Mild drinker	0.67 (0.53-0.83)	0.001	0.76 (0.57-1.02)	0.06
Moderate-to-heavy drinker	1.80 (1.44-2.23)	0.001	1.63 (1.19-2.23)	0.02
Sleep deprivation				
No	1 (reference)		1 (reference)	
Mild	3.89 (2.98-5.07)	0.001	1.97 (1.44-2.68)	0.001

Moderate-to-severe	10.55 (8.16-.64)	0.001	4.27 (3.14-5.81)	0.001
Physical activity				
Sedentary	6.50 (3.94-0.72)	0.001	3.09 (1.66-5.76)	0.001
Low intensity	3.21 (2.64-3.92)	0.001	2.81 (2.20 - 3.60)	0.001
Moderate-to-high intensity	1 (reference)		1 (reference)	
Salty food intake				
Low salty food intake	1 (reference)		1 (reference)	
Moderate-to-high salt intake	1.50 (1.24-1.80)	0.001	1.10 (0.84-1.43)	0.50
Fatty food intake				
Low fatty food	1 (reference)		1 (reference)	
Moderate-to-high fat	1.42 (1.18-1.70)	0.001	1.39 (1.08-1.78)	0.001
Hypertension awareness				
Low	1 (reference)		1 (reference)	
Moderate	1.68(1.35-2.08)	0.001	1.92(1.43-2.58)	0.001
High	1.79(1.36-2.36)	0.001	2.03(1.36-3.04)	0.001

drinker (OR=1.80, 95% CI, 1.44-2.23), moderate-to-high salt intake (OR = 1.50 95% CI, 1.24-1.80), moderate-to-high fatty food intake (OR = 1.42, 95% CI, 1.18-1.70), high awareness (OR= 1.79, 95% CI, 1.36-2.36) and family history of hypertension in a first-degree relative (OR=3.17, 95% CI, 2.46-4.08), showed statistically significant increase in the odds of hypertension, P=0.001

In the multivariate model, polluted environment remains significantly associated with hypertension (adjusted odds ratio [aOR] = 1.53, 95% CI 1.16-2.01), *P*=0.002 even after adjusted for other factors independently associated with the risk of hypertension including participant's age, family history of hypertension, body mass index, drinking status, sleep deprivation, level of physical activity and fat intake (Table 18). Participants with no education (aOR=1.34, 95% CI, 0.82-0.96), those that were ever married (aOR=1.56, 95% CI, 1.05-2.31) had increased odds of hypertension. Compared with participants with normal weight, overweight (aOR = 1.33, 95% CI

1.04 to 1.69) and obese (aOR = 1.49, 95% CI 1.06-2.11) participants were more likely to be hypertensive. Moderate-to-heavy consumption of alcohol (aOR = 1.63, 95% CI 1.19 to 2.23), moderate-to-severe sleep deprivation (aOR = 4.27, 95% CI 3.14 to 5.81), sedentary behaviour (aOR = 3.09, 95% CI 1.66 to 5.76), moderate-to-high fat intake (aOR = 1.39, 95% CI 1.08 to 1.78) were statistically significantly associated with increased risk of hypertension.

8.7 Interaction between Oil Pollution and various Covariates

The interaction between oil pollution and selected covariates (participant's sociodemographic characteristics and body weight) is shown in table 19. All participant's sociodemographic characteristics (interaction terms) except for age, body fat and education attainment were not statistically significant. The table showed that age and education attainment modifies the association between pollution status and risk of hypertension. Hence, the odds of hypertension was significantly higher among younger adults (less than 60 years) participants residing in polluted areas compared to their older counterparts (OR = 0.78, 95% CI, 0.64-0.95), P= 0.001. The predicted probability of hypertension (Figure 49) was significantly higher for participants from the polluted community than those from the non-polluted community between the age of 20 and 40 years. The difference between the predicted probabilities became smaller from 50 years onwards and the effect of pollution status tended to diminish after the age of 60.

Similarly, there was a positive interaction between oil pollution and participants' body fat such that body fat modified the association between oil pollution and risk of hypertension. Figure 50 showed the odds of hypertension was significantly higher among normal and overweight participants residing in polluted areas compared to their obese counterparts with BMI 30 and over, BMI [(OR = 1. 09, 95% CI, 1.05-1.14), P= 0.001]. This is also the case among participants with WHR regarded as obese and those with WC above 100cm, WHR [(OR = 5.0, 95% CI, 1.28-19.26), P= 0.020] and WC [(OR = 1.03, 95% CI, 1.01-1.05), P= 0.001]. In addition to the above assessment, I also found an interaction between education attainment (among those with no formal education) and oil pollution status on overall predisposition towards hypertension. Therefore, I further explored the prevalence of hypertension in these groups (obesity, 'BMI and WHR', age groups and education attainment level) stratified by oil pollution status (Tables 20, 21, 22 and 23). The interactions between oil pollution and both marital and employment status did not achieve statistical significance in the overall sample.

Table 19: Interaction between Sociodemographic Factors, Body Weight and Oil Pollution

Interaction variables	**Odd ratio (95% CI)**	**P-value**
Polluted (vs Non-polluted) area ##Age	0.78 (0.64–0.95)	0.001
Polluted (vs Non-polluted) area ##Education attainment	0.39 (0.22–0.72)	0.002
Polluted (vs Non-polluted) area ## Sex	Not incl.	Not incl.
Polluted (vs Non-polluted) area ## Income	Not incl.	Not incl.
Polluted (vs Non-polluted) area ## Marital status	0.88(0.45 to 1.69)	0.69
Polluted (vs Non-polluted) area ## Employment status	0.59(0.26 to 1.29)	0.18
Polluted (vs Non-polluted) area ##BMI	1.09(1.05-1.14)	0.001
Polluted (vs Non-polluted) area ##WHR	5.00 (1.28-19.26)	0.020
Polluted (vs Non-polluted) area ##Waist circumference	1.03 (1.01- 1.05)	0.001

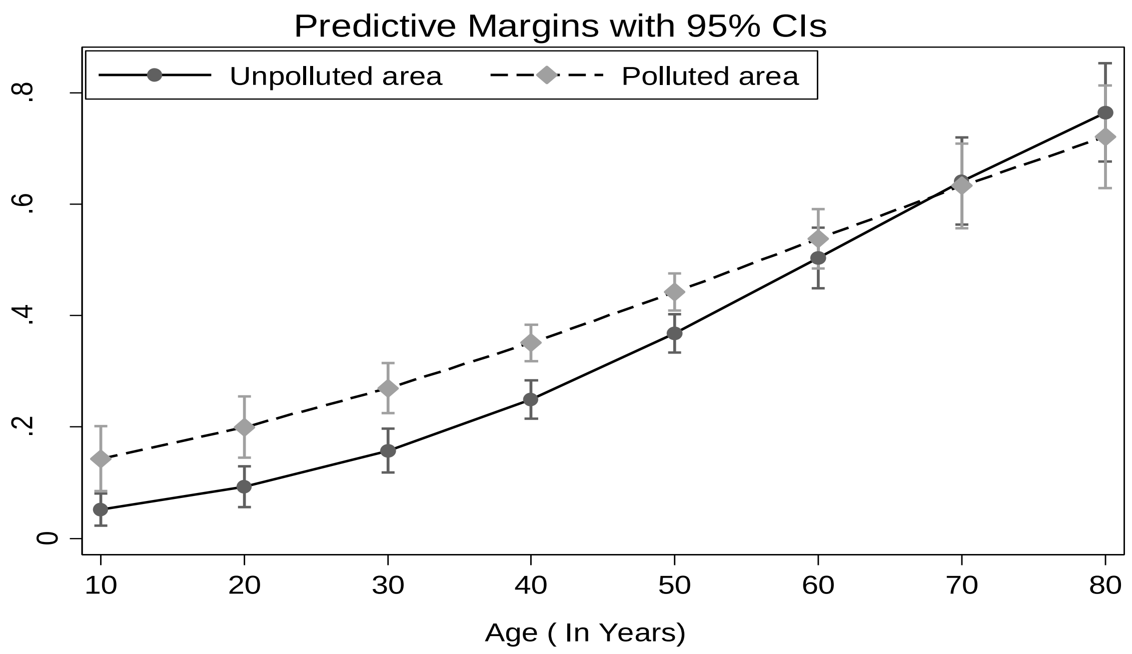


Figure 51: Predicted Probability of Hypertension for All Ages by Oil Pollution Status

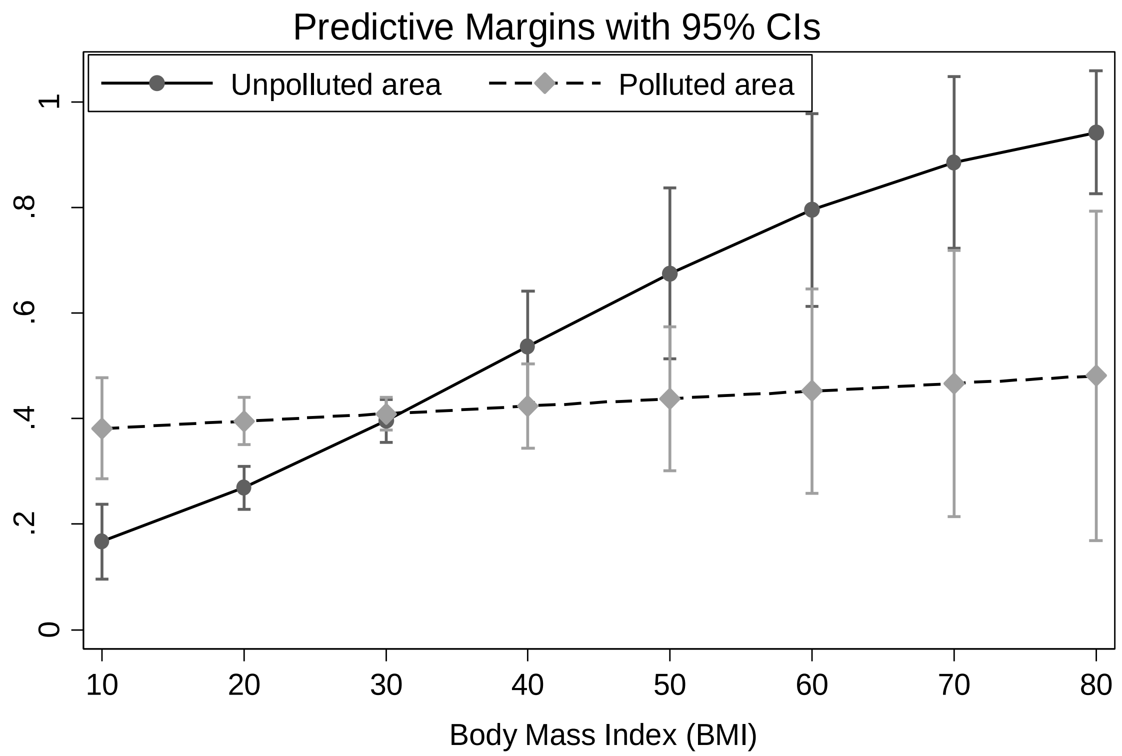


Figure 52: Predicted probability of hypertension for all BMI categories by oil pollution status

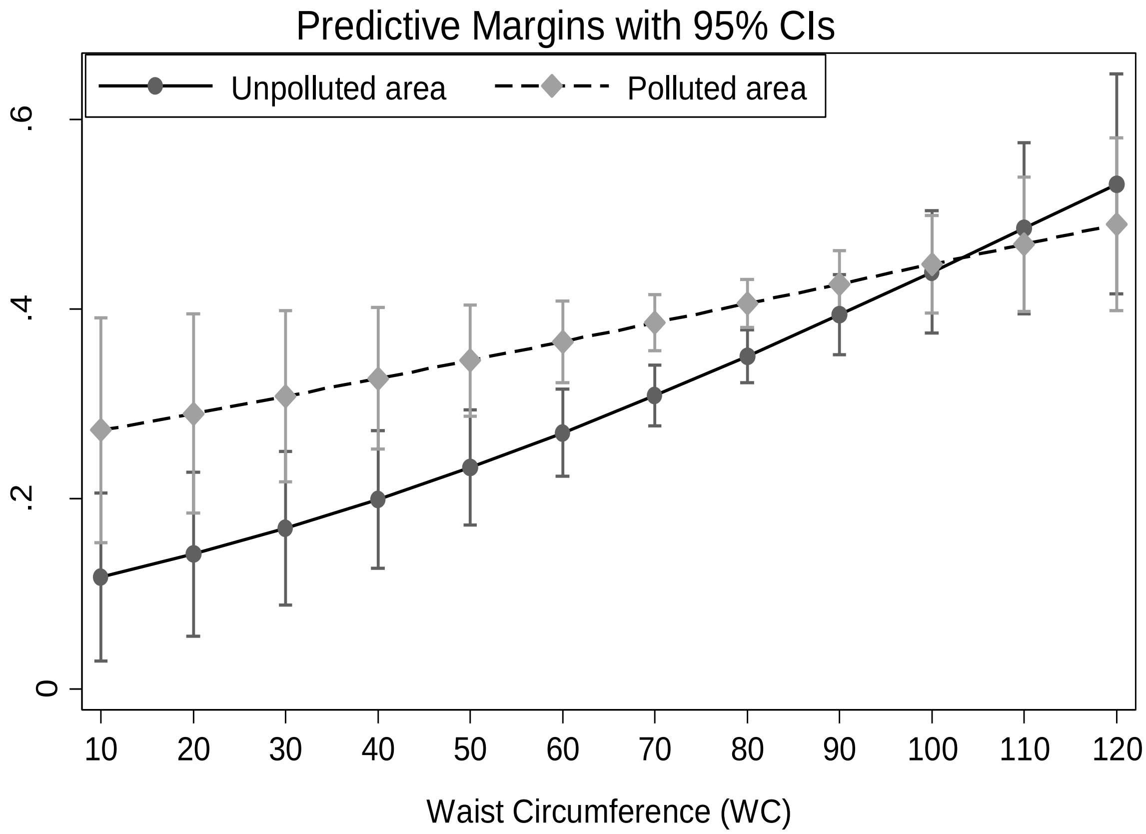


Figure 53: Predicted Probability of Hypertension for all Waist Circumference by Oil Pollution status

In figure 52, the margins of the predicted probabilities for BMI (≥ 45) may rarely be found in real life, however, the model provides additional knowledge and understanding of the interaction that may be happening in the study areas.

Table 20: Prevalence of Hypertension across Participants' Age Group (By Oil Pollution Status)

Variables	Polluted		Non-Polluted		
Age group (Years)	**Total**	**Hypertensive**	**Total**	**Hypertensive**	**P-value**
18-24	77(52.74)	3(75.0)	69(47.26)	1(25.0)	0.366
25-34	177(41.84)	33(70.21)	246(58.16)	14(29.79)	0.001
35-44	252(51.43)	97(68.79)	238(48.57)	44(31.21)	0.001
45-54	272(60.04)	146(65.77)	181(39.96)	76(34.23)	0.015
55-64	175(57.76)	117(58.50)	128(42.24)	83(41.50)	0.715
65-74	77(41.18)	49(40.50)	110(58.82)	72(59.50)	0.798
≥75	6(23.08)	4(17.39)	20(76.92)	19(82.61)	0.050

Table 21: Prevalence of hypertension across Participants' Education Attainment (by oil pollution status)

Variables	Polluted		Non-Polluted		
Education attainment	**Total**	**Hypertensive**	**Total**	**Hypertensive**	**P-value**
No Education (<6 Years)	221(61.05)	111(57.22)	141(38.95)	83(42.78)	0.108
Primary (6-11Years)	178(43.31)	89(50.0)	233(56.69)	71(30.47)	0.001
Secondary /Higher (≥12 Years)	637(50.76)	249(39.09)	618(49.24)	155(25.08)	0.001

Table 22 Prevalence of Hypertension across Participants Body Mass Index (by oil pollution status)

Variables	Polluted		Non-Polluted		
Body Mass Index	**Total**	**Hypertensive**	**Total**	**Hypertensive**	**P-value**
Underweight	17(48.57)	3(50.0)	18(51.43)	3(50.0)	0.939
Normal	374(42.69)	139(51.67)	502(57.31)	130(48.33)	0.001
Overweight	429(54.58)	185(60.86)	357(45.42)	119(39.14)	0.001
Obese	216(64.26)	122(68,16)	115(34.74)	57(31.84)	0.001

Table 23: Prevalence of Hypertension across Participant's WHRs (By Oil Pollution Status)

Variables	Polluted		Non-Polluted		
Waist-to-hip-ratio	**Total**	**Hypertensive**	**Total**	**Hypertensive**	**P-value**
Normal	348(51.03)	150(65.22)	334(48.97)	80(34.78)	0.001
Overweight	324(45.0)	129(51.39)	396(55.0)	122(48.61)	0.012
Obese	364(58.15)	179(61.37)	262(41.85)	107(38.63)	0.145

8.8 Model Fit Statistics

The regression diagnostics to assess the goodness-of-fit of the model were presented in table 24. The results showed that none of the model diagnostics provided reasons for concern. For age, education attainment, and BMI interactions, the mean variance inflation factors were 1.36, 0.20 and 1.32 respectively. As the rule, the variance inflation factor values and average variance inflation factor did not exceed 10 and 6, respectively, therefore I concluded that there was no multicollinearity problem and as such, there was no perfect linear relationship between the determining variables, and the estimates from the logistic regression models were valid.

Table 24: Model Fit Statistic Results

Variable	Model fit statistics	P-value
Age (In Years)		
	Area under ROC[16] curve	0.86
	Lemeshow test	0.28
	Link test	0.14
	Collinearity diagnostic (mean VIF[17])	1.36
Education Attainment		
	Area under ROC[1] curve	0.86
	Lemeshow test	0.32
	Link test	0.09
	Collinearity diagnostic (mean VIF[2])	0.20
Body Mass Index (BMI)		
	Area under ROC[1] curve	0.86
	Lemeshow test	0.55
	Link test	0.23
	Collinearity diagnostic (mean VIF[2])	1.32

[16] Receiver operating curve
[17] Variance inflation factor

The result of the link test (Table 24) indicated that the model was specified correctly (*P* = 0.14), (P= 0.09) and (P=0.23) for age, education attainment and BMI respectively. This suggests a very low likelihood of omitting relevant variable(s) that could predict the risk of hypertension. In addition, the Hosmer–Lemeshow test indicated that model fits the data well (*P* = 0.28) for age variable. The areas under the ROC curve for the final multivariate model were approximately 0.86. (Figure 52) This result indicated a relatively good predictive power and has a reasonably good discriminatory ability.

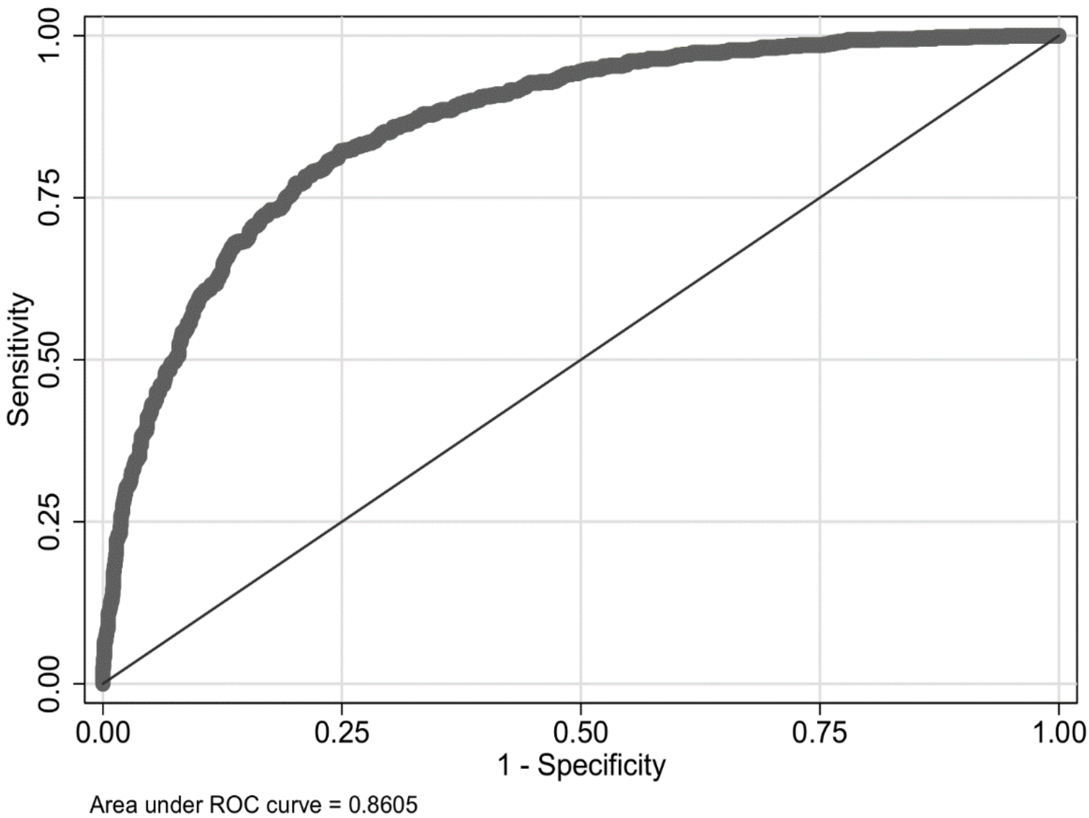


Figure 54: Receiver Operating Characteristics Curves for Final Multivariate Model

Summary

In this chapter, the result of the fieldwork data for hypertension in both study communities was presented. The next chapter will provide results for stroke in the study areas.

CHAPTER NINE

9.0 RESULTS: STROKE PREVALENCE

INTRODUCTION

This chapter presents the result of stroke assessment and diagnosis in the study population for both polluted and non-oil-polluted communities. These results are derived from the analysis of the participant's data collected during the fieldwork. The results provide details of all relevant statistical analysis. The chapter will first present the result of stroke diagnoses detailed in the flow diagram, followed by the participant's general characteristics including sociodemographic, lifestyle and stroke prevalence estimates. The crude, as well as the age-adjusted prevalence estimates, were presented for the same cohort.

9.1 Assessment and Diagnosis of Stroke

The sample size determination and sampling of participating households and the detailed study participant's sociodemographic, lifestyles and other characteristics related to hypertension have been described in previous sections. Briefly, a total of 2,028 subjects were included in the survey and completed the first phase of the screening. Overall, there were 386 positive responses for stroke following initial assessment. After the second screening phase using stroke-specific questionnaire, they were reduced to 249 suspected cases. These individuals were further invited for physical examination, clinical and neurological assessment at the primary health centres in the third phase of the assessment. A total of 248 individuals attended the final assessment and 1 person declined. In all 27 participants were diagnosed as having stroke, 16 from the polluted areas while 11 were from non-polluted areas. The consort diagram showing the assessment and diagnostic steps was shown in figure 53.

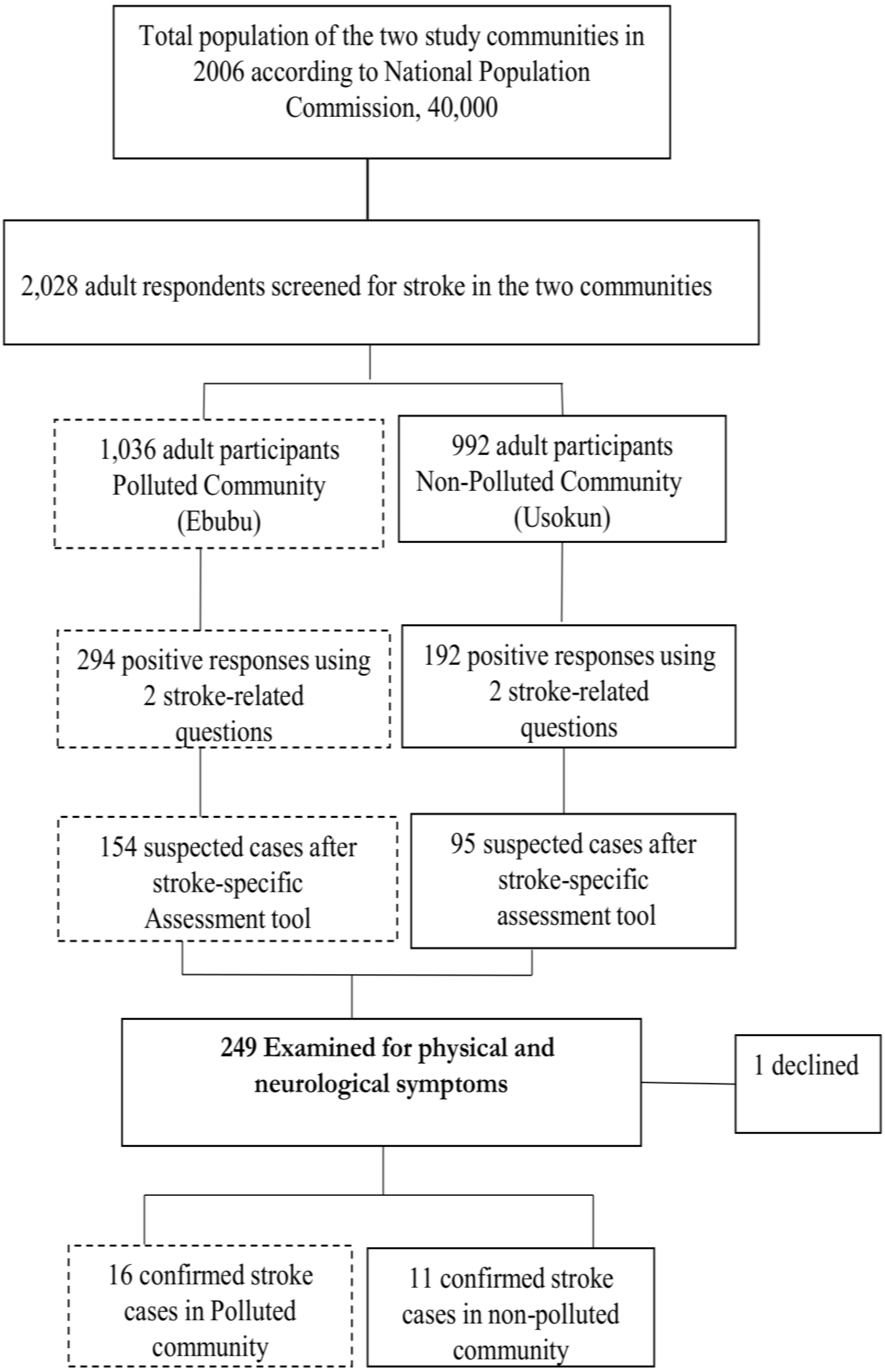


Figure 55: Flow diagram showing Assessment and Diagnostic steps for Stroke

9.2 Descriptive Statistics for the Study Participants

A total of 2028 subjects were included in the survey and completed the first phase of the screening. Almost equal numbers of the participants were from oil polluted areas (51%) with a preponderance of women (57.0%). The demographic profile and clinical data for all the participants were presented in table 13. The overall participants' mean age was 44.32 (standard deviation: 14.97). I also found the mean age of those diagnosed with stroke to be 68.08 (standard deviation: 7.79). The mean age of stroke survivor was significantly lower among those in polluted compared to non-polluted areas (66.38 vs. 70.54), P=0.001

9.3 Prevalence of Stroke in the Study Areas

The result showed 27 (16 in polluted and 11 in the non-polluted community) were diagnosed as having stroke giving a crude prevalence rate of 13.31/1,000 population. In the comparative analysis, the polluted community had a non-significantly higher estimate compared to non-polluted community, 15.44/1000 vs. 11.09/1000, P= 0.393. There is no gender difference among participants diagnosed with a stroke. The prevalence varies from 11·24/1000 (95% CI, 5·54–17·32) in female to 16·07/1000 (95% CI, 7·71-24·44) in male, P=0·347 (Table 25).

The results showed that almost all the stroke participants were hypertensives and/or have a family history of hypertension. In addition, stoke prevalence is higher among participants with a high level of knowledge related to hypertension (Table 25). A statistically significant difference in stroke prevalence was also observed among different age groups and measures of obesity and adiposity (BMI, WHR). Specifically, there was a significantly and graded increase in the prevalence of stroke across age groups. For instance, participants aged 18-24, 25-34 and 35-44 recorded no cases of stroke compared to older age groups. Specifically, the lowest age-specific prevalence was 4.42/1000 persons in the 45-54 age group, this increased to as high as

Table 25: Prevalence of Stroke in the Study Population

Variables	Total Population N (%)	Stroke cases /population (n/N)	Stroke prevalence (n/1000)	P value
Gender				
Male	871(42·95)	14/871	16·07	
Female	1157(57·05)	13/1157	11·24	0·347
Age group				
18–24	146(7·20)	0/146	0·00	
25–34	423(20·86)	0/423	0·00	
35–44	490(24·16)	0/490	0·00	
45–54	453(22·34)	2/453	4·42	
55–64	303(14·94)	4/303	13·20	
65–74	187(9·22)	17/187	90·91	
≥75	26(1·28)	4/26	153·85	0·001
Oil Pollution status				
Polluted	1,036(51·08)	16/1036	15·44	
Non-Polluted	992(48·92)	11/992	11·09	0·392
Education attainment				
Uneducated (< 6years)	362(17·85)	9/362	24·86	
Primary (6-11 years)	411(20·27)	7/411	17·03	
Secondary/higher (≥12 years)	1255(61.88)	11/1255	8.76	0.043
Employment status				
Unemployed	371(18.52)	5/371	13.33	
Currently working	1657(81.71)	22/1657	13.28	0.976
Body Mass Index				
Underweight	35(1·73)	0/35	0·00	
Normal	876(43·20)	5/876	5·71	
Overweight	786(38·75)	13/786	16·54	
Obese	331(16·32)	9/331	27·19	0·020
Waist-hip-ratio				
Normal	682(33.63)	6/682	8.80	
Overweight	720(35.50)	7/720	9.72	

Obese	626(30.87)	14/626	22.36	0.050
Smoking status				
Non smoker	1689(83·28)	21/1689	12·43	
Ever smoked	339(16·72)	6/339	17·70	0·440
Drinking status				
Non drinkers	799(39·40)	9/799	11·26	
Mild drinkers	656(32.35)	4/656	6.10	
Moderate-heavy drinker	573(28.25)	14/573	24.43	0.016
Salty food intake				
Low	800(39.45	13/800	16.25	
Moderate-high	1228(60.55)	14/1228	11.40	0.352
Fatty food intake				
Low fat intake	977(48.18)	18/977	18.42	
Moderate-high fat intake	1051(51.82)	9/1051	8.56	0.050
Sleep deprivation				
No sleep deprivation	1326(65.42)	4/1326	3.02	
Mild sleep deprivation	283(13.96)	4/283	14.13	
Moderate-severe sleep deprivation	418(20.62)	19/418	45.45	0.001
Hypertension status				
Normortensives	1270(62·62)	2/1270	1·57	
Hypertensives	758(37·38)	25/758	32·98	0·001
Family History of HTN				
No	1724(85·01)	8/1724	4·64	
Yes	304(14·99)	19/304	62·50	0·001
Hypertension awareness				
Low	1292(63.83)	12/1292	9.29	
Moderate	483(23.86)	4/483	8.28	
High	249(12.30)	11/249	44.18	0.001

90.91/1000 and 153.85/1000 among participants age between the age brackets of 65-74 and greater or equals 74 years respectively.

The prevalence of stroke in the study population also increases significantly with body fat distribution or adiposity using anthropometric indicators of BMI and WHR. The highest prevalence of stroke was found among study participants categorised as obese (27.19/1000) and overweight (16.54/1000) compared to those with normal weight (5.71/1000) or underweight (0.0/1000), P=0.020. Similarly, using WHR measure, the result showed a significant difference among obese (22.36/1000), overweight (9.72/1000) and normal weight participants with stroke (8.80/1000), P=0.050. With respect to lifestyle factors, only alcohol consumption and fatty food intake showed statistically significant differences in the prevalence of stroke with P values of 0.016 and 0.050 respectively.

9.4 Age-Specific and Age-adjusted Prevalence of Stroke

In table 26, I standardized the results to US Population 2000 standard population to compare better with data from other studies (Klein, Schoenborn et al. 2001). The result showed that age-standardised prevalence of stroke this study is 14.64/1000 population. Following age-adjustment and across age strata, the highest weighted-prevalence rate was in the age stratum 65-74 and 75 years and over.

Table 26: Crude and Age-Adjusted Prevalence of Stroke

Age group (Years)	Total population	Number of Stroke	Crude prevalence n/1,000	Age-adjusted prevalence (USA 2000 Population)
18–24	146	0	0·00	0·00
25–34	423	0	0·00	0·00
35–44	490	0	0·00	0·00
45–54	453	2	4·42	0·59
55–64	303	4	13.20	1·15
65–74	187	17	90·91	6·00
≥75	26	4	153·85	6·90
Total	**2028**	**27**	**13·31**	14·64

Summary

In this chapter, the result of the fieldwork data for stroke in both study communities was presented. The next chapter will discuss the findings of the study with respect to current evidence in the literature.

SECTION FIVE

- **DISCUSSION (SUMMARY & CONCLUSION)**

CHAPTER TEN

10.0 DISSCUSSION

INTRODUCTION

In this chapter, the main findings from each section of this thesis with respect to the study aims and objectives were presented. Summarized discussions of the main findings of the study in relation to the current evidence in the literature and fieldwork conducted were also presented. The study strength and limitations, as well as the implications of the finding for policy, practice, and further research, were also included. Finally, broad conclusions together with the scientific outputs of this project were presented.

10.1 Main Findings of the Thesis

This project was part of an ongoing collaboration between the University of Warwick Medical School and researchers from the Preventive and Social Medicine Department of the University of Port Harcourt in Nigeria. The study was launched to provide epidemiological evidence on the relationship between environmental pollution in Niger Delta region in Nigeria and cardiovascular and cerebrovascular conditions currently occurring in the region. Overall, 2,028 study participants took part in the survey where relevant individual data including sociodemographic, lifestyle, anthropometric and blood pressure measurement were collected. Prior to the field survey, two broad systematic reviews on the prevalence of hypertension in the Niger Delta region and the prevalence of stroke in LMICs including Nigeria were conducted.

The findings of the whole study corroborate the current evidence that hypertension and stroke are important and growing public health problems in LMICs including Nigeria, particularly in the Niger Delta region. The summary of the main findings is presented below;

1. In the systematic review and meta-analysis of epidemiological studies conducted in the Niger Delta, it revealed that the pooled prevalence of hypertension was 29.85% (95%, CI 25.91-33.94). Importantly, the result showed reverse epidemiology across study settings. Specifically, the burden of hypertension in rural population was significantly higher than those in urban areas of the Niger Delta, 32.0% (95%, CI 25.13-39.28) versus 26.84% (95%, CI 20.0-34.27), P< 0.0001.
2. The review also found gender difference which showed that hypertension is significantly higher in men compared to women 30.26% (95%, CI 23.76-37.17) versus 22.99% (17.60-28.86), P< 0.0001. Other study level characteristics that appear to influence the prevalence include; participant's age group, smokers, BMI, and alcohol use. For instance, it found a higher proportion of hypertensives among smokers compared to non-smokers 26.49% (95% CI 8.26–50.11) versus 18.07% (95% CI 15.79-20.60), *P*<0.001
3. The study finding provided evidence that hypertension is a huge public health issue in Niger Delta particularly in the rural oil and gas-host communities suggesting a potential interplay between socioeconomic, nutritional and environmental factors.
4. In the systematic review of stroke in LMICs, it found that the pooled stroke prevalence was 13.97 (95% CI 12.07-16.0) per 1000 population. The prevalence estimate varies from 21.16 (13.63, 30.26) per 1000 in Latin American and Caribbean to 3.54 (95% CI 1.86, 5.74) per 1000 in Sub-Saharan Africa.
5. The review also found that the pooled estimate of stroke prevalence in Nigeria was 1.45 (95% CI 0.72-2.41. However, the previous study conducted in oil-polluted Niger Delta, showed a much higher prevalence estimate for stroke, 8.51(95% CI 4.49-16.10) per 1000 population.
6. In the analysis of secular trends in stroke prevalence, the average annual percentage change (AAPC), found that there was a continuous increase in the prevalence of stroke

across all geographic regions. The increase is more pronounced in Latin America and Caribbean (trend = 0.157, P value = 0.0001) and followed by East Asia and Pacific (trend = 0.125, P value = 0.0001) and sub-Saharan Africa countries (trend = 0.113, P value = 0.0001), such that the prevalence of stroke have been increasing annually by 17.0%, 13.3% and 12.0% respectively.

7. Across World Bank income groups, the review revealed that the steepest increase in stroke prevalence occurred in low-income countries, increasing by 14.3% annually (trend = 0.134, P value = 0.0001), 12% in upper-middle income countries (trend = 0.113, P value = 0.0001) while the lowest increase (5.8%) occurred in lower-middle income countries (trend = 0.057, P value = 0.0001).
8. The review also found significant differences in the pooled prevalence of stroke across residential settings such as rural; 10.53(95%, CI 6.37-15.70), rural-urban; 10.66 (95%, CI 8.55-12.99) and urban; 22.10(95%, CI 16.92-27.75), p<0.001. Other study level characteristics that influence the prevalence include participant's age group and publication year.
9. In the multivariate model, the review found that for every 10 years increase in participants' mean age, the prevalence of stroke increases by 62% (95% CI 6% to 147%), p=0.027.
10. In the present study, the overall prevalence of hypertension was 37.28 %. The prevalence varies significantly from oil-polluted (43.34%) compared to non-polluted areas (31.15%), p<0.001. The prevalence reported in this study was similar to that reported in similar states in the Niger Delta and even higher than most studies in most urban areas in Nigeria as a whole.

11. The study found that hypertension was associated with older age, higher education attainment, oil polluted area, lifestyle factors, positive history of hypertension and poor sleep quality, and high body fat including overweight and obesity.
12. The result also showed that the prevalence of hypertension was more than doubled for every 10 years increase in participants age (aOR= 2.08, 95% CI, 1.77 to 2.43), among those with family history of hypertension (aOR=2.14, 95%CI, 1.54-2.99) and among those involved with sedentary (aOR=3.09, 95% CI, 1.66-5.76) or low physical activity (aOR=2.81, 95% CI, 2.20-3.60).
13. There was a positive and significant interaction between oil pollution and selected covariates (participant's sociodemographic characteristics and measures of body weight), the effect in each case being that participant's age modifies the association of oil pollution and risk hypertension, such that the risk of hypertension was higher among younger participants between the ages of 20-40 years or before the age of 60, Age (OR=0.78,0.64-0.95). Similarly, BMI, WHR and WC modify the association of oil pollution and hypertension, BMI (OR=1. 09, 95% CI, 2.65-58.55), WHR (OR=5.0, 95% CI, 1.28-19.26), WC (OR=1.03, 95% CI, 1.01-1.05).
14. In the present study also, the overall prevalence of stroke was 13.31/1,000 person. However, using the US standard population 2000, the age-adjusted prevalence of stroke was found to be 14.64/1000 population. The prevalence reported in this study was comparable to the previous study in the Niger Delta but significantly higher than the rate in Nigeria as a whole and by extension in sub-Saharan Africa.
15. Stroke prevalence varies across gender from 11·24/1000 (95% CI, 5·54–17·32) in female to 16·07/1000 (95% CI, 7·71–24·44) in male, P=0·347. However, the difference was not statistically significant.

16. There was a steep-rise in prevalence with advancing age with the highest burden between 65 and 74 years in both genders. The result also showed that stroke occurred at a younger age or below 55 years in the Niger Delta.
17. Apart from environmental pollution, unmeasured, uncontrolled blood pressure and family history of hypertension and lifestyle factors were the commonest risk factors for hypertension and stroke.

10.1.1 Comparison with other Studies

The systematic reviews and meta-analysis of hypertension prevalence in Niger Delta and stroke in LMICs including Nigeria confirmed to a large extent the limited primary studies on hypertension and stroke in an oil and gas–polluted environment. Previous studies on hypertension in Niger Delta have some important revelation particularly on the positive association of polluted environment and increased hypertension prevalence among population living in this area, however, that could not be said of stroke estimates given that only one study has been conducted in this region previously (Onwuchekwa, Tobin-West et al. 2014). The reverse epidemiology witnessed in the review in view of the increased hypertension prevalence in the rural areas compared to the urban population in the Niger Delta further underpins the huge importance of this current study.

The overall prevalence of hypertension in this study was as high as 37.38%. The comparative result presented in this study indicated that hypertension among exposed adult in the highly polluted areas (43.34%) compared to non-polluted areas (31.15%) was not only high but also statistically significant, P=0.001. The result was also higher than the previous pooled estimates of 29.85% reported in the review (Chapter Four). The result of the present study is comparable to local estimates previously reported (Onwuchekwa, Tobin-West et al. 2014). The overall and pollution-specific results for hypertension prevalence were very high especially when important participant's characteristics were compared. For instance, the prevalence (37.38%) was the same with a study conducted in Delta state (Oguoma, Nwose et al. 2015), however, the fact that the study participants were younger by almost a decade and the fact that the previous study was conducted in semi-urban environment calls for concern.

The overall and pollution-specific prevalence estimate for hypertension was also higher than the national estimates for both rural and urban areas (15.0 % vs. 22.30%) reported in 2012 (Ogah, Okpechi et al. 2012), and the most recent estimates (26.40% vs.30.60%) published last year (Adeloye, Basquill et al. 2015). Most importantly, the study prevalence for the non-polluted area was also higher than the national average despite the younger age of the study participant's. This on its own may also be related to socioeconomic and lifestyle factors.

The prevalence of hypertension found in this study is also higher than the prevalence in many countries and population groups in sub-Saharan Africa suggesting an interplay of factors outside the traditional risk factors that underpins increased hypertension risk in the current epidemiological transition driven by both demographic and nutritional changes (Yusuf, Reddy et al. 2001, Marcotullio, Rothenberg et al. 2005, Adeloye, Basquill et al. 2015). The study estimates for hypertension compares to some urban estimates in some African countries such as Tanzania, Burkina Faso, Ghana and Seychelles (Ibrahim and Damasceno 2012). Other developing countries outside Africa with comparable estimates include North India, Brazil, Venezuela, Chile and Paraguay (Ibrahim and Damasceno 2012).

The total prevalence of stroke recorded in this study was 13.31/1000 persons and 14.64/1000 after age-adjustment. This estimate was the highest rate recorded in any community-based study previously conducted anywhere in Nigeria. The current study findings add to the evidence that the prevalence estimate for stroke in the Niger Delta settings is at least as high as that seen in most upper-middle income countries in Europe and Latin America (Ezejimofor, Chen et al.

2016). The only important difference is that most studies in upper-middle-income were sampled from urban rather than rural settings like the current study and from an area with high life expectancy compared to Nigeria where life expectancy from birth averages 53 years in 2015 (WHO 2016).

The study estimate is also higher than studies conducted both in rural and urban population in Africa (Adeloye 2014). The fact that the result of this current study was comparable with the current estimates reported in most lower-middle and upper-middle income countries particularly in Latin America, South East Asia, Europe and Central Asia (Ezejimofor, Chen et al. 2016) further underpins the size of the problem in relation to the associated socioeconomic burden among the population in the rural Niger Delta in Nigeria.

The age-specific and age-adjusted prevalence of stroke in Niger Delta were consistently higher than that found in most lower-middle income countries (Ezejimofor, Chen et al. 2016). This could be tested in future studies, however, the fact that this study reported higher estimates among participants below 55 years remain an important etiological issue (Adeloye 2014, Chraa, Louhab et al. 2014).

It appears that the significantly higher prevalence of hypertension in the polluted area could be attributed to exposure to environmental pollution and differences in confounding variables listed above. Interestingly this exposures-relationship has been reported widely outside the study areas particularly in developed countries (Harrabi, Rondeau et al. 2006, Brook, Urch et al. 2009, Chan, Van Hee et al. 2015, Shah, Lee et al. 2015, Kim, Kim et al. 2016). In line with the study objectives, I estimated the associations between pollution and hypertension in this population. Nevertheless, after adjusting for potential confounding factors, the risk of hypertension associated with residing in the polluted area remains statistically significant, and indeed the estimated OR increased significantly. The significant difference in risk attributed to the polluted environment after adjustment confirms my study hypothesis that residents in the polluted community have increased risks of hypertension irrespective of their body mass index, socioeconomic status, lifestyle, and other predictors compared to their counterparts in the non-polluted area. Therefore, I found no evidence to reject the null hypothesis of no association between exposure to environmental pollution and increased risk of hypertension.

In addition to the above assessment, I also found that some covariates (participant's sociodemographic characteristics and measures of obesitys) may alter not only an individual's overall predisposition towards hypertension but also the association between living in the polluted area and risk of developing hypertension. I evaluated this by adding appropriate interaction terms between living in polluted area and each of the determinants to the multivariate model. I found that all the participants' sociodemographic characteristics and measures of obesitys (BMI, WC and WHR) except for annual income, gender, employment and marital status had statistically significant interaction with pollution status. For participant's age, the odds of hypertension were significantly higher among younger adults less than 60 years residing in polluted areas compared to their older counterparts (OR = 0.78=95% CI, 0.64-0.95), P= 0.001. The possible explanation here could be related to increased exposure to pollutants among young adults. There is no doubt, these cohorts (less than 60 years old) are highly mobile and often spend substantial time engaging in work (semi-skilled and unskilled jobs in the oil and gas facilities) and leisure (Egbe and Thompson 2010, Ordinioha 2010). Similarly, lack of awareness of the effect of pollution and other treatment options and increased exposure to western lifestyle (influenced by expatriates and local oil-company workers) in the oil and gas production areas among those with higher education may also increase the odds of hypertension among these cohorts (Egbe and Thompson 2010, Ogah, Okpechi et al. 2012).

In addition to age and education attainment, I found that measures of obesity (BMI, WC, WHR) could also alter participants overall predisposition towards hypertension among those living in the polluted area. This positive association and increased risk between measures of obesity and both pollution and hypertension, confirms my hypothesis of increased risk and prevalence of measure of body fat in the polluted community compared to the non-polluted area.

The positive association between measures of obesity and exposure to environmental pollution has previously been demonstrated in a relationship between PAH and obesity (Newbold 2010). The PAH component of oil and gas pollutants, an endocrine-disrupting chemical (EDCs) may have played a part in the significantly increased BMI seen in residents from the polluted community (De Coster and van Larebeke 2012). Review evidence revealed that PAH act on adipocytes by altering the metabolism or lipid homeostasis (Jerrett, McConnell et al. 2014, McConnell, Shen et al. 2015). This is done through the activation of the peroxisome proliferator–activated receptor (PPAR), which differentiates the pre-adipocyte cells in fat tissue (Newbold 2010). This relationship needs to be examined further in longitudinal studies.

I found a very high prevalence of main risk factors for both hypertension and stroke in the present study. I also found that these were generally similar to those which have been reported previously (Ogah, Okpechi et al. 2012, Suleiman, Amogu et al. 2013). With changes in economic circumstances in most rural Niger Delta communities due to increased oil and gas production and related activities, the rural communities are differentially exposed to environmental pollution (Ordinioha and Sawyer 2008, Onwuchekwa, Mezie-Okoye et al. 2012). In addition to food shortages and loss in productivities, these populations are rapidly adopting western lifestyle and nutritional habits due to the influence of expatriates and oil company workers who live and work in the oil and gas facilities in these areas. These lifestyle changes, socioeconomic interaction and pollution exposure may have resulted in increased prevalence of stroke and hypertension risk factors such as obesity/overweight, blood pressure and ageing in the rural populations (Ogah, Okpechi et al. 2012, Adeloye, Basquill et al. 2015) and may also help to explain the increasing trend of hypertension and stroke in this study and reverse epidemiology when compared with study conducted in urban areas in Nigeria and in sub-Sharan Africa (Adeloye 2014) .

Risk factors for hypertension and stroke in this study could be categorised into modifiable and non-modifiable (Grundy, Pasternak et al. 1999). The non–modifiable factors include; age, genetic family history, and gender (Roger, Go et al. 2011, Gupta, Gudapati et al. 2013). The major modifiable risk factors considered included lifestyle factors (such as blood pressure, cigarette smoking, alcohol consumption, physical activity and fatty food and salt intake. Others were sleep deprivation, knowledge of hypertension, BMI and WHR (Grundy, Pasternak et al. 1999, Roger, Go et al. 2011). Epidemiological investigation has revealed that many of these risk factors are linked. This implies that the existence of one may increase the likelihood of others. This has been shown in many observational studies which found a consistent association of major cardiovascular and cerebrovascular risk factors such as obesity and hypertension (Kannel 2000). Framingham heart study data reported that the quantitative relationship of these risk factors is additive in terms of predictive power. This is the basis of algorithms for cardiovascular risk estimate currently used world-wide (Grundy, Pasternak et al. 1999). Interestingly, this current study result showed such relationship across the range of variables evaluated. Specifically, results of the univariate and multivariate logistics regression models in this study (Chapter seven) found that advancing age is a major independent risk factor for hypertension which in turn predicts stroke. This is consistent with evidence from many systematic reviews and meta-analysis of epidemiological studies (Grundy, Pasternak et al. 1999, Sarki, Nduka et al. 2015). For instance, there is a general decline in organ function which is positively associated with ageing. Even in the absence of atherosclerosis and other condition that trigger high blood pressure, ageing leads to intimal and medial thickening or vascular remodelling as well as gradual loss of arterial elasticity (Wang and Bennett 2012).

The study findings corroborated this known fact about the association between increasing age and hypertension which has been reported in similar studies conducted both in the Niger Delta and elsewhere (Kadiri, Walker et al. 1999, Onwuchekwa, Mezie-Okoye et al. 2012, Adeloye and Basquill 2014, Ataklte, Erqou et al. 2015). I also found a sharp drop in hypertension rate among participants aged 74 years and over in both study areas, however, the reason behind this drop may be due to the fact that the sample of participants in this age bracket was relatively few (and typical of population demography in developing country such as Nigeria) and that hypertension-related mortality has been associated with advanced age (Johnston, Mendis et al. 2009, Roth, Forouzanfar et al. 2015).

Similarly, I found a huge difference in the age-specific prevalence reported in this study and those conducted previously in Nigeria (Table 27). I also noted a steep-rise in prevalence with advancing age with the highest burden between 65 and 74 years in both genders. The result of this study suggests the occurrence of stroke at a younger age or below 55 years. This is corroborated by previous studies conducted in the rural Niger Delta and in an urban population of Lagos state in Nigeria (Danesi, Okubadejo et al. 2007, Onwuchekwa, Tobin-West et al. 2014).

In the southwest region of Nigeria (Danesi, Okubadejo et al. 2007), stroke prevalence rose from 2.45/1000 in the fifth decade to as high as 47.60/1000 in the 9th decade, however, in the previous study in the Niger Delta region (in south–south Nigeria), the age of onset of stroke appeared in much younger adults, rising from 5.4/1000 in the fourth decade to 57.7/1000 in the seventh decade. In the current study, the prevalence estimate rose from 4.42/1000 in the 5th decade to as high as 153.85/1000 in the 8th decades. I also observed that the prevalence dropped sharply to zero in the previous study in Niger Delta after the seventh decade, whereas there was an exponential and sustained build-up as seen in the current study (Figure 54). This trend may suggest some improvement in health services and epidemiological and/or nutritional transitions characterised by hypertensive heart disease and a huge proportion of haemorrhagic stroke (Cappuccio 2004). It is not known if measures of obesity and socioeconomic interaction played any role particularly among the cohorts residing in the polluted areas. In fact, there is a large body of epidemiological evidence on the high prevalence of undetected, poorly managed or uncontrolled hypertension in LMICs including Nigeria which is likely to play a major role in the early initiation and increased burden of stroke in these settings (Adebisi and Samali 2013).

Specific genetic epidemiological studies found that family history or hereditary factors defined as first-degree blood relative was a significant independent predictor of hypertension and stroke (Yarnell, Yu et al. 2003, Lloyd-Jones, Nam et al. 2004). A review of studies revealed that genetic factors play an important role in hypertension such that patients who had family history of hypertension would have a 2-4fold higher risk of the disease and that first-degree relatives with hypertension had a significantly higher risk of hypertension compared to the second-degree relatives (Muldoon, Terrell et al. 1993, Winnicki, Somers et al. 2006, Ranasinghe, Cooray et al. 2015).

Consistent with the above evidence, I found that family history of hypertension has a 3-fold (3.17) increased risk, however, this risk reduced to 2-fold (2.14) in the adjusted model.

Overweight and obesity are the most important risk factors for hypertension and stroke (Ezejimofor, Chen et al. 2016, Ezejimofor, Uthman et al. 2016). Evidence has shown that overweight and obesity (as a measure of BMI, WC and WHR) are associated with metabolic complications (Despres, Moorjani et al. 1990), such as hypertension, diabetes, insulin resistance, hyperinsulinemia, lipoproteins and changes in the concentration of plasma lipids (Krauss, Winston et al. 1998). This evidence is corroborated by our review findings (Ezejimofor, Uthman et al. 2016) and previous studies (Onwuchekwa, Mezie-Okoye et al. 2012, Onwuchekwa, Tobin-

West et al. 2014, Oguoma, Nwose et al. 2015) in the Niger Delta which found that obesity and overweight are strong risk factors for hypertension and stroke.

Contrary to what has been established in other studies, I found no association between hypertension and either ever smoking (cigarette) or salt intake after adjustment (Onwuchekwa, Mezie-Okoye et al. 2012). These two lifestyle risk factors though common, particularly in riverine areas, may have been under-reported in this study. Although not evaluated, participants who chew tobacco and/or snuff tobacco had a higher prevalence of hypertension, and a valid association was established as documented in other studies conducted previously (Ike, Aniebue et al. 2010, Schwandt, Coresh et al. 2010, Onwuchekwa, Mezie-Okoye et al. 2012, Okpechi, Chukwuonye et al. 2013). New cohort studies are needed to evaluate these in this population.

Exposure to air pollution has been shown to increase the risk of obesity and metabolic syndrome in both human and animal studies (Griffiths, Hawkins et al. 2010, Bolton, Smith et al. 2012, Wei, Zhang et al. 2016). It is worthy of note that the prevalence of obesity and overweight were very high in the current study though significant different still exist between the study areas. I found that obesity prevalence based on BMI reference data was 20.85% and 11.59% in polluted and non-polluted areas respectively. These estimates were 2-3 folds higher than the national estimates reported by WHO (WHO 2015). In addition, based on WHR reference data, the prevalence rose to 35.14% in polluted compared to 26.41% in non-polluted areas. The WHR has been reported to be a better predictor of hypertension risk with strong discriminating power for both men and women compared to BMI (Hemberal, Chandregowda et al. 2015). These prevalence estimates were significantly higher than the 6.5% considered as the national average by WHO (WHO 2015).

Table 27: Comparison with other Population-Based Studies of Prevalence of Stroke in Nigeria

First Author	Publication Years	Location	Study Setting	Sample size	Mean age (Years)	Age range studied	Age-adjusted prevalence (n/1000)
Osuntokun	1982	South West	Rural	903	Nil	All	4.4
Osuntokun	1987	South West	Rural	18954	Nil	>7	0.6
Longe	1989	South West	Rural	2925	Nil	All	0.7
Danesi	2007	South West	Urban	13127	26.9±15.4	All	1.1
Onwuchekwa	2014	South South	Rural	1057	35.8 ± 14.8	≥18	8.5
Enwereji	2014	South East	Rural	6150	29.0±20.8	All	1.6
Sanya	2015	North Central	Semi-Urban	12992	58.2±11.5	≥18	1.3
This study (Overall)	**2016**	**South South**	**Rural**	**2028**	44.3 ±14.0	**18-80**	**14.64**
This study (Polluted)	**2016**	**South South**	**Rural**	**1036**	**44.7±13.3**	**18-80**	**15·44**
This study (Non-Polluted)	**2016**	**South South**	**Rural**	**992**	**43.9± 14.7**	**18-80**	**11.09**

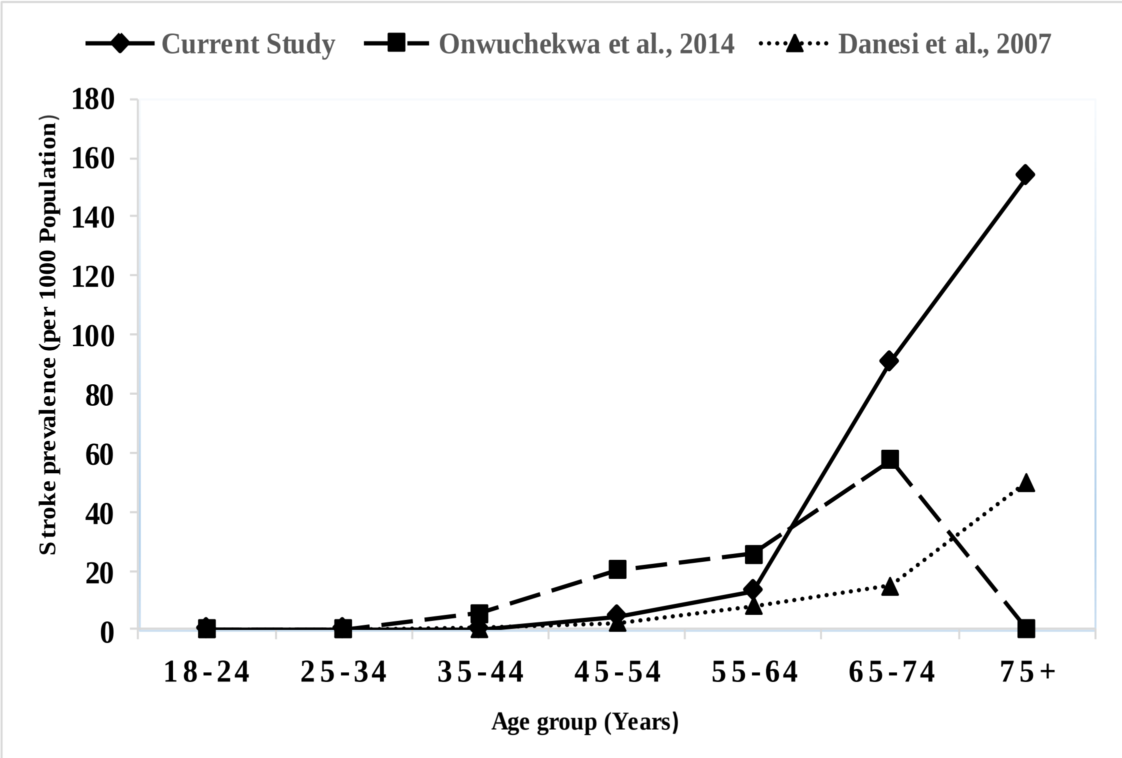


Figure 56: Age-Specific Comparison of Stroke Prevalence with Previous Studies

Similarly, updated review evidence has revealed that body fat distribution (WC) is a better predictor of hypertension risk, and it is independent of BMI (Després 2012). Review evidence further revealed that WC greater than 40 inches (102 cm) for men and 35 inches (88 cm) for women increase the risk of CVDs and diabetes (Klein, Allison et al. 2007, Hou, Lu et al. 2013). Both BMI and WC were all similarly associated with hypertension in the fully adjusted model. It is interesting to note that WC correlated more to hypertension compared to BMI and other anthropometric indicators (Chapter Seven), the possible explanation is that BMI does not differentiate between fat and lean mass as against WC (Shuster, Patlas et al. 2014).

Recent data clearly indicate that at any BMI level, an increased WC is predictive of an increased risk of comorbidities (Cornier, Després et al. 2011). The evidence provides additional and important benefits in the assessment and evaluation of an individual's level of excess adiposity and risk for associated comorbidities, and why WC measurement in addition to BMI have been recommended by Health/National Heart, Lung, and Blood Institute and the National Cholesterol Education Program Adult Treatment Panel III (Panel 1998).

Evidence from the previous meta-analysis revealed an excess risk of hypertension and ischemic stroke among cigarette smokers (Shinton and Beevers 1989). A critical appraisal of most studies found that the effect was strongly dose-related with the potential for risk doubling particularly when characterised in terms of number of years of smoking and lifetime cigarette consumption (Bhat, Cole et al. 2008, Thuy, Blizzard et al. 2010). Smoking also acts synergistically with other risk factors leading to significant risk of hypertension and CHD (Anderson, Wolson et al. 1991). This evidence is very consistent in a similar systematic review and meta-analysis of 86 prospective studies involving 3.9 million participants which reported a highly significant relationship between smoking and coronary heart disease, $p<0·0001$ (Anderson, Wolson et al. 1991). The result also found no difference between participants who had previously smoked compared with those who never had, (RR- 0·96, 95% CI 0·86-1.08, $p=0·53$) (Huxley and Woodward 2011). I tested this relationship in the current study and found a positive correlation and risk of hypertension among participants with current or previous smoking history (ever smokers).

The study findings also demonstrated a consistent and significant association of alcohol consumption with hypertension outcomes. Recently updated evidence of 84 studies found that alcohol at 2.5–14.9 g/day (about ≤1 drink a day) was consistently associated with a 14–25% reduction in the risk of all outcomes assessed compared with abstaining from alcohol (Ronksley, Brien et al. 2011).

However, previous study found that more than 1 drink per day has also been associated with increases in SBP and DBP by 1.0 and 0.5mm Hg respectively (Whelton, He et al. 2002), Stranges and colleagues also found about 2-fold increased risk of hypertension among drinkers without food (Stranges, Wu et al. 2004). The finding of this study is consistent and comparable with the previous literature evidence.

Physical activity is associated with a reduced risk of hypertension and other cardiovascular morbidity and mortality (Reddigan, Ardern et al. 2011). This has also been found to improve several metabolic risk factors. While physical activity has a significant health benefit, a sedentary lifestyle increases the risk of hypertension by 2-fold (Ben-Sira and Oliveira 2007). Evidence from a meta-analysis involving 21 prospective studies of 650,000 adults found that high to moderate level of physical activity have a beneficial effect on cardiovascular health by lowering the risk of incident coronary heart disease and stroke in both men and women by 20-30 and 10- 20%, respectively (Li and Siegrist 2012).

I did not stratify participants according to their respective occupation, however, evidence from the previous study found that differences between occupation groups were found to be associated with different levels of physical activity intensity (Duncan, Badland et al. 2010). This is consistent with the study population. Specifically, participants residing in non-polluted areas engaged mostly in fishing and crop faming occupation and may have been exposed differentially to moderate-vigorous physical activity. The study found that the risk of developing hypertension is less among persons who are physically active (Assah, Ekelund et al. 2011, Ogah, Okpechi et al. 2012). I also found that sedentary lifestyle (physical inactivity) and physical activity of low intensity increased the risk of hypertension by 3 and 2-folds respectively, compared to moderate-to-high intensity.

I also found a significant interaction between participant's age, education attainment, measures of obesity and hypertension but not for gender, employment and marital status. The study showed that the odd of hypertension was high among younger adults less than 60 years residing in polluted communities. This is also true for both education attainment and measures of obesity including BMI, WHR and WC.

For individuals living in the polluted community, increasing BMI and WC were associated with greater increase in the risk of hypertension compared to those living in the non-polluted community. Therefore, participants ages, education attainments and measures of body fat need to be considered when assessing the relationship between pollution status and hypertension risk in population studies.

10.1.2 Implications for Policy

Epidemiological studies into hypertension and stroke can generate awareness, inform policy, and encourage appropriate deployment of services both in the developed and low-resource settings like the Niger Delta in Nigeria. The economic burden of cardiovascular and cerebrovascular diseases like hypertension and stroke in LMICs like Nigeria are enormous. These conditions cost billions of dollars to the government, private and the social sectors (Ezejimofor, Chen et al. 2016). The wider socioeconomic implication of the increased hypertension prevalence and stroke observed in the present study portends huge underinvestment and decline in gross domestic product (GDP) reflecting increased loss in productivity and reduced labour efficiency (Ezejimofor, Chen et al. 2016).

It is not in doubt that these conditions are having a profound effect on the health of vulnerable populations in the rural Niger Delta region with limited resources. This is in addition to other burdens associated with oil and gas pollution on the health and welfare of the inhabitants of the host communities. However, collaborations and response to curbing hypertension and stroke within sub-Saharan Africa particularly in Nigeria remains poor, as these conditions still ranks very low among national health priorities, owing to competition for the limited resources from a co-existing high burden of infectious diseases such as HIV/AIDs, malaria, vaccine preventable diseases (like polio and TB) and other communicable diseases and services related to maternal and child health (Fuentes, Ilmaniemi et al. 2000).

The financial burden associated with hypertension and/or stroke in the form of direct and indirect healthcare costs are huge (Adeloye 2014, Adeloye and Basquill 2014). These costs are borne by the individuals and their families in rural communities of Niger Delta without health insurance cover. The study communities have functional primary health centres with some levels of care for hypertension, however, the standard of health service delivery is poor and inadequate in addition to the lack of essential drugs (van de Vijver, Akinyi et al. 2014). Many cases of hypertension are detected late, treatments rarely follow standard guidelines, and the costs of medications are generally high (van de Vijver, Akinyi et al. 2014). The socioeconomic burden of stroke in rural areas in Nigeria are compounded by the lack of functional stroke unit or human resources, however, where this exits in specialised centres in the urban areas, the cost implication is huge for rural population and communities like Ebubu and Isokun in the Niger Delta.

The findings will be useful for the design of hypertension and stroke screening (including high blood pressure and other predictors), treatment, rehabilitation, and related public health prevention strategies particularly in Niger Delta and Nigeria as a whole. It is expected that this will bring down the numbers of cases with hypertension and stroke, and other comorbidities on one hand, and help to narrow the existing health inequality.

The main recommendation proposed in this study anchors on policy re-alignment to accommodate the control and prevention of non-communicable diseases, including hypertension and stroke in the national health policy by the Ministry of Health (MOH) in Nigeria. In this regard, an integrated approach to the prevention and management of non-communicable diseases, irrespective of cause, is needed in primary health care (PHC) settings in Nigeria. The WHO integrated approaches (Bloom, Chisholm et al. 2011, Contractor, Sarkar et al. 2014) if adopted will provide cost-effective and affordable interventions in resource-constrained settings like Nigeria. Country-specific prevention and management strategies as recommended by World Health Assembly (WHA) and the WHO Regional Committee for Africa should also be considered by the federal government of Nigeria (van de Vijver, Akinyi et al. 2014). Similarly, Niger Delta-specific recommendation for prevention and management of hypertension and stroke should provide holistic approach by taking into account the extra risk associated with environmental pollution and its correlates such that environmental pollution data should be useful for screening purposes to identify high-risk population long before a diagnosis of hypertension and/or stroke is made and to target interventions appropriately.

Finally, sector-wide approaches and consideration of important environmental management intervention such as air pollution abatement strategies (Salonen, Vallius et al. 2007) must be pursued and implemented by government and relevant stakeholders (such as local and the international oil and gas companies).

10.1.3 Implications for Public Health and Clinical Practice

The prevalence estimates of hypertension and stroke, and the risk of hypertension associated with pollution as contained in this thesis not only constitute the best available evidence in the Niger Delta region but also provide policy makers with accurate and useful information required to both encourage reduction in environmental pollution and to effectively allocate resources to the high risk groups particularly among those who need these resources most. The huge socioeconomic implication in rural communities in Niger Delta may help policymakers across several oil-producing countries institute effective public health response to the growing burden.

As a result of demographic transition currently occurring in Nigeria, and as the trend for life expectancy is increasing, numbers of people with hypertension and/or stroke will continue to grow, particularly among young adults and the oldest old living in the Niger Delta among whom comorbidity is an important issue. An urgent political and public health priority will be policies to reduce environmental pollution and scale up early and sustained adoption of healthy lifestyle and other public health interventions strategies. This is in addition to the provision of adequate long term care needs for patients including support for dependents in the whole Niger Delta region. Such population–wide approach would be more effective given that a small reduction in risk among a large proportion of vulnerable adults may prevent a large number of more cases (Harper 2009).

The findings in this study have provided a justifiable basis for routine epidemiological exercise to effectively monitor the trends and patterns of hypertension and stroke as they occur particularly in the Niger Delta. In addition, to monitoring disease burden and trends, the epidemiological rigor and procedures could be relied upon or improved especially in designing preventive and management strategies to reduce the burden. Though public health professionals and clinicians have a role to play, this will no doubt add to performance improvement not only in capacity building but also in monitoring and evaluation of diseases and related risk factors.

Based on the findings of this study, it is suggested that pollution profile or status should be considered when assessing the blood pressure of young adults both in primary health care and hospital settings in Nigeria and other countries where environmental pollution has risen above WHO recommended ambient thresholds especially for priority air pollutants (World Health Organization 2006). Therefore, a comprehensive effort to address the chronic disease epidemic, environmental pollution and other cardiovascular risk factors for hypertension will be most effective when clinical prevention is combined with population-level prevention strategies.

10.1.4 Implications for Research

The cross-sectional design implemented in the present study provided local estimates of the prevalence of hypertension and stroke in the Niger Delta. The information helps to inform the concerned individual, community, health services and other stakeholders about the contribution and burden of these conditions for future policy prioritisation, and for promoting the understanding the household and societal cost of the conditions. The findings of this study showed that hypertension and stroke are an important research priority in Nigeria in general and Niger Delta in particular. Therefore, future research on hypertension and stroke in this population should include:

I. Large epidemiological survey to include such factors as dietary intakes and patterns, relevant biomarkers such as serum triglycerides, lipoprotein, prothrombotic factors, and inflammatory markers (Grundy, Pasternak et al. 1999), salt intakes (using the 24-hour urine test), physical activity level using a gold standard method, laboratory-based calorimetry or doubly labelled water (DLW) technique, standard measures of fatty food intake and genetic linkages which may provide additional information in determining the aetiology of hypertension and stroke in this population.

II. Future epidemiological research that will consider specifically socioeconomic factors, measures of body fat and longer term follow-up between early, middle age and late life. This is because I found evidence that socioeconomic factors such as participants' age and measures of body fat such as BMI modify the association between hypertension and environmental pollution. Such studies will be costly and would require a long-term funding commitment in poor settings like Niger Delta. However, the benefits of such long-term cohort research extend far beyond a better understanding of the aetiology of hypertension and stroke but also to other NCDs like cancer.

III. Longitudinal studies to investigate changes overtime not only on risk factors and prevalence of hypertension and stroke but also on the prevalence and incidence of other chronic disease conditions such as diabetes and cancer. The study should also investigate other important morbidity measures such as disability, functioning and dependence. Measures such as trends in longitudinal studies may be expensive and time consuming, however, less expensive strategies such as panel surveys with repeated representative prevalence phase sampling can be used to achieve the same research goals in low-resource settings like the Niger Delta with logistic and feasibility problems. Results from both types of designs are extremely useful for tracking trends, however, apart from cost consideration, panel surveys not only have the added advantage of allowing individual change to be measured and their possible causal explanations determined but also the extent to which these trends are attributable to increased surveillance, earlier diagnosis, increases survival with disease, or to cohort differences in the underlying disease-disability processes (Tourangeau 2003, Jagger, Matthews et al. 2007, Goldstein, Lynn et al. 2015). Such studies can also be useful in monitoring and evaluation of the effectiveness of the appropriate interventions which may influence planning for future health programmes tailored to the study population.

IV. Epidemiological surveys with standardised protocols that can be used to develop Niger-Delta specific cut-off points for blood pressure and anthropometric measures. There is a need for standardised population-specific measures due to biological and environmental differences between populations and environmental threats. It may be important to establish a cut-off points or threshold above which a radical step could be initiated. It will also help to provide valuable insight on the disease and to quantify the risk in this vulnerable population.

V. Epidemiological studies that would provide a disaggregated analysis of the comparative prevalence and risk of hypertension and stroke in the study areas. In the current study, I found a higher risk of hypertension associated with polluted compared to the non-polluted area, however, I did not take into consideration the trans-community or trans-boundary behaviours (through the air or through the river as the case in the Niger Delta) of environmental pollutants as the ideal culprits in this study. Secondly, participants that spend short or long time in the polluted areas before retiring to their current base were not considered as well. Although the result of this study is not conclusive, further research in this area remains a priority. Such future studies may consider conducting multiple separate analyses at the unit or some other level of aggregation (for instance, participants without access to water, or those that have never left their locality) or using mixture models.

VI. Studies estimating or examining the pollutant concentrations in the Niger Delta need to be conducted or monitored routinely. It is reasonable that areas with the highest hypertension prevalence were characterized by the intense representation of air (and not only) pollutants. However, a consideration of other pollutants in another medium such as water and land may provide important and alternative explanations in addition to the differential influence of various effect modifiers.

VII. Qualitative and/or quantitative studies on contextual and structural factors such as the state of health care services and availability, loss of farm yield or income loss and occupational displacement resulting from land (farm holding) and water (fishing area) pollution need to be encouraged. Others may include; the state of regulatory affairs, political atmosphere and social capital. Evidence has suggested the influence of social structural and income inequalities on health could be mediated by the erosion of social trust or occupational displacement and loss of farm land or produce, which in turn was associated with engaging in risk behaviour, thus increasing the odds of reporting chronic stress and hypertension which are major risk factors for stroke (Uphoff, Pickett et al. 2013, Reiter 2014).

VIII. Studies evaluating the efficacy and cost-effectiveness of public health intervention and pollutants abatement strategies such as healthy lifestyle promotion, and carbon capture and storage, green technology and relevant mitigatory measures need to be conducted in the context of disease reduction and socioeconomic improvement of the population.

IX. Further research to generate country-specific or region-specific data (using epidemiological tools like stroke register) on hypertension and stroke and its major determinants across states and regions in Nigeria remains an important public health policy priority. Such data can be analysed by using novel statistical techniques such as Bayesian Geo-additive models to account for spatial effects on hypertension and stroke aetiology in the Niger Delta communities and other regions in Nigeria.

X. Longitudinal studies with standardised protocols to investigate the risk of exposure through assessment of environmental pollutants in human tissues remain an important area for future research. This would suggest a possible use of environmental pollutant for screening purposes to identify high-risk population long before a diagnosis of hypertension is made and to target intervention appropriately.

10.2 Strengths and Limitations of the Study

The main strength of this study is the huge reliance on extensive systematic literature review and meta-analysis on the increased prevalence of hypertension and stroke both in the rural Niger Delta in Nigeria and in the LMICs. This provided the background knowledge and evidence that elicited relevant research questions and hypothesis in this study.

The second and most important strength of this study is the standardised design and rigorous assessment procedures, in a large representative study population with high response rates of 99.49% for individual participants and 98.62 for households in a cross-sectional survey. Such high response rate lays credence to sound survey protocol including detailed survey procedures and sampling strategy. This ensured that significant numbers of study participants were not missed. This, in addition, provided evidence of low risk of sampling bias.

It is important to note that the sampling and recruitment strategies and wide pre-consultative (stakeholders/community entry) meetings employed enabled me and the collaborators to build a strong and organic relationship with the communities and among all stakeholders involved, thus leading to improved response and facilitating follow-up and increased uptake in the provision of free medical consultations. The long assessment durations were well tolerated, as indicated by the high levels of participant's participation and response rates. A weakness in the sampling strategy and assessment methodology in this study could have limited the generalisation of the result beyond the study areas and similar communities, but this is unlikely to lead to bias in the prevalence estimates and association reported.

This research provided the first systematic review and meta-analysis of hypertension prevalence in the Niger Delta including an up-to-date systematic review and meta-analysis of stroke in LMICs including Nigeria. Interestingly, the review on stroke provided additional information which included meta-analysis of secular trends beyond the pooled prevalence estimates. In all, the two reviews included 128 eligible studies (101 for stroke and 27 for hypertension). The review results found that hypertension and stroke are major public health issues in the Niger Delta.

Consistent with the review results, the findings from the survey of hypertension prevalence in the current study found that more than 1 in 3 adults living in the rural Niger Delta in Nigeria suffers from hypertension while stroke prevalence in the region remained higher than the estimates found in urban areas both in Nigeria and elsewhere in sub-Saharan Africa. This is also the first research to examine the relationship between oil-gas polluted environment and the prevalence of hypertension and/or stroke in the Niger Delta in Nigeria. From a public health stand point, the importance of this study in the rural and resource-poor setting cannot be overemphasized. This is in view of the additional socioeconomic and health burden that may be associated with exposure to environmental pollution in a poor setting like this.

Care was taken to minimise error due to measurements and assessment. This reduced the risk of measurement bias to the barest minimum. For instance, anthropometric and blood pressure measurements were carried out by myself and well-trained research assistants using appropriate and validated measuring equipment. I ensured that all the measurements were carried out in line with the standard methodology and protocols already detailed in the methods chapter. Inter-observer and intra-observer reliability were not reported in the result section, however, the outcome found during the training of the research assistants do not suggest the likelihood of any significant difference.

For blood pressure measurements, an automated digital monitor was used as against the standard mercury sphygmomanometer. My preference was guided by quality evidence of comparison reported previously (Altunkan, Ilman et al. 2007, Altunkan, Ilman et al. 2008). In particular, automated digital monitor removes potential inter-observer and/or intra-observer bias related to discrepancies in Korotkoff sound in determining blood pressure cut-off points in adults.

I ensured that all participants were attended to calmly, and all questions answered ethically and professionally. I also made sure participants were provided adequate study information including

an explanation of what a positive result might mean beforehand to avoid the likelihood of increased participants' blood pressure which could be related to anxiety particularly in the presence of health or research professional or within the primary health centre, an anomaly used to describe white coat-hypertension (Pickering, James et al. 1988, Khattar, Senior et al. 1998).
I ensured that hypertension diagnosis was confirmed using the standard procedure. Participants were measured three times on the first day and the average of the last two reading taken. Those above normal range were invited two days later where a medical practitioner confirms the diagnosis following further measurements before referral. This is because multiple blood pressure readings on different days produce more precise and accurate diagnosis of hypertension compared to multiple measurement values on a single occasion (Kaplan, Thomas et al. 2015). I relied on the WHO standard blood pressure classification (Jones and Hall 2004) for an adult to avoid any obvious misclassification in the determination of the hypertension prevalence in the study population.

For the assessment and diagnosis of stroke, well-trained and practising neurological consultants conducted both the physical and neurological evaluation before the diagnosis and/or confirmation of the previous diagnosis of stroke. The study relied on validated general stroke screening and stroke-specific tools adopted from a modified WHO protocol for epidemiologic studies of neurological disorders and stroke and which have been used in previous studies (Danesi, Okubadejo et al. 2007, Onwuchekwa, Tobin-West et al. 2014). The use of these validated instruments and standard protocols ensured the elimination of the risk of under-diagnoses or over-diagnosis of stoke in the study.

The study is of relatively large sample size (n=2028) with a detailed study protocol. The result is very reliable because of the survey approach and the fact that I used validated instruments that have been used in previous studies. Despite the several strengths of the study, it also has some important limitations. First, the cross-sectional nature of the study cannot establish temporality and causality between the exposure and the outcome but can only suggest possible associations (Kestenbaum 2009). It is difficult or impossible to establish in this study whether the risk factor such as exposure to oil/gas pollution preceded the occurrence of hypertension or stroke which is a major criterion for determining causality since the risk factors and outcomes are measured simultaneously. Secondly, the lack of positive association might have been explained by reverse causality. For example, weight loss or lower BMI can be a consequence caused by hypertension and/or stroke. Hence, I cannot discountenance a prevalence case or length-bias as the observed association in this study may reflect survival rather than aetiology (Asgharian, M'Lan et al. 2002).

Niger Delta region has many ethnic groups in both rural and urban areas. The non-consideration of the urban population in the study design and recruitment may increase the likelihood of selection bias. This is because urban setting provided a more diverse multicultural and multi-socioeconomic mix compared to the rural environment (Pateman 2011). Secondly, there may be obvious cross-contamination of participants such that some participants residing in the rural areas may have spent good number of time in the urban environment. However, I took this important factor into consideration in the choice of study areas and individual participants. I made sure that eligible participants must have lived a total of 10 years in the study area. This amount of time offers adequate protection against cross-contamination of ideal study participants. This is because oil and gas host community, particularly in the rural Niger Delta, has continued to attract different population groups both in ethnicity and in socioeconomic outlooks. This explanation is also found in many literatures where oil and gas production bring about rapid socioeconomic activities leading to an influx of people in these areas. The large sample size and good response rate in this study demonstrated that the sample population was a good representative of the entire Niger Delta population mix.

The study relied on self-reported information for most variables associated with hypertension and stroke such as socioeconomic, lifestyle and sleep deprivation. Hence, the likelihood of recall or information bias which might potentially affect the integrity of the study result cannot be ruled out. Although there are many multiple proxy measures for socioeconomic characteristics of the study participants, NDHS 2010 and UNEP reports found that most families and individual in rural Niger Delta were far below the poverty line. Hence the consideration of education attainment, employment and marital status are important and adequate proxy measures at least to compensate for various measurements errors and to avoid unreliable and/or unstable results. I also adopted these proxy measures in this study because they have widely been used in many studies undertaken in developing countries particularly in Nigeria and other countries in sub-Saharan Africa without any agreed standardised socioeconomic scales compared to developed world (Ogah, Okpechi et al. 2012, Onwuchekwa, Mezie-Okoye et al. 2012).

I did not provide results or data on the estimates or types of environmental pollutants in the Niger Delta or study areas. Such data is important for correlation analysis and other important measures such as dose-response relationship; however, I am unable to determine which characteristics of pollutants (PM, PAH etc.) have the strongest influence on the outcome seen. In addition, I could not ascertain the concentration of the principal pollutant culprit and the corresponding influence on hypertension prevalence estimates. The behaviour of environmental pollutants has been studied in greater detail, and as such, the increased prevalence also seen in the control area could be due to trans-community or trans-boundary properties of the pollutants particularly the PM10 or PM2.5 (Johansson, Gregor et al. 2004, Bergin, West et al. 2005).

I did not measure some important structural and contextual factors (such as social capital and social cohesion, occupational displacement, health care services and availability) which may have an important influence to the hypertension estimate found in the study. Apart from their direct effect, the indirect relationship of these factors needs to be known and understood. Evidence has suggested the influence of income inequalities which are a potential trigger to the risk of hypertension (Diez-Roux, Link et al. 2000). Other important factors such as job losses and poor farm yield could be triggered by pollution of farmland or fishing water. For instance, subsistent farmers that lost their small farm holding and source of fishing and drinking water to oil pollution may be affected adversely due to loss of occupational activities, income, and leisure. This increases exposure to chronic stress, possibly leading to disturbed sleep patterns, lifestyles and behavioural changes, and reduced access to health care. The results of these are inequality in health outcomes including hypertension and stroke (Uphoff, Pickett et al. 2013, Reiter 2014).

I could not disapprove of recall bias in the study questionnaire with respect to the measure of participant's physical activity, salt and fatty food intake and alcohol consumption. The lack of detailed dietary history or unified servings units for alcohol in the local communities consistent with the international standard may have also limited the accurate classification. These self–reports have been at best a valued discretionary use rather than gold standard. For instance, salt intake would be best determined through a 24-hour urine collection as against dietary recall, records from 24 to 96 hours or food frequency questionnaire methods (World Health Organization 2007, Ortega, López-Sobaler et al. 2011).

While International Physical Activity Questionnaire (IPAQ) has been recommended as a cost-effective method to assess physical activity the issue of recalls for both long and short duration (at least 7 days) remain important factors that undermine its usefulness (Lee, Macfarlane et al. 2011).

I did not provide data on stroke-related disability or case-fatality. Although such data are important for stroke care planning and management, such estimates may be unreliable in this rural population due to conflicting information on causes of death, non-existence of stroke registers and overlapping disabilities caused by other disorders that accompany stroke particularly in older patients and the fact that majority of stroke do not access the health service due to prohibitive out-of-pocket expenses, distance to urban hospital and lack of stroke functioning units in the primary health care centres in the study communities.

In addition, I could not use the brain computerised tomography (CT) scan and magnetic resonance imaging (MRI) which are gold standard according to WHO stroke surveillance system in the diagnosis of stroke (World Health Organization 2005). These are common limitations in stroke surveillance in low-resource settings like Nigeria (Feigin, Forouzanfar et al. 2014). Apart from the cost implication, and associated logistics, availability of CT and MRI in few neurological units in specialist hospitals remains a huge barrier. Therefore, I was unable to distinguish or ascertain specific stroke subtypes. It could be argued that some participants with acute stroke with quick recovery time and mild disability could have been missed especially if the stroke occurred long before the survey. However, the survey protocol including detailed epidemiological exercise (including physical, neurological and other clinical indicators in each case), increased publicity and recruitment strategies ensured that elderly, out-of-reach persons or those with restricted mobility were not missed.

Information or observer bias may also have occurred, since the assessors for the stroke were neurological specialists and public health physician on speciality training in the same catchment areas where the research project was conducted. Therefore, while the interview was for the most part fully structured, interviewer identification and coding of symptoms could have been based upon prior knowledge of diagnoses or other previous clinical impressions. This situation may have led to a minority of patients previously known to services or consulted with the clinicians carrying out the physical and neurological assessment to be diagnosed with stroke.

My inability to assess other biomarkers, such as lipid profiles, blood sugars and some important modifiers including healthcare spending, quality of care, access and availability may not only confound but also limit the understanding of the aetiology and influence of these to the increased stroke and hypertension estimates. Other extrinsic factors such as pollutant types, concentration, and weather and climatic variation must be factored in as well.

10.3 Conclusion

The present study provided contemporary estimates that reflected the high prevalence of hypertension and stroke in the rural Niger Delta population which mirrors the challenges faced by individuals, families and the health sector in Nigeria and sub-Saharan Africa. Apart from environmental pollution, unmeasured and uncontrolled blood pressure and lifestyle factors were the commonest risk factors identified. The wider socioeconomic implication of the increased hypertension and stroke prevalence estimates in this study portends huge underinvestment reflecting increased loss in productivity and reduced labour efficiency and increased poverty level. The findings from this study underscore the need to improve the understanding of environmental pollution and other risk factors associated with hypertension and stroke in the rural Niger Delta populations, as well as the need for appropriate pollution management strategies and public health programs in a population that is currently experiencing some improvement in life expectancy and well advanced in epidemiological and environmental risk transitions.

In this community-based comparative cross-sectional survey, I found that the prevalence of hypertension was high in both polluted and non-polluted communities and even higher than most urban estimates reported previously. I also found a higher estimate for stroke in both areas. However, hypertension prevalence was significantly higher among participants in the polluted environment compared to those in a non-polluted area, suggesting a possible association between pollution and negative impact on health. Even though it was not evaluated, the influence and properties of environmental pollutants particularly the PM and VOCs (Transboundary pollutants) which extend to the whole Niger Delta regions and exert comparable health influence on study participants cannot be ruled out. This not only makes the current high estimates in the two areas realistic but could be generalised in the region. The existent of several point sources of pollution in the Niger Delta region and the resultant discharge of potential pollutants in the air, land and water bodies implies that the risk of exposure is substantially high among the residents living in the region due to persistent air emission and spillage on water and land. This understanding would encourage appropriate regulatory and control mechanism by relevant agency to protect vulnerable residents.

Apart from environmental pollution, some well-known risk factors for hypertension and stroke are confirmed but not others. The study provides consistent evidence that ageing and family history of hypertension were independent risk factors for hypertension. In this population, the risk of hypertension more than doubled for every 10 years increase in participant's age and among those with a family history of hypertension. Alcohol consumption, physical activity, education attainment, marital status, sleep deprivation and measures of body fat (overweight and obesity) were associated with the prevalence of hypertension in this population.

I found a significant interaction between oil/gas pollution and selected covariates including age, education attainment and measures of obesity. Age, education attainment and measures of obesity modify the association between pollution status and risk of hypertension. The effect of pollution is higher among younger participants compared to their older counterparts. Similarly, BMI equal to or less than 30 or participants' WC less than 102cm were associated with increased risk of hypertension among those residing in the polluted areas. This implies that participant's age, their education attainment and their BMI and waist circumference need to be considered when assessing the relationship between exposure to pollution or residing in the polluted area and hypertension risk.

This study also provides evidence of a positive association between measures of body fat or adiposity and pollution among the rural population in the Niger Delta and advocates that environmental pollution status should be taken into consideration when assessing the prevalence of overweight and obesity in population studies. Consistent with the study hypothesis, individual exposed or residing in a polluted environment may be associated with increased risk of overweight/obesity, once the effect of discernible genetic or lifestyle factors is controlled for.

Furthermore, the result of this study corroborates the initial findings of the systematic review on the high prevalence of hypertension and stroke in the Niger Delta and LMICs respectively (Ezejimofor, Chen et al. 2016, Ezejimofor, Uthman et al. 2016). The review found that 1 in 3 adults living in the Niger Delta suffer from hypertension while stroke in rural Niger Delta are significantly higher in both urban cities in Nigeria and other sub-Saharan African countries. In all, the current study estimates and review evidence are consistent with the reverse epidemiology ongoing in the Niger Delta and also highlighted the influence of major traditional and emerging risk factors on hypertension and stroke prevalence.

The findings will be useful for the design of hypertension and stroke screening, treatment and rehabilitation, and for environmental pollution control strategies particularly in Niger Delta and Nigeria as a whole.

References

Abe, I. M., et al. (2011). "Stroke prevalence in a poor neighbourhood of São Paulo, Brazil: applying a stroke symptom questionnaire." International Journal of Stroke **6**(1): 33-39.

Abu, G. O. and P. O. Dike (2008). "A study of natural attenuation processes involved in a microcosm model of a crude oil-impacted wetland sediment in the Niger Delta." Bioresource Technology **99**(11): 4761-4767.

Addo, J., et al. (2007). "Hypertension in Sub-Saharan Africa a systematic review." Hypertension **50**(6): 1012-1018.

Adebisi, O. O. and A. Samali (2013). "Poverty and Hypertension in Nigerian Adults: A Barrier to Its Control and Treatment: A Review." Unique Research Journals **1**: 013-014.

Adeloye, D. (2014). "An estimate of the incidence and prevalence of stroke in Africa: a systematic review and meta-analysis." PloS one **9**(6): e100724.

Adeloye, D. and C. Basquill (2014). "Estimating the prevalence and awareness rates of hypertension in Africa: a systematic analysis." PloS one **9**(8): e104300.

Adeloye, D., et al. (2015). "An estimate of the prevalence of hypertension in Nigeria: a systematic review and meta-analysis." Journal of Hypertension **33**(2): 230-242.

Adoki, A. (2013). "Petroleum Hydrocarbons Contamination Profile of Ochani Stream in Ejamah Ebubu, Eleme Local Government Area of Rivers State, Nigeria." Journal of Applied Sciences and Environmental Management **15**(4): 547-557.

African Development Bank (2013). Federal Republic of Nigeria Country Strategy Paper 2013 - 2017

Aghalino, S. and B. Eyinla (2009). "Oil Exploitation and Marine Pollution: Evidence from the Niger Delta, Nigeria." Journal of Human Ecology **28**(3): 177-182.

Agyemang, C., et al. (2009). "Cardiovascular disease, diabetes and established risk factors among populations of sub-Saharan African descent in Europe: a literature review." Global Health **5**(7): 1.

Ahmadu, J. and J. Egbodion (2013). "Effect of Oil Spillage on Cassava Production in Niger Delta Region of Nigeria." American Journal of Experimental Agriculture **3**(4): 914-926.

Aigbedion, I. (2005). "Environmental Pollution in the Niger-Delta, Nigeria." Inter-Disciplinary Journal **3**(4): 205-210.

Akpa, M., et al. (2008). "Current epidemiology of hypertension in Port Harcourt metropolis, Rivers state, Nigeria." Port Harcourt Medical Journal **2**(3): 218-223.

Akpan, N. S. and E. M. Akpabio (2009). "Oil and conflicts in the Niger Delta region, Nigeria: facing the facts." Journal of Social Development in Africa **24**(1).

Alaba, O. and E. Ifelola (2011). "Impact Assessment of Oil Spillage on Farmlands of Some Communities in llaje Area of Ondo State, Nigeria." Journal of Environmental Science and Engineering **5**(12): 1581-1584.

Allen, C. (1983). "Clinical diagnosis of the acute stroke syndrome." QJM **52**(4): 515-523.

Altunkan, S., et al. (2007). "Validation of the Omron M6 (HEM-7001-E) upper-arm blood pressure measuring device according to the International Protocol in adults and obese adults." Blood pressure monitoring **12**(4): 219-225.

Altunkan, S., et al. (2008). "Validation of the Omron M6 (HEM-7001-E) upper arm blood pressure measuring device according to the International Protocol in elderly patients." Blood pressure monitoring **13**(2): 117-122.

Ana, G. (2011). Air pollution in the Niger Delta Area: Scope, Challenges and Remedies, The Impact of Air Pollution on Health, Economy, Environment and Agricultural Sources. M. Khallaf (Ed.), ISBN: 978-953-307-528-0, 2011 In Tech.

Ana, G. R. E. E., et al. (2012). "Polycyclic aromatic hydrocarbon burden in ambient air in selected Niger Delta communities in Nigeria." Journal of the Air and Waste Management Association **62**(1): 18-25.

Ana, G. R., et al. (2009). "Environmental risk factors and health outcomes in selected communities of the Niger delta area, Nigeria." Perspectives in Public Health **129**(4): 183-191.

Ana, G., et al. (2010). "Environmental risk factors and hospital-based cancers in two Nigerian cities." J Public Health Epidemiol **2**(8): 216-223.

Anderson, H. R., et al. (2013). "Long-term exposure to air pollution and the incidence of asthma: meta-analysis of cohort studies." Air Quality, Atmosphere & Health **6**(1): 47-56.

Anderson, K. M., et al. (1991). "An updated coronary risk profile: a statement fo rhealth professionals." Circulation **83**(1): 356-362.

Andy, J. J., et al. (2012). "Prevalence and correlates of hypertension among the Ibibio/Annangs, Efiks and Obolos: a cross sectional community survey in rural South-South Nigeria." Ethnicity and Disease **22**(3): 335.

Antai, D. (2011). "Regional inequalities in under-5 mortality in Nigeria: a population-based analysis of individual-and community-level determinants." Population health metrics **9**(1): 6.

Arambepola, C., et al. (2008). "Urban living and obesity: is it independent of its population and lifestyle characteristics?" Tropical medicine & international health **13**(4): 448-457.

Arowosegbe, J. O. (2009). "Violence and national development in Nigeria: The political economy of youth restiveness in the Niger Delta." Review of African Political Economy **36**(122): 575-594.

Asgharian, M., et al. (2002). "Length-biased sampling with right censoring: an unconditional approach." Journal of the American Statistical Association **97**(457): 201-209.

Assah, F. K., et al. (2011). "Urbanization, physical activity, and metabolic health in sub-Saharan Africa." Diabetes Care **34**(2): 491-496.

Asuzu, M. (2005). "Commentary: The necessity for a health systems reform in Nigeria." Journal of community medicine and primary health care **16**(1): 1-3.

Ataklte, F., et al. (2015). "Burden of undiagnosed hypertension in Sub-Saharan Africa A systematic review and meta-analysis." Hypertension **65**(2): 291-298.

Avezum, Á., et al. (2015). "Stroke in Latin America: Burden of Disease and Opportunities for Prevention." Global Heart.

Banegas, J. R., et al. (1998). "Blood pressure in Spain distribution, awareness, control, and benefits of a reduction in average pressure." Hypertension **32**(6): 998-1002.

Barrett-Connor, E., et al. (2011). A Nationwide Framework for Surveillance of Cardiovascular and Chronic Lung Diseases. Washington, DC Institute of Medicine of the National Academies.

Bauen, A. (2006). "Future energy sources and systems—acting on climate change and energy security." Journal of Power Sources **157**(2): 893-901.

Beaglehole, R., et al. (2011). "UN high-level meeting on non-communicable diseases: addressing four questions." The Lancet **378**(9789): 449-455.

Beauchemin, C. (2011). "Rural–urban migration in West Africa: towards a reversal? Migration trends and economic situation in Burkina Faso and Côte d'Ivoire." Population, Space and Place **17**(1): 47-72.

BeLue, R., et al. (2009). "An overview of cardiovascular risk factor burden in sub-Saharan African countries: a socio-cultural perspective." Globalization and health **5**(1): 10.

Bennett, D. A. (2011). "Methodology of the global and regional burden of stroke study." Neuroepidemiology **38**(1): 30-40.

Ben-Sira, D. and J. Oliveira (2007). "Hypertension in aging: physical activity as primary prevention." European Review of Aging and Physical Activity **4**(2): 85.

Bergin, M. S., et al. (2005). "Regional atmospheric pollution and transboundary air quality management*." Annu. Rev. Environ. Resour. **30**: 1-37.

Bharucha, N. E., et al. (1988). "Prevalence of stroke in the Parsi community of Bombay." Stroke **19**(1): 60-62.

Bhat, V. M., et al. (2008). "Dose-response relationship between cigarette smoking and risk of ischemic stroke in young women." Stroke **39**(9): 2439-2443.

Bishwajit, G., et al. (2014). "Social Determinants of Infectious Diseases in South Asia." International Scholarly Research Notices **2014**.

Blench, R. and T. Morakinyo (2013). The Natural and Social Environment of the Niger Delta. Cambridge, United Kingdom**:** 17.

Bloom, D. E., et al. (2011). From burden to" best buys": reducing the economic impact of non-communicable disease in low-and middle-income countries, Program on the Global Demography of Aging.

Bolton, J. L., et al. (2012). "Prenatal air pollution exposure induces neuroinflammation and predisposes offspring to weight gain in adulthood in a sex-specific manner." The FASEB Journal **26**(11): 4743-4754.

Booth, M. L., et al. (2003). "International physical activity questionnaire: 12-country reliability and validity." Med sci sports Exerc **195**(9131/03): 3508-1381.

Boutayeb, A. (2006). "The double burden of communicable and non-communicable diseases in developing countries." Transactions of the Royal Society of Tropical Medicine and Hygiene **100**(3): 191-199.

Brand Correa, L. I. (2014). "The economic growth engine. How energy and work drive material prosperity." Cuadernos de Economía **33**(62): 319-325.

Brennan, E. M. (1999). "Population, urbanization, environment, and security: a summary of the issues." Environmental Change and Security Project Report **5**: 4-14.

Briggs, D. (2003). "Environmental pollution and the global burden of disease." British Medical Bulletin **68**(1): 1-24.

British Petroleum (2014). BP Statistical Review of World Energy United Kingdom**:** 48.

Brook, R. D. (2007). "Is air pollution a cause of cardiovascular disease? Updated review and controversies." Reviews on environmental health **22**(2): 115-138.

Brook, R. D., et al. (2009). "Insights into the mechanisms and mediators of the effects of air pollution exposure on blood pressure and vascular function in healthy humans." Hypertension **54**(3): 659-667.

Brook, R. D., et al. (2010). "Particulate matter air pollution and cardiovascular disease an update to the scientific statement from the American Heart Association." Circulation **121**(21): 2331-2378.

Bunker, C. H., et al. (1992). "Factors associated with hypertension in Nigerian civil servants." Preventive medicine **21**(6): 710-722.

Burke, T. A. and R. N. Venketasubramanian (2006). "The epidemiology of stroke in the East Asian region: a literature-based review." International Journal of Stroke **1**(4): 208-215.

Burns, N., Grove, S.K. (2009). The Practice of Nursing Research: Appraisal, Synthesis and Generation of Evidence. St. Louis, Saunders Elsevier.

Canter, L. W., et al. (1996). "Environmental impact assessment." 2nd Edition, New York, McGraw-Hill

Cappuccio, F. P. (2004). "Commentary: epidemiological transition, migration, and cardiovascular disease." International journal of epidemiology **33**(2): 387-388.

Cavalieri, E., et al. (1991). "Comparative dose—response tumorigenicity studies of dibenzo [a, l] pyrene versus 7, 12-dimethylbenz [a] anthracene, benzo [a and two dibenzo [a, l] pyrene dihydrodiols in mouse skin and rat mammary gland." Carcinogenesis **12**(10): 1939-1944.

Central Bank of Nigeria (2015). "Statistical Bulletin: Domestic Production, Consumption and Prices". Abuja, Nigeria.

Chan, K. Y., et al. (2012). "How big is the 'next big thing'? Estimating the burden of non–communicable diseases in low–and middle–income countries." Journal of global health **2**(2).

Chan, S. H., et al. (2015). "Long-Term Air Pollution Exposure and Blood Pressure in the Sister Study." Environmental Health Perspectives **123**(10): 951-958.

Charlton, K. E., et al. (2008). "Development and validation of a short questionnaire to assess sodium intake." Public health nutrition **11**(01): 83-94.

Cheikh Ismail, L., et al. (2016). "Gestational weight gain standards based on women enrolled in the Fetal Growth Longitudinal Study of the INTERGROWTH-21st Project: a prospective longitudinal cohort study." BMJ **352**.

Chobanian, A. V., et al. (2003). "The seventh report of the joint national committee on prevention, detection, evaluation, and treatment of high blood pressure: the JNC 7 report." Jama **289**(19): 2560-2571.

Chokshi, D. (2010). "Teaching About Health Disparities Using a Social Determinants Framework." Journal of General Internal Medicine **25**(2): 182-185.

Chraa, M., et al. (2014). "Stroke in young adults: about 128 cases." The Pan African medical journal **17**.

Chukwuonye, I. I., et al. (2013). "Prevalence of overweight and obesity in adult Nigerians–a systematic review."

Clancy, L., et al. (2002). "Effect of air-pollution control on death rates in Dublin, Ireland: an intervention study." The Lancet **360**(9341): 1210-1214.

Clegg, L. X., et al. (2009). "Estimating average annual per cent change in trend analysis." Statistics in medicine **28**(29): 3670-3682.

Coleman, J. S. (1965). Nigeria: Background to nationalism, Univ of California Press.

Contractor, A., et al. (2014). "Addressing Cardiovascular Disease Burden in low and Middle Income Countries (LMICs)." Current Cardiovascular Risk Reports **8**(11): 1-9.

Copstein, L., et al. (2013). "Prevalence and risk factors for stroke in a population of Southern Brazil." Arquivos de neuro-psiquiatria **71**(5): 294-300.

Cornier, M.-A., et al. (2011). "Assessing adiposity a scientific statement from the American Heart Association." Circulation **124**(18): 1996-2019.

Cornier, M.-A., et al. (2011). "Assessing adiposity a scientific statement from the American Heart Association." Circulation **124**(18): 1996-2019.

Danbauchi, S. (1996). "Ischaemic heart disease and myocardial infarction in ABU Teaching Hospital, Zaria: a 10 year review (1985 to 1994); a short report." The Central African journal of medicine **42**(7): 209-211.

Danesi, M., et al. (2007). "Prevalence of stroke in an urban, mixed-income community in Lagos, Nigeria." Neuroepidemiology **28**(4): 216-223.

Davies, S. (1996). Adaptable livelihoods: coping with food insecurity in the Malian Sahel, Macmillan Press Ltd.

De Coster, S. and N. van Larebeke (2012). "Endocrine-disrupting chemicals: associated disorders and mechanisms of action." Journal of environmental and public health **2012**.

Department of Health (2016). Alcohol Guidelines Review – Report from the Guidelines development group to the UK Chief Medical Officers. London, United Kingdom**:** 1-43.

DerSimonian, R. and N. Laird (1986). "Meta-analysis in clinical trials." Controlled clinical trials **7**(3): 177-188.

DESA, U. (2015). World Population Prospects: The 2015 Revision, Key Findings and Advance Tables, Working Paper No ESA/P/WP. 241, United Nations, Department of Economic and Social Affairs, Population Division, New York.

Desalu, O. O., et al. (2011). "A review of stroke admissions at a tertiary hospital in rural Southwestern Nigeria." Annals of African medicine **10**(2).

Després, J.-P. (2012). "Body fat distribution and risk of cardiovascular disease an update." Circulation **126**(10): 1301-1313.

Despres, J.-P., et al. (1990). "Regional distribution of body fat, plasma lipoproteins, and cardiovascular disease." Arteriosclerosis, Thrombosis, and Vascular Biology **10**(4): 497-511.

Diez-Roux, A. V., et al. (2000). "A multilevel analysis of income inequality and cardiovascular disease risk factors." Social science & medicine **50**(5): 673-687.

Dong Y, L. S., Zhao-Qiang S, et al. (2010). " Investigation on prevalence of stroke in rural old groups of Liaoning province." Shanxi Medical Journal(39): 404-406.

DPR (2010). "National oil and gas reserve estimate." Retrieved April 10, 2016, from http://www.dprnigeria.com/

Duncan, M. J., et al. (2010). "Physical activity levels by occupational category in non-metropolitan Australian adults." Journal of Physical Activity and Health **7**(6): 718-723.

Dunton, G. F., et al. (2009). "Physical environmental correlates of childhood obesity: a systematic review." Obesity Reviews **10**(4): 393-402.

Duren, D. L., et al. (2008). "Body composition methods: comparisons and interpretation." Journal of diabetes science and technology **2**(6): 1139-1146.

Ebegbulem, J., et al. (2013). "Oil Exploration and Poverty in the Niger Delta Region of Nigeria: A Critical Analysis." International Journal of Business and Social Science **4**(3): 279-287.

Ebeku, K. S. (2006). "Oil and the Niger Delta People in International Law-Resource Rights, Environmental and Equity Issues." Oil, Gas & Energy Law Journal (OGEL) **4**(1).

Ebrahim, S., et al. (2013). "Tackling non-communicable diseases in low-and middle-income countries: is the evidence from high-income countries all we need." PLoS Med **10**(1): e1001377.

Eckert, S. and S. Kohler (2014). "Urbanization and health in developing countries: a systematic review." World Health & Population **15**(1): 7-20.

Economy, E. (2006). "Environmental governance: the emerging economic dimension." Environmental Politics **15**(02): 171-189.

Efe, S. I. (2008) "Spatial distribution of particulate air pollution in Nigerian cities: Implications for human health." Journal of Environmental Health Research **7**(2)107-116.

Egbe, R. E. and D. Thompson (2010). "Environmental challenges of oil spillage for families in oil producing communities of the niger delta region." Journal of Home Economics Research **13**: 24-34.

Egbi, O. G., et al. (2015). "Prevalence of hypertension and its correlates among employees of a tertiary hospital in Yenagoa, Nigeria." Annals of African medicine **14**(1): 8.

Egger, M., et al. (1997). "Bias in meta-analysis detected by a simple, graphical test." BMJ **315**(7109): 629-634.

Egwurugwu, J., et al. (2013). "Prolonged Gas Flaring and Water Quality in Obiakpu Egbema, IMO State, Nigeria." International Research Journal Environmental Science **2**(4): 1-5.

Ejughemre, U. J. (2014). "Accelerated reforms in healthcare financing: the need to scale up private sector participation in Nigeria." International journal of health policy and management **2**(1): 13.

Ekanem, U., et al. (2013). "High blood pressure in a semi-urban community in south-south Nigeria: a community-based study." African Health Sciences **13**(1): 56-61.

Ekpenyong, C. and E. Akpan (2013). "Urbanization drift and obesity epidemic in sub-Saharan Africa: a review of the situation in Nigeria." European Journal of Sustainable Development **2**(2): 141.

Ekpenyong, C. E., et al. (2012). "Urban city transportation mode and respiratory health effect of air pollution: a cross-sectional study among transit and non-transit workers in Nigeria." BMJ Open **2**(5).

Ekpenyong, C., et al. (2012b). "Double burden, non-communicable diseases and risk factors evaluation in sub-Saharan Africa: The Nigerian experience." European Journal of Sustainable Development **1**(2): 249-270.

Ekpo, A. H. (2005). "Industrialization and Nigeria‟ s Economic Development." The Challenges of Industrialization: A Pathway of Nigeria Becoming a Highly Industrialized Country in the Year 2015: 3-26.

Ekpoh, I. J. and A. E. Obia (2010). "The role of gas flaring in the rapid corrosion of zinc roofs in the Niger Delta Region of Nigeria." The Environmentalist **30**(4): 347-352.

Ekwunife, O. I. and C. N. Aguwa (2011). "A meta-analysis of prevalence rate of hypertension in Nigerian populations." J Public Health Epidemiol **3**(13): 604-607.

Elliott, P., et al. (1996). "Intersalt revisited: further analyses of 24 hour sodium excretion and blood pressure within and across populations." BMJ **312**(7041): 1249-1253.

Emmanuel, O. G., Douglason (2006). "The effect of oil spillage on crop yield and farm income in Delta State, Nigeria." Journal of Central European Agriculture **7**(1).

EPA (2003). Framework for cummulative risk assessment. Washington, DC, Unted States Environmental Protection Agency. **2003:** 1-109.

Eze, I. C., et al. (2015). "Association between ambient air pollution and diabetes mellitus in Europe and North America: systematic review and meta-analysis." Environ Health Perspect **123**(5): 381-389.

Ezejimofor, M. C., et al. (2016). "Stroke survivors in low-and middle-income countries: A meta-analysis of prevalence and secular trends." Journal of the Neurological Sciences **364**: 68-76.

Ezejimofor, M. C., et al. (2016). "The Burden of Hypertension in an Oil-and Gas-Polluted Environment: A Comparative Cross-Sectional Study." American journal of hypertension: hpw009.

Ezzati, M., et al. (2005). "Rethinking the "diseases of affluence" paradigm: global patterns of nutritional risks in relation to economic development." PLoS Med **2**(5): e133.

Familoni, B. O., et al. (2004). "Knowledge and awareness of hypertension among patients with systemic hypertension." Journal of the National Medical Association **96**(5): 620.

Fasona, M. J. and A. Omojola (2005). Climate change, human security and communal clashes in Nigeria. Human Security and Climate Change Conference.

Feigin, V. L., et al. (2003). "Stroke epidemiology: a review of population-based studies of incidence, prevalence, and case-fatality in the late 20th century." The Lancet Neurology **2**(1): 43-53.

Feigin, V. L., et al. (2014). "Global and regional burden of stroke during 1990–2010: findings from the Global Burden of Disease Study 2010." The Lancet **383**(9913): 245-255.

Fernandes, T. G., et al. (2014). "Stroke in the Rain Forest: Prevalence in a Ribeirinha Community and an Urban Population in the Brazilian Amazon." Neuroepidemiology **42**(4): 235-242.

Ferri, C. P., et al. (2011). "Prevalence of stroke and related burden among older people living in Latin America, India and China." Journal of Neurology, Neurosurgery & Psychiatry **82**(10): 1074-1082.

Finkel, M. L. and A. Law (2011). "The rush to drill for natural gas: a public health cautionary tale." Public Health **101**(784).

Florescu, M., et al. (2007). "Prevalence and control of cardiovascular risk factors in Romania cardio-zone national study." Mædica A Journal of Clinical Medicine **2**(4): 278.

Fouquet, R. (2010). "The slow search for solutions: Lessons from historical energy transitions by sector and service." Energy Policy **38**(11): 6586-6596.

Frynas, J. G. (2000). Oil in Nigeria: Conflict and litigation between oil companies and village communities, LIT Verlag Münster.

Frynas, J. G. (2001). "Corporate and state responses to anti-oil protests in the Niger Delta." African Affairs **100**(398): 27-54.

Fuentes, R., et al. (2000). "Hypertension in developing economies: a review of population-based studies carried out from 1980 to 1998." Journal of hypertension **18**(5): 521-529.

Gallagher, C., et al. (2011). The role of host communities' involvement in decision making for the sustainable development of the Niger Delta. **7:** 375-387.

Ganiyu, K. A., et al. "Prevalence of Undiagnosed Elevated Blood Pressure in Okparabe Community in Southern Nigeria."

Garrow, J. S. and J. Webster (1984). "Quetelet's index (W/H2) as a measure of fatness." International Journal of Obesity **9**(2): 147-153.

Ghg, I. (1999). "The reduction of greenhouse gas emission from the oil refining and petrochemical industry." IEA Greenhouse Gas R&D Programme, Cheltenham, UK.

Gill, D. A., et al. (2011). "The Exxon Valdez and BP oil spills: A comparison of initial social and psychological impacts*." American Behavioral Scientist: 0002764211408585.

Goldstein, H. and H. Goldstein (1981). The design and analysis of longitudinal studies: Their role in the measurement of change. Academic Press, No. 04; BF713, G6

Goldstein, H., et al. (2015). "Population sampling in longitudinal suverys." Longitudinal and Life Course Studies **6**(4): 447-475.

Gorber, S. C., et al. (2007). "A comparison of direct vs. self-report measures for assessing height, weight and body mass index: a systematic review." Obesity Reviews **8**(4): 307-326.

Griffiths, L., et al. (2010). "Risk factors for rapid weight gain in preschool children: findings from a UK-wide prospective study." International journal of obesity **34**(4): 624-632.

Griggs, D., et al. (2013). "Policy: Sustainable development goals for people and planet." Nature **495**(7441): 305-307.

Griggs, J. W. (2011). "BP Gulf of Mexico oil spill." Energy LJ **32**: 57.

Grotto, I., et al. (2008). "Hypertension and socioeconomic status." Current opinion in cardiology **23**(4): 335-339.

Grundy, S. M., et al. (1999). "Assessment of cardiovascular risk by use of multiple-risk-factor assessment equations: a statement for healthcare professionals from the American Heart Association and the American College of Cardiology." Journal of the American College of Cardiology **34**(4): 1348-1359.

Grydeland, M., et al. (2014). "Comparison of three generations of ActiGraph activity monitors under free-living conditions: do they provide comparable assessments of overall physical activity in 9-year old children?" BMC sports science, medicine and rehabilitation **6**(1): 1.

Guinhouya, K., et al. (2010). "[Cost of stroke in Lome (Togo).]." Sante (Montrouge, France).

Gundlach, E. R., et al. (2005). Incorporating biodiversity into sensitivity maps of the Niger river delta.

Gupta, S., et al. (2013). "Emerging risk factors for cardiovascular diseases: Indian context." Indian journal of endocrinology and metabolism **17**(5): 806.

Hamra, G. B., et al. (2014). "Outdoor particulate matter exposure and lung cancer: a systematic review and meta-analysis."

Hardoy, J. E. and D. Satterthwaite (1991). "Environmental problems of Third World cities: a global issue ignored?" Public administration and development **11**(4): 341-361.

Harper, S. (2009). "Rose's Strategy of Preventive Medicine. Geoffrey Rose with commentary by Kay-Tee Khaw and Michael Marmot." International Journal of Epidemiology **38**(6): 1743-1745.

Harrabi, I., et al. (2006). "Effects of particulate air pollution on systolic blood pressure: a population-based approach." Environmental Research **101**(1): 89-93.

Hayworth, J., et al. (2011). "Deepwater Horizon oil spill impacts on Alabama beaches." Hydrology and Earth System Sciences **15**(12): 3639.

He, Y., et al. (2006). "Prevalence of the metabolic syndrome and its relation to cardiovascular disease in an elderly Chinese population." Journal of the American College of Cardiology **47**(8): 1588-1594.

Hemberal, M., et al. (2015). "Evaluation of waist-to-hip ratio as a predictor of cardiovascular risk factors." International Journal of Medical Science and Public Health **4**(7): 961-963.

Higgins, J. and S. G. Thompson (2002). "Quantifying heterogeneity in a meta-analysis." Statistics in medicine **21**(11): 1539-1558.

Higgins, J. P., et al. (2003). "Measuring inconsistency in meta-analyses." BMJ: British Medical Journal **327**(7414): 557.

Hill, A. B. (1965). "The environment and disease: association or causation?" Proceedings of the Royal Society of Medicine **58**(5): 295.

Hoek, G., et al. (2013). "Long-term air pollution exposure and cardio-respiratory mortality: a review." Environ Health **12**(1): 43.

Holland, W. W., et al. (1979). "Health effects of particulate pollution: reappraising the evidence." American journal of epidemiology **110**(5): 527-527.

Horwitz, R. I., et al. (1984). "Case-control research: Temporal precedence and other problems of the exposure-disease relationship." Archives of internal medicine **144**(6): 1257-1259.

Hou, X., et al. (2013). "Impact of waist circumference and body mass index on risk of cardiometabolic disorder and cardiovascular disease in Chinese adults: a national diabetes and metabolic disorders survey." PloS one **8**(3): e57319.

Huxley, R. R. and M. Woodward (2011). "Cigarette smoking as a risk factor for coronary heart disease in women compared with men: a systematic review and meta-analysis of prospective cohort studies." The Lancet **378**(9799): 1297-1305.

Ibekwe, R. (2015). "Modifiable risk factors of hypertension and socio demographic profile in Oghara, Delta state; prevalence and correlates." Annals of medical and health sciences research **5**(1): 71-77.

Ibrahim, M. M. and A. Damasceno (2012). "Hypertension in developing countries." The Lancet **380**(9841): 611-619.

Ibrahim, M. M. and A. Damasceno (2012). "Hypertension in developing countries." The Lancet **380**(9841): 611-619.

Idahosa, P. (1987). "Hypertension: an ongoing health hazard in Nigerian workers." American journal of epidemiology **125**(1): 85-91.

Idemudia, U. (2009). "Oil extraction and poverty reduction in the Niger Delta: a critical examination of partnership initiatives." Journal of Business Ethics **90**(1): 91-116.

Ifedi, J. A. and J. N. Anyu (2011). "“Blood Oil,” Ethnicity, and Conflict in the Niger Delta Region of Nigeria." Mediterranean Quarterly **22**(1): 74-92.

Ijezie, I. C., et al. (2013). "Prevalence of abdominal obesity in Abia State, Nigeria: results of a population-based house-to-house survey." Diabetes, metabolic syndrome and obesity: targets and therapy **6**: 285.

Ike, S., et al. (2010). "Knowledge, perceptions and practices of lifestyle-modification measures among adult hypertensives in Nigeria." Transactions of the Royal Society of Tropical Medicine and Hygiene **104**(1): 55-60.

Ikelegbe, A. (2005). "The economy of conflict in the oil rich Niger Delta region of Nigeria." Nordic Journal of African Studies **14**(2): 208-234.

Iliescu, C., et al. (2008). "Socioeconomic questionnaire and clinical assessment in the HELENA Cross-Sectional Study: methodology." International Journal of Obesity **32**: S19-S25.

Initiative, N. O. E. (2010). Clinical guidelines on the identification, evaluation, and treatment of overweight and obesity in adults.

International Energy Agency (2010). Energy Poverty-How to make modern energy access universal? Special Early Excerpt of the World Energy Outlook 2010 for the UN General Assembly on the Millennium Development Goals. Paris." *International Energy Agency/OECD*

Ioannidis, J., et al. (2008). "Reasons or excuses for avoiding meta-analysis in forest plots: Heterogeneous data are a common problem in meta-analysis." British Medical Journal **7658**: 1413.

Ipingbemi, O. (2009). "Socio-economic implications and environmental effects of oil spillage in some communities in the Niger delta." Journal of Integrative Environmental Sciences **6**(1): 7-23.

Isara, A. R. and P. O. Okundia (2015). "The burden of hypertension and diabetes mellitus in rural communities in southern Nigeria." Pan African Medical Journal **20**(103).

Isezuo, S., et al. (2011). "Prevalence, associated factors and relationship between prehypertension and hypertension: a study of two ethnic African populations in Northern Nigeria." Journal of human hypertension **25**(4): 224-230.

Ite, A. E. and U. J. Ibok (2013). "Gas flaring and venting associated with petroleum exploration and production in the Nigeria's Niger Delta." American Journal of Environmental Protection **1**(4): 70-77.

Jaeschke, L., et al. (2015). "Measurement of Waist and Hip Circumference with a Body Surface Scanner: Feasibility, Validity, Reliability, and Correlations with Markers of the Metabolic Syndrome." PloS one **10**(3): e0119430.

Jagger, C., et al. (2007). "Educational differences in the dynamics of disability incidence, recovery and mortality: Findings from the MRC Cognitive Function and Ageing Study (MRC CFAS)." International Journal of Epidemiology **36**(2): 358-365.

Jeppesen, S., et al. (2006). Urban Environmental Managment in Developing Countries-Land Use, Environmental Health and Pollution Management-A Review, University of Copenhagen.

Jerrett, M., et al. (2014). "Traffic-related air pollution and obesity formation in children: a longitudinal, multilevel analysis." Environ Health **13**(1): 49.

Johansson, M., et al. (2004). Twenty-five years of effects research for the convention on long-range transboundary air pollution. Proceedings of the 13th World Clean Air and Environmental Protection Congress and Exhibition.

Johnston, S. C., et al. (2009). "Global variation in stroke burden and mortality: estimates from monitoring, surveillance, and modelling." The Lancet Neurology **8**(4): 345-354.

Jones, D. W. and J. E. Hall (2004). "Seventh report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure and evidence from new hypertension trials." Hypertension **43**(1): 1-3.

Kadafa, A. A. (2012). "Environmental impacts of oil exploration and exploitation in the Niger Delta of Nigeria." Global Journal of Science Frontier Research Environment & Earth Sciences **12**(3): 19-28.

Kadafa, A. A. (2012b). "Oil exploration and spillage in the Niger Delta of Nigeria." Civil and Environmental Research **2**(3): 38-51.

Kadiri, S., et al. (1999). "Blood pressure, hypertension and correlates in urbanised workers in Ibadan, Nigeria: a revisit." Journal of human hypertension **13**(1): 23-27.

Kandala, N.-B., et al. (2008). "Morbidity from diarrhoea, cough and fever among young children in Nigeria." Annals of tropical medicine and parasitology **102**(5): 427-445.

Kandala, N.-B., et al. (2013). "Geographic variation of hypertension in Sub-Saharan Africa: a case study of South Africa." American journal of hypertension: hps063.

Kannel, W. B. (2000). "The Framingham Study: ITS 50-year legacy and future promise." Journal of atherosclerosis and thrombosis **6**(2): 60-66.

Kaplan, N., et al. (2015). "Blood pressure measurement in the diagnosis and management of hypertension in adults." Blood pressure measurement in the diagnosis and management of hypertension in adults, UpToDate, Waltham, MA.

Kario, K., et al. (2006). "Morning hypertension: the strongest independent risk factor for stroke in elderly hypertensive patients." Hypertension research **29**(8): 581.

Katibi, I., et al. (2010). "Knowledge and practice of hypertensive patients as seen in a tertiary hospital in the middle belt of Nigeria." Nigerian journal of clinical practice **13**(2).

Katsouyanni, K., et al. (2001). "Confounding and effect modification in the short-term effects of ambient particles on total mortality: results from 29 European cities within the APHEA2 project." Epidemiology **12**(5): 521-531.

Kearney, P. M., et al. (2005). "Global burden of hypertension: analysis of worldwide data." The Lancet **365**(9455): 217-223.

Kengne, A. P. and C. S. Anderson (2006). "The neglected burden of stroke in Sub-Saharan Africa." International Journal of Stroke **1**(4): 180-190.

Kestenbaum, B. (2009). Cross-Sectional Studies. Epidemiology and Biostatistics: An Introduction to Clinical Research. New York, NY, Springer New York**:** 29-31.

Khan, S. A. (1994). "Nigeria: The political economy of oil."

Khattar, R. S., et al. (1998). "Cardiovascular outcome in white-coat versus sustained mild hypertension A 10-year follow-up study." Circulation **98**(18): 1892-1897.

Kim, K.-N., et al. (2016). "Associations of air pollution exposure with blood pressure and heart rate variability are modified by oxidative stress genes: A repeated-measures panel among elderly urban residents." Environmental Health **15**(1): 1.

King, R. O. (2010). Deepwater horizon oil spill disaster: Risk, recovery, and insurance implications. Pennsylvania, USA, Diane Publishing.

Kio, P. (1982). "Forest conservation strategies for tropical Africa." NRTS-United Nations University (UNU).

Kirkpatrick, C. and N. Lee (1997). Sustainable development in a developing world: integrating socio-economic appraisal and environmental assessment, Edward Elgar Publishing Ltd.

Klein, R. J., et al. (2001). "Age adjustment using the 2000 projected US population."

Klein, S., et al. (2007). "Waist circumference and cardiometabolic risk: a consensus statement from shaping America's health: Association for Weight Management and Obesity Prevention; NAASO, the Obesity Society; the American Society for Nutrition; and the American Diabetes Association." Obesity **15**(5): 1061-1067.

Kosinski, A. S. and W. D. Flanders (1999). "Evaluating the exposure and disease relationship with adjustment for different types of exposure misclassification: a regression approach." Statistics in medicine **18**(20): 2795-2808.

Krakoff, L. R., et al. (2014). "2014 hypertension recommendations from the eighth joint national committee panel members raise concerns for elderly black and female populations." Journal of the American College of Cardiology **64**(4): 394-402.

Kranakis, E. (2009). "Heat, Power, and Light: Revolutions in Energy Services (review)." Technology and Culture **50**(3): 699-701.

Krause, T., et al. (2011). "Management of hypertension: summary of NICE guidance." BMJ **343**: d4891.

Krauss, R. M., et al. (1998). "Obesity impact on cardiovascular disease." Circulation **98**(14): 1472-1476.

Krishna, K. (1989). "Conducting key informant interviews in developing countries." Retrieved from January **27**: 2010.

Krzyzanowski, M., et al. (2005). "Particulate matter air pollution: how it harms health." World Health Organization.

Kuklina, E. V., et al. (2012). "Epidemiology and prevention of stroke: a worldwide perspective." Expert review of neurotherapeutics **12**(2): 199-208.

Künzli, N. (2012). "Air pollution and atherosclerosis: new evidence to support air quality policies." PLoS medicine **10**(4): e1001432-e1001432.

La Merrill, M. and L. S. Birnbaum (2011). "Childhood obesity and environmental chemicals." Mount Sinai Journal of Medicine: A Journal of Translational and Personalized Medicine **78**(1): 22-48.

Lagrand, W. K., et al. (1999). "C-reactive protein as a cardiovascular risk factor more than an epiphenomenon?" Circulation **100**(1): 96-102.

Lam, C. S. (2011). "The Socioeconomics of Hypertension How $50 000 May Buy a Drop in Blood Pressure." Hypertension: HYPERTENSIONAHA. 111.175984.

Lavados, P. M., et al. (2007). "Stroke epidemiology, prevention, and management strategies at a regional level: Latin America and the Caribbean." The Lancet Neurology **6**(4): 362-372.

Lawanson, A., et al. (1983). The effects of waste-gas flares on the surrounding cassava plantations in the Niger Delta regions of Nigeria. Symposium of the International Society for Tropical Root Crops (6, 1983, Lima, Peru). Proceedings.

Lawes, C. M., et al. (2006). "Blood pressure and the global burden of disease 2000. Part II: estimates of attributable burden." Journal of hypertension **24**(3): 423-430.

Lee, K. K., et al. (2014). "Air Pollution and Stroke: A Systematic Review and Meta-Analysis." Circulation **130**(Suppl 2): A9900-A9900.

Lee, P. H., et al. (2011). "Validity of the international physical activity questionnaire short form (IPAQ-SF): A systematic review." International Journal of Behavioral Nutrition and Physical Activity **8**(1): 115.

Li, J. and J. Siegrist (2012). "Physical activity and risk of cardiovascular disease—a meta-analysis of prospective cohort studies." International Journal of Environmental Research and Public Health **9**(2): 391-407.

Li, S.-c., et al. (1985). "Cerebrovascular disease in the People's Republic of China Epidemiologic and clinical features." Neurology **35**(12): 1708-1708.

Liberati, A., et al. (2009). "The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate health care interventions: explanation and elaboration." Annals of internal medicine **151**(4): W-65-W-94.

Lim, S. S., et al. (2013). "A comparative risk assessment of burden of disease and injury attributable to 67 risk factors and risk factor clusters in 21 regions, 1990–2010: a systematic analysis for the Global Burden of Disease Study 2010." The Lancet **380**(9859): 2224-2260.

Lloyd-Jones, D. M., et al. (2004). "Parental cardiovascular disease as a risk factor for cardiovascular disease in middle-aged adults: a prospective study of parents and offspring." Jama **291**(18): 2204-2211.

Lloyd-Sherlock, P. (2010). "Stroke in developing countries: epidemiology, impact and policy implications." Development Policy Review **28**(6): 693-709.

Lopez, A. D., et al. (2006). "Global and regional burden of disease and risk factors, 2001: systematic analysis of population health data." The Lancet **367**(9524): 1747-1757.

Mainous, A. G., et al. (2004). "Race, rural residence, and control of diabetes and hypertension." The Annals of Family Medicine **2**(6): 563-568.

Marcotullio, P. J., et al. (2005). Globalization and urban environmental transitions: Comparison of New York's and Tokyo's experiences. Globalization and Urban Development, Springer**:** 289-310.

Marcotullio, P. J., et al. (2005). Globalization and urban environmental transitions: Comparison of New York's and Tokyo's experiences. Globalization and Urban Development, Springer**:** 289-310.

Maredza, M. and L. Chola (2016). "Economic burden of stroke in a rural South African setting." eNeurologicalSci **3**: 26-32.

Marschke, M. J. and F. Berkes (2006). "Exploring strategies that build livelihood resilience: a case from Cambodia." Ecology and Society **11**(1): 42.

Masdeu, J. C. and J. Biller (2011). Localization in clinical neurology, Lippincott Williams & Wilkins.

Mbah, B., et al. (2013). "Prevalence and risk factors of hypertension among middle-aged adults in Ahiazu Mbaise Local Government Area, Imo State, Nigeria." International Journal of Basic & Applied Sciences **13**: 26-30.

McConnell, R., et al. (2015). "A longitudinal cohort study of body mass index and childhood exposure to secondhand tobacco smoke and air pollution: the Southern California Children's Health Study." Environmental Health Perspectives **123**(4): 360.

McCrea-Strub, A., et al. (2011). "Potential impact of the Deepwater Horizon oil spill on commercial fisheries in the Gulf of Mexico." Fisheries **36**(7): 332-336.

McEniery, C. M., et al. (2007). "Age, hypertension and arterial function." Clinical and Experimental Pharmacology and Physiology **34**(7): 665-671.

McLean, R. M. (2014). "Measuring population sodium intake: a review of methods." Nutrients **6**(11): 4651-4662.

Mendez, M. and B. Popkin (2004). "Globalization, urbanization and nutritional change in the developing world." Globalization of food systems in developing countries: Impact on food security and nutrition: 55-80.

Meneghini, F., et al. (1991). "Door-to-door prevalence survey of neurological diseases in a Sicilian population." Neuroepidemiology **10**(2): 70-85.

Micha, R., et al. (2014). "Global Burden of Diseases Nutrition and Chronic Diseases Expert Group NutriCoDE. Global, regional, and national consumption levels of dietary fats and oils in 1990 and 2010: a systematic analysis including 266 country--specific nutrition surveys." BMJ **348**: g2272.

Mickey, R. and S. Greenland (1987). "A study of the impact of confounder-selection criteria on effect estimation." American Journal of Epidemiology **126**(4): 737-737.

Millar, S. R., et al. (2015). "Assessing cardiometabolic risk in middle-aged adults using body mass index and waist–height ratio: are two indices better than one? A cross-sectional study." Diabetology & metabolic syndrome **7**(1): 1.

Miller, A. (2012). Alcohol Guidelines: Eleventh Report of Session 2010-12,[Vol. 1]: Report, Together with Formal Minutes, Oral and Written Evidence, The Stationery Office.

Miller, J. J. (1978). "The inverse of the Freeman–Tukey double arcsine transformation." The American Statistician **32**(4): 138-138.

Miller, M. A., et al. (2014). "Cross-sectional study of sleep quantity and quality and amnestic and non-amnestic cognitive function in an ageing population: the English longitudinal study of ageing (ELSA)." PloS one **9**(6): e100991.

Minor, D., et al. (2008). "Does socioeconomic status affect blood pressure goal achievement?" Current hypertension reports **10**(5): 390-397.

Mittelmark, M. B. and B. Sternberg (1985). "Assessment of salt use at the table: comparison of observed and reported behavior." American journal of public health **75**(10): 1215-1216.

Mohan, P. (1996). "Nigeria: Poverty in the midst of plenty-The challenge of growth with inclusion." World Bank Group Findings: African Region.

Moher, D., et al. (2009). "Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement." Annals of internal medicine **151**(4): 264-269.

Moore, E. (2003). "Preparing for an aging world: the case for cross-national research, Panel on a Research Agenda and New Data for an Aging World." International Journal of Population Geography **9**(5): 435-436.

Moreno, C. (2010). "Prevalence of stroke and associated risk factors in older adults in Havana City and Matanzas Provinces, Cuba (10/66 population-based study)." MEDICC review **12**(3): 20.

Mozaffarian, D., et al. (2015). "Heart disease and stroke statistics-2015 update: a report from the american heart association." Circulation **131**(4): e29.

Mukherjee, D. and C. G. Patil (2011). "Epidemiology and the global burden of stroke." World neurosurgery **76**(6): S85-S90.

Muldoon, M. F., et al. (1993). "Family History Studies in Hypertension Research Review of the Literature." American journal of hypertension **6**(1): 76-88.

National Population Commission (2007). Report of Nigeria's National Population Commission on the 2006 census, Blackwell Oxon, England.

National Population Commission, I. M. (2008). Nigeria demographic and health survey 2008. Abuja, Nigeria, National Population Commission and ORC Macro.

National Population Commission, I. M. (2014). "ICF International. Nigeria. Demographic and health survey 2013." Abuja, Nigeria.

Navti, L. K., et al. (2014). "Contribution of socioeconomic status, stature and birth weight to obesity in Sub-Saharan Africa: cross-sectional data from primary school-age children in Cameroon." BMC public health **14**(1): 1.

Navti, L. K., et al. (2015). "Height-obesity relationship in school children in Sub-Saharan Africa: results of a cross-sectional study in Cameroon." BMC research notes **8**(1): 98.

NDDC (1997). Niger Delta Environmental Survey, Environmental and Socio-Economic Characteristics

Nduka, J., et al. (2008). "Acid rain phenomenon in Niger delta region of Nigeria: Economic, biodiversity, and public health concern." The Scientific World Journal **8**: 811-818.

New Nigerian Foundation (2011). "Analysis of Economic Opportunities in the Niger Delta." Retrieved September, 10, 2015, from http://www.nnfng.org/news/8-analysis-of-economic-opportunities-in-niger-delta.

Newbold, R. R. (2010). "Impact of environmental endocrine disrupting chemicals on the development of obesity." Hormones (Athens) **9**(3): 206-217.

Newby, D. E., et al. (2014). "Expert position paper on air pollution and cardiovascular disease." European heart journal: ehu458.

Nielsen, L. (2011). "Classifications of countries based on their level of development: How it is done and how it could be done." IMF Working Papers: 1-45.

Nkhoma, O. W., et al. (2013). "Early-stage primary school children attending a school in the Malawian School Feeding Program (SFP) have better reversal learning and lean muscle mass growth than those attending a non-SFP school." The Journal of nutrition **143**(8): 1324-1330.

Nkwocha, E. E. and E. C. Pat-Mbano (2010). "Effect of gas flaring on buildings in the oil producing rural communities of River State, Nigeria." African Research Review **4**(2).

Noonan, R. J., et al. (2016). "Cross-sectional associations between high-deprivation home and neighbourhood environments, and health-related variables among Liverpool children." BMJ open **6**(1): e008693.

Normand, S. (1999). "Meta-analysis: formulating, evaluating, combining and reporting Stat Med 18: 321–359." Find this article online.

Nriagu, J. (2011). "Oil Industry and the Health of Communities in the Niger Delta of Nigeria." Encyclopedia of Environmental Health: 240-250.

Nwafor, A. and A. Owhoji (2010). "Prevalence of diabetes mellitus among Nigerians in Port Harcourt correlates with socio-economic status." Journal of Applied Sciences and Environmental Management **5**(1).

Nwidu, L., et al. (2008). "Assesment of the water quality and prevalence of water borne diseases in Amassoma, Niger Delta, Nigeria." African Journal of Biotechnology **7**(17).

Nwilo, P. and O. Badejo (2005). Oil spill problems and management in the Niger Delta. International Oil Spill Conference, American Petroleum Institute.

Nwokeji, G. U. (2007). The Nigerian national petroleum corporation and the development of the Nigerian oil and gas industry: History, strategies and current directions, James A. Baker III Institute for Public Policy, Rice University.

Nwoko, C. N. (2014). "Assessing the Socioeconomic Impacts Arising from Oil Pollutions in the Niger Delta Region of Nigeria–Environmental Law and Management."

Obadan, M. I. (2001). "Poverty reduction in Nigeria: The way forward." CBN Economic and financial review **39**(4): 159-188.

Obia, A. (2009). "The effect of industrial air-borne pollutants on the durability of galvanized iron roofs in the tropical humid region of Nigeria." Global Journal of Environmental Sciences **8**(2): 89.

Obia, A. E., et al. (2011). "The role of sulphur dioxide and gas flare particulates on the corrosion of galvanized iron roof sheets in south-south region of Nigeria." Scientific Research and Essays **6**(27): 5734-5740.

O'Brien, E., et al. (2001). "Blood pressure measuring devices: recommendations of the European Society of Hypertension." British Medical Journal **322**(7285): 531.

Odeniran O.A, S. A. "Poverty and hypertension in Nigerian adults: A barrier to its control and treatment. A review." Unique Research Journal **1**(3): 14-20.

Odili, A. N. and E. O. Abatta (2015). "Blood pressure indices, life-style factors and anthropometric correlates of casual blood glucose in a rural Nigerian community." Annals of African medicine **14**(1): 39.

Odjugo, P. and E. Osemwenkhae (2009). "Natural gas flaring affects microclimate and reduces maize (Zea mays) yield." International Journal of Agriculture and Biology **11**(4): 408-412.

Odoemene, A. (2011). "Social consequences of environmental change in the Niger Delta of Nigeria." Journal of Sustainable Development **4**(2): 123-135.

Odoemene, A. (2011). "Social consequences of environmental change in the Niger Delta of Nigeria."

Ofuya, Z. M. (2007). "The incidence of hypertension among a select population of adults in the Niger Delta region of Nigeria."

Ogah, O. S., et al. (2012). "Blood pressure, prevalence of hypertension and hypertension related complications in Nigerian Africans: A review." World J Cardiol **4**(12): 327-340.

Ogechi, U. P., et al. (2007). "Nutritional status and energy intake of adolescents in Umuahia urban, Nigeria." Pakistan journal of Nutrition **6**(6): 641-646.

Oguntona, C. R. and I. O. Akinyele (2002). "Food and nutrient intakes by pregnant Nigerian adolescents during the third trimester." Nutrition **18**(7): 673-679.

Oguoma, V. M., et al. (2015). "Prevalence of cardiovascular disease risk factors among a Nigerian adult population: relationship with income level and accessibility to CVD risks screening." BMC public health **15**(1): 1.

Okeahialam, B., et al. (2014). "Cardiovascular epidemiological transition in a rural habitat of Nigeria: the case of Mangu local government area." West African journal of medicine **31**(1): 14–18.

Okoji, M. A. (2002). "Social implications of the petroleum oil industry in the Niger Delta." International Journal of Environmental Studies **59**(2): 197-210.

Okojie, O., et al. (2000). "Assessment of health of senior executives in a developing country." Public Health **114**(4): 273-275.

Okonkwo, C. N. P., et al. (2015). "The Niger Delta wetland ecosystem: What threatens it and why should we protect it?" African Journal of Environmental Science and Technology **9**(5): 451-463.

Okpechi, I. G., et al. (2013). "Blood pressure gradients and cardiovascular risk factors in urban and rural populations in Abia State South Eastern Nigeria using the WHO STEPwise approach." PloS one **8**(9): e73403.

Olatunbosun, S., et al. (2011). "Prevalence of obesity and overweight in urban adult Nigerians." Obesity Reviews **12**(4): 233-241.

O'Leary, Z. (2013). The essential guide to doing your research project, Sage.

Olubodun, J. O., et al. (1997). "Salt intake and blood pressure in Nigerian hypertensive patients." International journal of cardiology **59**(2): 185-188.

Omorogiuwa, A., et al. (2009). "Comparative study on risk factors for hypertension in a University setting in Southern Nigeria." International Journal Biomedical and Health Science [serial on the Internet].

Omran, A. R. (2005). "The epidemiologic transition: a theory of the epidemiology of population change." Milbank Quarterly **83**(4): 731-757.

Omuemu, V., et al. (2008). "Awareness of high blood pressure status, treatment and control in a rural community in Edo state." Nigerian journal of clinical practice **10**(3): 208-212.

Onwuchekwa, A. C., et al. (2012). "Prevalence of hypertension in Kegbara-Dere, a rural community in the Niger Delta region, Nigeria." Ethn Dis **22**(3): 340-346.

Onwuchekwa, A. C., et al. (2014). "Prevalence and risk factors for stroke in an adult population in a rural community in the Niger delta, south-south Nigeria." Journal of Stroke and Cerebrovascular Diseases **23**(3): 505-510.

Onwuchekwa, A., et al. (2009). "Stroke in young Nigerian adults." Journal of Vascular Nursing **27**(4): 98-102.

Onyechi, K. C. N., et al. (2016). "Probable Psychological Impacts of Environmental Pollution (Oil Spills) in the Coastal Areas of the Niger Delta of Nigeria: a Philosophical Discourse." American-Eurasian Journal of Agricultural and Environmental Science **16**(2): 374-379

Opie, L. H. and B. M. Mayosi (2005). "Cardiovascular disease in sub-Saharan Africa." Circulation **112**(23): 3536-3540.

Ordinioha, B. (2013). "The prevalence of hypertension and its modifiable risk factors among lecturers of a medical school in Port Harcourt, south-south Nigeria: implications for control effort." Nigerian journal of clinical practice **16**(1): 1-11.

Ordinioha, B. and S. Brisibe (2013). "Prevalence of hypertension and its modifiable risk factors amongst traditional chiefs of an oil-bearing community in south-south Nigeria." Sahel Medical Journal **16**(1): 24.

Ordinioha, B. and S. Brisibe (2013). "The human health implications of crude oil spills in the Niger delta, Nigeria: An interpretation of published studies." Nigerian Medical Journal **54**(1): 10.

Ordinioha, B. and W. Sawyer (2008). "Food insecurity, malnutrition and crude oil spillage in a rural community in Bayelsa State, south-south Nigeria." Nigerian Journal of Medicine: Journal of the National Association of Resident Doctors of Nigeria **17**(3): 304-309.

Ordinioha, B., Sawyer, W. (2010). "Acute health effects of a crude oil spill in a rural community in Bayelsa State, Nigeria" Nigerian Journal of Medicine 19(2).

Orogun, P. S. (2010). "Resource control, revenue allocation and petroleum politics in Nigeria: The Niger Delta question." GeoJournal **75**(5): 459-507.

Ortega, R. M., et al. (2011). "Estimation of salt intake by 24 h urinary sodium excretion in a representative sample of Spanish adults." British Journal of Nutrition **105**(05): 787-794.

Ortolano, L. (1997). Environmental regulation and impact assessment, John Wiley and Sons.

Osagie, J., et al. (2010). "Causes of Conflicts in the Niger Delta Region of Nigeria as Expressed by the Youth in Delta State." Procedia-Social and Behavioral Sciences **5**: 82-89.

Ostro, B., et al. (2007). "The effects of components of fine particulate air pollution on mortality in California: results from CALFINE." Environmental Health Perspectives: 13-19.

Osuji, L. C. and S. O. Adesiyan (2005). "Extractable hydrocarbons, nickel and vanadium contents of ogbodo-isiokpo oil spill polluted soils in Niger Delta, Nigeria." Environmental Monitoring and Assessment **110**(1-3): 129-139.

Osuji, L. C., et al. (2004). "Post‐Impact Assessment of Oil Pollution in Agbada West Plain of Niger Delta, Nigeria: Field Reconnaissance and Total Extractable Hydrocarbon Content." Chemistry & Biodiversity **1**(10): 1569-1578.

Osuntokun, B. O., et al. (1982). "Research protocol for measuring the prevalence of neurologic disorders in developing countries." Neuroepidemiology **1**(3): 143-153.

Otaha, J. I. (2012). "Dutch disease and Nigeria oil economy." African Research Review **6**(1): 82-90.

Otaigbe, B. and A. Adesina (2005). "Crude oil poisoning in a 2 year old Nigerian-A case report." Anil Aggrawals Intern J Forens Med Toxicol **6**(2).

Owolabi, M. O., et al. (2015). "The burden of stroke in Africa: a glance at the present and a glimpse into the future: review article."

Oyedepo, S. O. (2012). "Energy and sustainable development in Nigeria: the way forward." Energy, Sustainability and Society **2**(1): 1-17.

Panayotou, T. (1993). Empirical tests and policy analysis of environmental degradation at different stages of economic development, International Labour Organization.

Pandian, J. D. and P. Sudhan (2013). "Stroke epidemiology and stroke care services in India." J Stroke **15**(3): 128-134.

Panel, N. O. E. I. E. (1998). "on the Identification, Evaluation, and Treatment of Overweight and Obesity in Adults. Clinical guidelines on the identification, evaluation, and treatment of overweight and obesity in adults—the evidence report." Obes Res **6**(Suppl 2): 51S-209S.

Pateman, T. (2011). "Rural and urban areas: comparing lives using rural/urban classifications." Regional Trends **43**(1): 11-86.

Pearson, S. R. (1970). Petroleum and the Nigerian economy, Stanford University Press.

Peters, A., et al. (1997). "Increased plasma viscosity during an air pollution episode: a link to mortality?" The Lancet **349**(9065): 1582-1587.

Pickering, T. (1999). "Cardiovascular pathways: socioeconomic status and stress effects on hypertension and cardiovascular function." Annals of the New York Academy of Sciences **896**(1): 262-277.

Pickering, T. G., et al. (1988). "How common is white coat hypertension?" Jama **259**(2): 225-228.

Pickering, T. G., et al. (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**(1): 142-161.

Pierin, A. M., et al. (2008). "Blood pressure measurements taken by patients are similar to home and ambulatory blood pressure measurements." Clinics **63**(1): 43-50.

Pinto, E. (2007). "Blood pressure and ageing." Postgraduate medical journal **83**(976): 109-114.

Polsa, P., et al. (2011). "Comparing the perceived quality of private and public health services in Nigeria." Journal of Management Policy and Practice **12**(7): 18-26.

Pope III, C. A. and D. W. Dockery (2006). "Health effects of fine particulate air pollution: lines that connect." Journal of the Air & Waste Management Association **56**(6): 709-742.

Pope, C. A., et al. (1995). "Review of epidemiological evidence of health effects of particulate air pollution." Inhalation toxicology **7**(1): 1-18.

Pope, C. A., et al. (2004). "Cardiovascular mortality and long-term exposure to particulate air pollution epidemiological evidence of general pathophysiological pathways of disease." Circulation **109**(1): 71-77.

Poungvarin, N. (1998). "Stroke in the developing world." The Lancet **352**: S19-S22.

Powell, C. (1993). "Sites and species of conservation interest in the Central Axis of the Niger Delta (Section C), report submitted to the Natural Resources Conservation Council of Nigeria." Biodiversity Unit, Rivers State University of Science and Technology, Port Harcourt, Nigeria.

Pradilla, A. G., et al. (2002). "[Study of neurological diseases prevalence in Aratoca, a rural area of eastern Colombia]." Revista medica de Chile **130**(2): 191-199.

Pradilla, A., et al. (2003). "National neuroepidemiological study in Colombia (EPINEURO)." Revista Panamericana de Salud Pública **14**(2): 104-111.

Qureshi, A. I. (2008). "Acute hypertensive response in patients with stroke pathophysiology and management." Circulation **118**(2): 176-187.

Raji, A. and T. Abejide (2013). "An Assessment Of Environmental Problems Associated With Oil Pollution And Gas Flaring In The Niger Delta Region Nigeria, C. 1960s-2000." Arabian Journal of Business and Management Review (Oman Chapter) **3**(3): 48.

Ranasinghe, P., et al. (2015). "The influence of family history of Hypertension on disease prevalence and associated metabolic risk factors among Sri Lankan adults." BMC public health **15**(1): 1.

Rankin, J. and M. Nieuwenhuijsen (2011). "Ambient air pollution and risk of congenital anomalies: a systematic review and meta-analysis." Environmental Health Perspectives **119**(5): 599.

Reddigan, J. I., et al. (2011). "Relation of physical activity to cardiovascular disease mortality and the influence of cardiometabolic risk factors." The American journal of cardiology **108**(10): 1426-1431.

Reiter, E. M. (2014). "The Impact of Social Support, Psychosocial Characteristics, and Contextual Factors on Racial Disparities in Hypertension." Doctoral dissertation, Utah State University.

Remais, J. V., et al. (2012). "Convergence of non-communicable and infectious diseases in low- and middle-income countries." International Journal of Epidemiology: dys135.

Robert, K. W., et al. (2005). "What is sustainable development? Goals, indicators, values, and practice." Environment: science and policy for sustainable development **47**(3): 8-21.

Roger, V. L., et al. (2011). "Heart disease and stroke statistics—2011 update a report from the American Heart Association." Circulation **123**(4): e18-e209.

Ronksley, P. E., et al. (2011). "Association of alcohol consumption with selected cardiovascular disease outcomes: a systematic review and meta-analysis." BMJ **342**: d671.

Roth, G. A., et al. (2015). "Demographic and epidemiologic drivers of global cardiovascular mortality." New England Journal of Medicine **372**(14): 1333-1341.

Rundle, A., et al. (2012). "Association of childhood obesity with maternal exposure to ambient air polycyclic aromatic hydrocarbons during pregnancy." American journal of epidemiology **175**(11): 1163-1172.

Sacco, R. L., et al. (2013). "An updated definition of stroke for the 21st century a statement for healthcare professionals from the American Heart Association/American Stroke Association." Stroke **44**(7): 2064-2089.

Sachs, J. D. (2012). "From millennium development goals to sustainable development goals." The Lancet **379**(9832): 2206-2211.

Sajjad, A., et al. (2013). "A systematic evaluation of stroke surveillance studies in low-and middle-income countries." Neurology **80**(7): 677-684.

Saka, Ö., et al. (2009). "Cost of stroke in the United Kingdom." Age and ageing **38**(1): 27-32.

Salerno, F., et al. (2008). Concept maps for combining hard and soft system thinking in the management of socio-ecosystems. 3rd International Conference on Concept Mapping, OÜ Vali Press.

Salonen, R. O., et al. (2007). "Abatement strategies for air pollution and health effects from locally emitted and transnationally transported biomass combustion aerosols (NORDAIR-BIOS)."

Saposnik, G. and O. H. Del Brutto (2003). "Stroke in South America A Systematic Review of Incidence, Prevalence, and Stroke Subtypes." Stroke **34**(9): 2103-2107.

Sarki, A. M., et al. (2015). "Prevalence of Hypertension in Low-and Middle-Income Countries: A Systematic Review and Meta-Analysis." Medicine **94**(50): e1959.

Satcher, D. (2010). "Include a Social Determinants of Health Approach to Reduce Health Inequities." Public Health Rep. **125**(4): 6-7.

ScHARR (2016). Mortality and morbidity risks from alcohol consumption in the UK: Analyses using the Sheffield Alcohol Policy Model (v.2.7) to inform the UK Chief Medical Officers' review of the UK lower risk drinking guidelines, University of Shefield**:** 1-74.

Schröder, H., et al. (2001). "Use of a three-day estimated food record, a 72-hour recall and a food-frequency questionnaire for dietary assessment in a Mediterranean Spanish population." Clinical Nutrition **20**(5): 429-437.

Schwandt, H. M., et al. (2010). "Marital status, hypertension, coronary heart disease, diabetes, and death among African American women and men: incidence and prevalence in the Atherosclerosis Risk in Communities (ARIC) study participants." Journal of family issues.

Scoones, I. (1998). "Sustainable rural livelihoods: a framework for analysis." IDS Working Paper 72

Seaton, A., et al. (1995). "Particulate air pollution and acute health effects." The Lancet **345**(8943): 176-178.

Shadish, W. R., et al. (2002). Experimental and quasi-experimental designs for generalized causal inference, Houghton, Mifflin and Company.

Shah, A. S., et al. (2015). "Short term exposure to air pollution and stroke: systematic review and meta-analysis." BMJ **350**: h1295.

Shamseer, L., et al. (2015). "Preferred reporting items for systematic review and meta-analysis protocols (PRISMA-P) 2015: elaboration and explanation." BMJ **349**: g7647.

Shell Petroleum Develoment Company (20016). Oil spills in the Niger Delta - Monthly Data for 2014. Lagos, Nigeria.

Shinton, R. and G. Beevers (1989). "Meta-analysis of relation between cigarette smoking and stroke." BMJ **298**(6676): 789-794.

Shuster, A., et al. (2014). "The clinical importance of visceral adiposity: a critical review of methods for visceral adipose tissue analysis." The British journal of radiology.

Simkhovich, B. Z., et al. (2008). "Air pollution and cardiovascular injury: epidemiology, toxicology, and mechanisms." Journal of the American College of Cardiology **52**(9): 719-726.

Singh, J., et al. (1995). "Defining an environmental development strategy for the Niger Delta (two volumes)." World Bank (Industry and Energy Operations Division, West Central Africa Department), Lagos.

Smil, V. (1994). "Energy in world history."

Smith, K. R., et al. (1999). "How much global ill health is attributable to environmental factors?" Epidemiology-Baltimore **10**(5): 573-584.

Sojinu, O. S., et al. (2010). "Polycyclic aromatic hydrocarbons in sediments and soils from oil exploration areas of the Niger Delta, Nigeria." Journal of Hazardous Materials **174**(1-3): 641-647.

Solomon, G. M. and S. Janssen (2010). "Health effects of the Gulf oil spill." Jama **304**(10): 1118-1119.

Spurgeon, J., et al. (2009). "Impact of Climate Change on Nigeria's Economy." Delivering sustainable solutions in a more competitive world. Environmental Resources Management 82608.

Straif, K., et al. (2005). "Carcinogenicity of polycyclic aromatic hydrocarbons." The lancet oncology **6**(12): 931-932.

Stranges, S., et al. (2004). "Relationship of alcohol drinking pattern to risk of hypertension a population-based study." Hypertension **44**(6): 813-819.

Stranges, S., et al. (2008). "Correlates of short and long sleep duration: A cross-cultural comparison between the United Kingdom and the United States the Whitehall II study and the Western New York health study." American journal of epidemiology **168**(12): 1353-1364.

Sudlow, C., et al. (1997). "Comparable studies of the incidence of stroke and its pathological types results from an international collaboration." Stroke **28**(3): 491-499.

Suh, H. H., et al. (2011). "Chemical properties of air pollutants and cause-specific hospital admissions among the elderly in Atlanta, Georgia." Environmental Health Perspectives **119**(10): 1421.

Suleiman, I. A., et al. (2013). "Prevalence and control of hypertension in a Niger Delta semi urban community, Nigeria." Pharmacy practice **11**(1): 24-29.

Sun, Q., et al. (2010). "Comparison of dual-energy x-ray absorptiometric and anthropometric measures of adiposity in relation to adiposity-related biologic factors." American Journal of Epidemiology: kwq306.

Suri, V. and D. Chapman (1998). "Economic growth, trade and energy: implications for the environmental Kuznets curve." Ecological Economics **25**(2): 195-208.

Tawari, C. and J. Abowei (2012). "Air Pollution in the Niger Delta Area of Nigeria." Int. J. Fish. Aquatic Sci **1**(2): 94-117.

Tenkorang, E. Y., et al. (2015). "Validity of Self-Report Data in Hypertension Research: Findings From The Study on Global Ageing and Adult Health." The Journal of Clinical Hypertension **17**(12): 977-984.

Thorogood, M., et al. (2007). "A cross-sectional study of vascular risk factors in a rural South African population: data from the Southern African Stroke Prevention Initiative (SASPI)." BMC public health **7**(1): 1.

Thuy, A. B., et al. (2010). "The association between smoking and hypertension in a population-based sample of Vietnamese men." Journal of hypertension **28**(2): 245-250.

Tourangeau, R. (2003). "Recurring Surveys: Issues and Opportunities: A report to the National Science Foundation based on a workshop held on March 28-29 2003." Arlington: National Science Foundation.

Tse, L., et al. (2012). "Incidence of ischaemic and haemorrhagic stroke and the association with smoking and smoking cessation: a 10-year multicentre prospective study in China." Public Health **126**(11): 960-966.

Tsze, D. S. and J. H. Valente (2011). "Pediatric stroke: a review." Emergency medicine international **2011**.

Ubani, E. and I. Onyejekwe (2013). "Environmental impact analysis of gas flaring in the Niger delta region of Nigeria." American J. of Scientific and Industrial Research **4**(2): 246-252.2013.

Udoh, I. A., et al. (2009). "Potential pathways to HIV/AIDS transmission in the Niger Delta of Nigeria: poverty, migration and commercial sex." AIDS Care **21**(5): 567-574.

Ugochukwu, C. N. and J. Ertel (2008). "Negative impacts of oil exploration on biodiversity management in the Niger De area of Nigeria." Impact Assessment and Project Appraisal **26**(2): 139-147.

Uhlig, K., et al. (2012). "Self-measured blood pressure monitoring: comparative effectiveness."

Ulasi, I., et al. (2010). "A community-based study of hypertension and cardio-metabolic syndrome in semi-urban and rural communities in Nigeria." BMC Health Services Research **10**(1): 1-6.

Unachukwu, C., et al. (2008). "Pattern of non-communicable diseases among medical admissions in Port Harcourt, Nigeria." Nigerian journal of clinical practice **11**(1): 14-17.

UNDP (2006). "Niger Delta human development report." Abuja: United Nations Development Programme.

UNDP (2009). Human Development Report Nigeria 2008 - 2009 Achieving growth with equity. Abuja: 167.

United Nations Environment Programme (2011). Environmental Assessment of Ogoniland. Nairobi, Kenya: 1-257.

Uphoff, E. P., et al. (2013). "A systematic review of the relationships between social capital and socioeconomic inequalities in health: a contribution to understanding the psychosocial pathway of health inequalities." Int J Equity Health **12**(1): 54.

US Energy Infomation Administration (2015, May 6, 2016). "Country Analysis Brief: Nigeria." Retrieved April 10, 2016, 2016, from http://www.eia.gov/beta/international/analysis_includes/countries_long/Nigeria/nigeria.pdf.

Van de Vijver, S., et al. (2014). "Status report on hypertension in Africa-consultative review for the 6th Session of the African Union Conference of Ministers of Health on NCD's." Pan African Medical Journal **16**(1).

Van der Sande, M. (2003). "Cardiovascular disease in sub-Saharan Africa: a disaster waiting to happen." Neth J Med **61**(2): 32-36.

Van Minh, H., et al. (2008). "Self-Reported Prevalence of Chronic Diseases and Their Relation to Selected Sociodemographic Variables: A Study in INDEPTH Asian Sites, 2005." Preventing chronic disease **5**(3).

Vandenbroucke, J. P., et al. (2007). "Strengthening the Reporting of Observational Studies in Epidemiology (STROBE): explanation and elaboration." Annals of internal medicine **147**(8): W-163-W-194.

Vlahov, D. and S. Galea (2002). "Urbanization, urbanicity, and health." Journal of Urban Health **79**(1): S1-S12.

Vyas, S. and L. Kumaranayake (2006). "Constructing socio-economic status indices: how to use principal components analysis." Health policy and planning **21**(6): 459-468.

Wahab, K. W. (2008). "The burden of stroke in Nigeria." International Journal of Stroke **3**(4): 290-292.

Wang, J. C. and M. Bennett (2012). "Aging and atherosclerosis mechanisms, functional consequences, and potential therapeutics for cellular senescence." Circulation Research **111**(2): 245-259.

Wang, X., et al. (2015). "A comparison of the physical and optical properties of anthropogenic air pollutants and mineral dust over Northwest China." Journal of Meteorological Research **29**: 180-200.

Wang, Y., et al. (2012). "Prevalence of Chronic Diseases and Influencing Factors Among Middle-aged and Senior Adults Aged over 50 in Rural Areas of Rushan City, 2009 [J]." Preventive Medicine Tribune **4**: 007.

Wei, Y., et al. (2016). "Chronic exposure to air pollution particles increases the risk of obesity and metabolic syndrome: findings from a natural experiment in Beijing." The FASEB Journal: fj. 201500142.

Welcome, M. O. (2011). "The Nigerian health care system: Need for integrating adequate medical intelligence and surveillance systems." Journal of Pharmacy and Bioallied Sciences **3**(4): 470.

Whelton, P. K., et al. (2002). "Primary prevention of hypertension: clinical and public health advisory from The National High Blood Pressure Education Program." Jama **288**(15): 1882-1888.

WHO (2000). The world health report 2000: health systems: improving performance, World Health Organization.

WHO (2015). "Nigeria: WHO Statistical Profile. ." Retrieved February 20, 2016, 2015, from http://www.who.int/gho/countries/nga.pdf.

WHO (2016). Health profile. Geneva, World Health Organization.

Willmot, M., et al. (2004). "High blood pressure in acute stroke and subsequent outcome a systematic review." Hypertension **43**(1): 18-24.

Winnicki, M., et al. (2006). "Lifestyle, family history and progression of hypertension." Journal of hypertension **24**(8): 1479-1487.

Woo, D., et al. (2004). "Effect of untreated hypertension on hemorrhagic stroke." Stroke **35**(7): 1703-1708.

World Bank (2014). Nigeria Economic Report. Washington, DC

World Health Organization (2005). "WHO STEPS Stroke Manual: The WHO STEPwise approach to stroke surveillance."

World Health Organization (2005b). "WHO STEPS surveillance manual: the WHO STEPwise approach to chronic disease risk factor surveillance."

World Health Organization (2006). "WHO Air quality guidelines for particulate matter, ozone, nitrogen dioxide and sulfur dioxide: global update 2005: summary of risk assessment."

World Health Organization (2006b). Health Risks of Particulate Matter from Long-range Transboundary Air Pollution: Joint WHO/Convention Task Force on the Health Aspects of Air Pollution, European Centre for Environment and Health.

World Health Organization (2007). "Reducing salt intake in populations: report of a WHO forum and technical meeting, 5-7 October 2006, Paris, France."

World Health Organization (2011). Waist circumference and waist–hip ratio : Report of a WHO expert consultation, Geneva, 8-11 December 2008. Geneva: 39.

World Health Organization (2016). Health profile. Geneva, World Health Organization.

World Health Organization and International Society of Hypertension Writing Group (2003). "2003 World Health Organization (WHO)/International Society of Hypertension (ISH) statement on management of hypertension." Journal of hypertension **21**(11): 1983-1992.

Xu, G., et al. (2013). "Is there a stroke belt in China and why?" Stroke **44**(7): 1775-1783.

Yarnell, J., et al. (2003). "Family history, longevity, and risk of coronary heart disease: the PRIME Study." International Journal of Epidemiology **32**(1): 71-77.

Yew, K. S. and E. Cheng (2009). "Acute stroke diagnosis." American family physician **80**(1): 33.

Yusuf, S., et al. (2001). "Global burden of cardiovascular diseases part I: general considerations, the epidemiologic transition, risk factors, and impact of urbanization." Circulation **104**(22): 2746-2753.

APPENDICES

Appendix 1: Study search strategy for hypertension studies

#1	hypertension' or 'blood pressure' or 'hypertens*'
#2	'population -based' or 'aetiology' or etiology' or 'prevalence' 'burden' or 'surveillance' or 'survey' or ' community-based' or 'etiology' or aetiology' or 'epidemiolog*
#3	'Niger Delta'or 'Oil producing States' or 'Oil producing communit*' or 'South South'or 'Abia' or 'Akwa Ibom'or 'Bayelsa' or 'Cross River' or 'Delta' or 'Edo' or 'Imo' or 'Ondo' or 'Rivers'
#4	#1 and #2 and #3

Appendix 2: Risk of bias assessment tool (Newcastle-Ottawa scale) for hypertension

Domain (source of bias)	Assessment	Risk of bias
Selection (Sample representative)	All subjects or random sampling (A)	Low
	Non-random sampling (B)	Moderate
	Selected group of users (C)	High
	No description of sampling strategy (D)	Unclear/High
Selection (Sample size)	Justified and satisfactory (A)	Low
	Not justified (B)	High
Detection (Outcome measurement)	Validated measurement tool (A)	Low
	Tool described but non-validated (B)	High
	Tool not described (C)	Unclear/High
Confounding (Controlled)	Adjusted for confounders (A)	Low
	No adjustment for confounders (B)	High
Detection (Outcome assessment)	Independent blind assessment (A)	-
	Record linkage (B)	-
	Self-report (C)	-
	No description (D)	-

Appendix 3: Risk of bias assessment for included hypertension studies

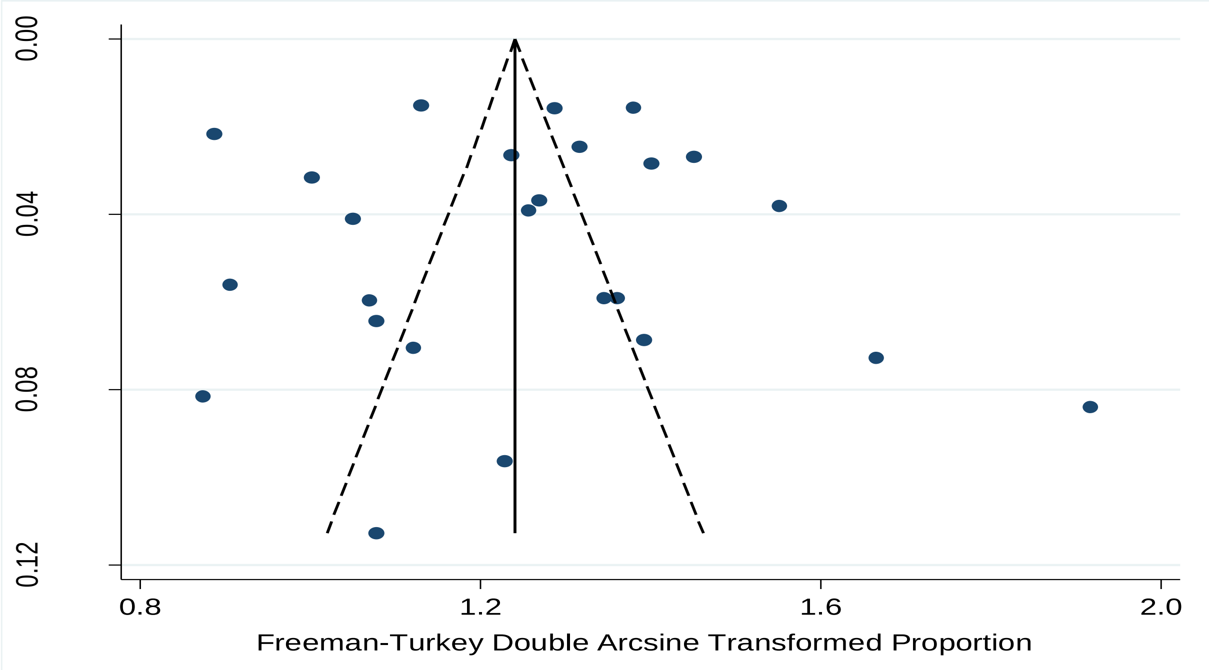
First Author	Publication Year	State	Selection Sampling	Selection (Sample size)	Detection (Outcome exposure)	Confounder (Controlled)	Detection (Outcome Assessment)
Idahosa	1987	Edo	Moderate risk	Moderate risk	Low risk	High risk	Moderate risk
Bunker	1992	Edo	Moderate risk	Moderate risk	Low risk	Moderate risk	Moderate risk
Okojie	2000	Edo	Moderate risk	Moderate risk	Low risk	High risk	Moderate risk
Omuemu	2006	Edo	Low risk	Low risk	Low risk	Low risk	Low risk
Ofuya	2007	Rivers	Moderate risk	Moderate risk	Low risk	High risk	Moderate risk
Akpa	2008	Rivers	Low risk	Low risk	Low risk	Moderate risk	Moderate risk
Ike	2008	Abia	Moderate risk	Moderate risk	Low risk	Moderate risk	Moderate risk
Omorogiuwa	2009	Edo	Moderate risk	Moderate risk	Low risk	Moderate risk	Moderate risk
Onwuchekwa	2012	Rivers	Low risk	Low risk	Low risk	Moderate risk	Moderate risk
Ekpenyong	2012	Akwa Ibom	Moderate risk	Low risk	Low risk	Moderate risk	Moderate risk
Andy	2012	Cross River	Moderate risk	Moderate risk	Low risk	Low risk	Low risk
Ijezie	2013	Abia	Low risk	Low risk	Low risk	Low risk	Low risk
Okpechi	2013	Abia	Low risk	Low risk	Low risk	Low risk	Low risk
Ekanem	2013	Akwa Ibom	Low risk	B	Low risk	Low risk	Low risk
Suleiman	2013	Bayelsa	Low risk	Low risk	Low risk	Moderate risk	Moderate risk
Ordinioha	2013	Rivers	Moderate risk	Moderate risk	Low risk	Moderate risk	Moderate risk
Ordinioha	2013	Rivers	Moderate risk	Moderate risk	Low risk	Moderate risk	Moderate risk
Mbah	2013	Imo	Moderate risk	Moderate risk	Low risk	Moderate risk	Moderate risk
Ganiyu	2014	Delta	Low risk	Moderate risk	Low risk	Moderate risk	Moderate risk
Oguoma	2015	Delta	Low risk	Low risk	Low risk	Low risk	Low risk
Oguoma	2015	Delta	Low risk	Low risk	Low risk	Low risk	Low risk
Ibekwe	2015	Delta	Low risk	Low risk	Low risk	Moderate risk	Moderate risk
Egbi	2015	Bayelsa	Moderate risk	Moderate risk	Low risk	Moderate risk	Moderate risk
Odili	2015	Imo	Moderate risk	Moderate risk	Low risk	Moderate risk	Moderate risk
Isara	2015	Edo	Moderate risk	Moderate risk	Low risk	Low risk	Low risk

Appendix 4: PRISMA checklist for hypertension studies

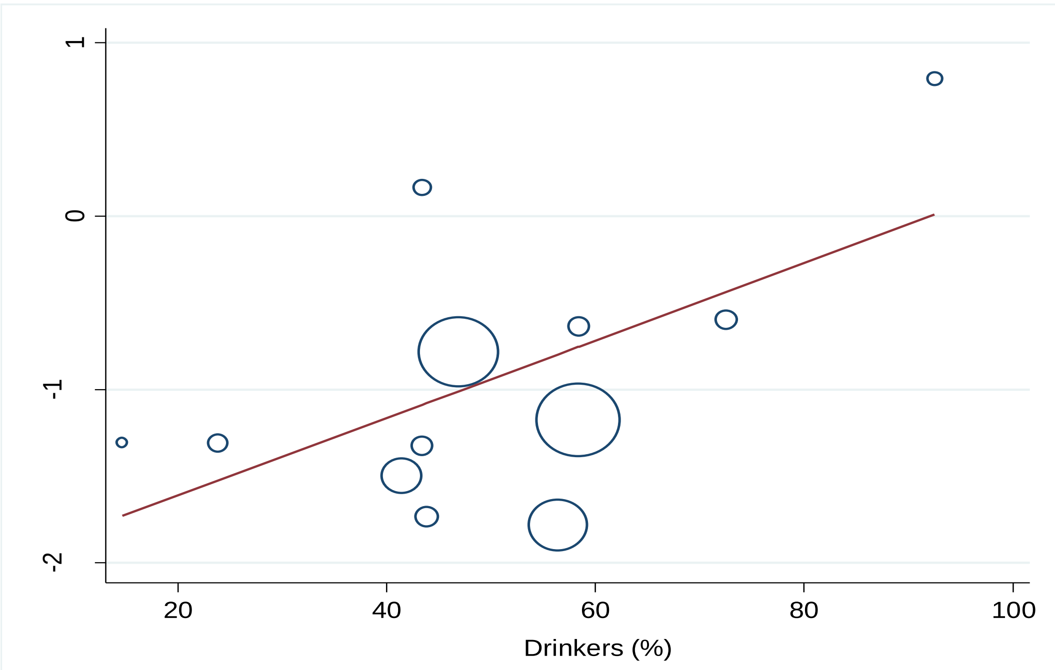
Section/topic	#	Checklist item	Reported on page #
TITLE			
Title	1	Identify the report as a systematic review, meta-analysis, or both.	
ABSTRACT			
Structured summary	2	Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number.	2
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known.	3
Objectives	4	Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS).	4
METHODS			
Protocol and registration	5	Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration information including registration number.	4
Eligibility criteria	6	Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale.	4-5
Information sources	7	Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched.	4-5
Search	8	Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated.	5
Study selection	9	State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis).	5
Data collection process	10	Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators.	6
Data items	11	List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made.	6
Risk of bias in individual studies	12	Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis.	6
Summary measures	13	State the principal summary measures (e.g., risk ratio, difference in means).	6

Section/topic	#	Checklist item	Reported on page #
Synthesis of results	14	Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g., I^2) for each meta-analysis.	6-7
Risk of bias across studies	15	Specify any assessment of risk of bias that may affect the cumulative evidence (e.g., publication bias, selective reporting within studies).	6
Additional analyses	16	Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified.	6-7
RESULTS			
Study selection	17	Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram.	8
Study characteristics	18	For each study, present characteristics for which data were extracted (e.g., study size, PICOS, follow-up period) and provide the citations.	8
Risk of bias within studies	19	Present data on risk of bias of each study and, if available, any outcome level assessment (see item 12).	8
Results of individual studies	20	For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group (b) effect estimates and confidence intervals, ideally with a forest plot.	9-10
Synthesis of results	21	Present results of each meta-analysis done, including confidence intervals and measures of consistency.	9-10
Risk of bias across studies	22	Present results of any assessment of risk of bias across studies (see Item 15).	9
Additional analysis	23	Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression [see Item 16]).	10
DISCUSSION			
Summary of evidence	24	Summarize the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g., healthcare providers, users, and policy makers).	10-13
Limitations	25	Discuss limitations at study and outcome level (e.g., risk of bias), and at review-level (e.g., incomplete retrieval of identified research, reporting bias).	13-
Conclusions	26	Provide a general interpretation of the results in the context of other evidence, and implications for future research.	14
FUNDING			
Funding	27	Describe sources of funding for the systematic review and other support (e.g., supply of data); role of funders for the systematic review.	15

Appendix 5: Funnel plot to detect publication bias

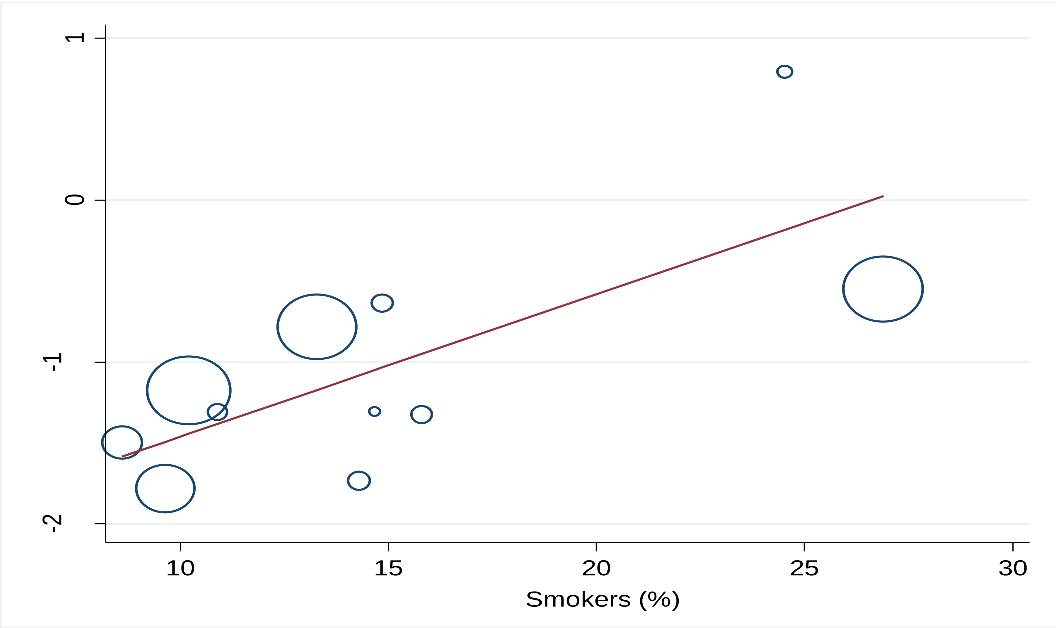


Appendix 6: Meta-regression of hypertension prevalence against proportion of alcohol drinkers



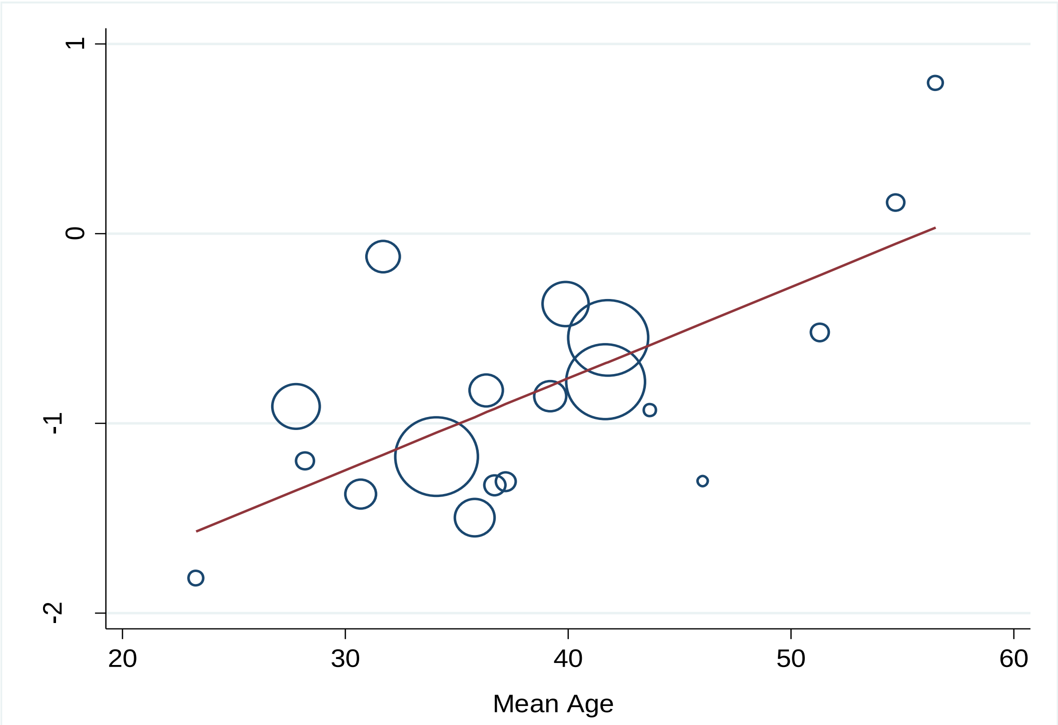
Coefficient: 0.02 (95% CI, 0.00-0.04), P=0.046

Appendix 7: Meta-regression of hypertension prevalence against smokers/Ex-smokers



Coefficient: 0.04 (95% CI, 0.03-0.12), P=0.016

Appendix 8: Meta-regression of hypertension prevalence against participants mean-age



Coefficient: 0.05 (95% CI, 0.02-0.07), P<0.001

Appendix 9: Search strategy for stroke studies

#1	stroke' or 'brain infarction' or 'brain stem infarctions' or 'cerebral infarction' or cerebrovascular accident' or 'cerebrovascular disease'
#2	'population based' or 'aetiology' or etiology' or 'prevalence' 'surveillance' or 'survey' or ' community based' or 'epidemiolog*
#3	'low-and middle-income countries' or 'developing countries' or 'Afghanistan 'or 'Albania' or 'Algeria 'or 'American Samoa' or 'Angola' or 'Antigua and Barbuda' or 'Argentina' or 'Armenia or 'Azerbaijan' or 'Bangladesh' or 'Belarus' or 'Belize' or 'Benin' or 'Bhutan' or 'Bolivia' or 'Bosnia and Herzegovina' or 'Botswana' or 'Brazil' or 'Bulgaria' or 'Burkina Faso' or 'Burundi' or 'Cambodia' or 'Cameroon' or 'Cape Verde 'or 'Central African Republic' or 'Chad' or 'China' or 'Colombia' or 'Comoros' or 'Congo Democratic Republic' or 'Congo' or 'Costa Rica' or 'Cote d'Ivoire' (Ivory Coast) or 'Cuba' or 'Djibouti' or 'Dominica' or 'Dominican Republic' or ' Egypt' or 'El Salvador' or 'Eritrea' or 'Ethiopia' or 'Fiji' or 'Gabon' or 'Gambia' or 'Georgia' or 'Ghana' or 'Grenada' or 'Guatemala' or 'Guinea' or 'Guinea-Bissau' or 'Guyana' or 'Haiti' or 'Honduras' or 'India' or 'Indonesia' or 'Iran Islamic Republic' or 'Iraq' or 'Jamaica' or 'Jordan' or 'Kazakhstan' or 'Kenya' or 'Kiribati' or 'Korea Democratic Republic' or 'Kosovo' or 'Kyrgyz Republic' or 'Lao Peoples Democratic Republic' or 'Lebanon' or 'Lesotho' or 'Liberia' or 'Libya' or 'Macedonia' or 'Madagascar' or 'Malawi' or 'Malaysia' or 'Maldives' or 'Mali' or 'Marshall Islands' or 'Mauritania' or 'Mauritius' or 'Mayotte' or 'Mexico' or 'Federated States of Micronesia' or 'Moldova' or 'Mongolia' or 'Montenegro' or 'Morocco' or 'Mozambique' or 'Myanmar' or 'Namibia' or 'Nepal' or 'Nicaragua' or 'Niger' or 'Nigeria' or 'Pakistan' or 'Palau' or 'Panama' or 'Papua New Guinea' or 'Paraguay' or 'Peru' or 'Philippines' or 'Romania' or 'Rwanda' or 'Samoa' or 'Sao Tome and Principe' or 'Senegal' or 'Serbia' or 'Seychelles' or 'Sierra Leone' or 'Solomon Islands' or 'Somalia' or 'South Africa' or 'Sri Lanka' or 'Saint Lucia' or 'Saint Vincent and the Grenadines' or 'Sudan' or 'Suriname' or 'Swaziland' or 'Syrian Arab Republic' or 'Tajikistan' or 'Tanzania' or 'Thailand' or 'Timor-Leste' or 'Togo' or 'Tonga' or 'Tunisia' or 'Turkey' or 'Turkmenistan' or 'Tuvalu' or 'Uganda' or 'Ukraine' or 'Uzbekistan' or 'Vanuatu' or 'Venezuela' or 'Vietnam' or 'West Bank and Gaza' or 'Yemen Republic' or 'Zambia' or 'Zimbabwe'.
#4	#1 and #2 and #3

Appendix 10: Risk of bias assessment tool (Newcastle-Ottawa scale) for stroke

Domain (source of bias)	Assessment	Risk of bias
Selection (Sample representative)	All subjects or random sampling (A)	Low
	Non-random sampling (B)	Moderate
	Selected group of users (C)	High
	No description of sampling strategy (D)	Unclear/High
Selection (Sample size)	Justified and satisfactory (A)	Low
	Not justified (B)	High
Detection (Outcome measurement)	Validated measurement tool (A)	Low
	Tool described but non-validated (B)	High
	Tool not described (C)	Unclear/High
Confounding (Controlled)	Adjusted for confounders (A)	Low
	No adjustment for confounders (B)	High
Detection (Outcome assessment)	Independent blind assessment (A)	-
	Record linkage (B)	-
	Self-report (C)	-
	No description (D)	-

Appendix 11: PRISMA checklist for stroke

Section/topic	#	Checklist item	Reported on page #
TITLE			
Title	1	Identify the report as a systematic review, meta-analysis, or both.	1
ABSTRACT			
Structured summary	2	Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number.	2
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known.	3
Objectives	4	Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS).	4
METHODS			
Protocol and registration	5	Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration information including registration number.	4
Eligibility criteria	6	Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale.	4-5
Information sources	7	Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched.	4-5
Search	8	Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated.	5
Study selection	9	State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis).	5
Data collection process	10	Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators.	6
Data items	11	List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made.	6
Risk of bias in individual studies	12	Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis.	6
Summary measures	13	State the principal summary measures (e.g., risk ratio, difference in means).	6

Section/topic	#	Checklist item	Reported on page #
Synthesis of results	14	Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g., I^2) for each meta-analysis.	6-7
Risk of bias across studies	15	Specify any assessment of risk of bias that may affect the cumulative evidence (e.g., publication bias, selective reporting within studies).	6
Additional analyses	16	Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified.	7-8
RESULTS			
Study selection	17	Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram.	9
Study characteristics	18	For each study, present characteristics for which data were extracted (e.g., study size, PICOS, follow-up period) and provide the citations.	9
Risk of bias within studies	19	Present data on risk of bias of each study and, if available, any outcome level assessment (see item 12).	10
Results of individual studies	20	For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group (b) effect estimates and confidence intervals, ideally with a forest plot.	9-10
Synthesis of results	21	Present results of each meta-analysis done, including confidence intervals and measures of consistency.	10-12
Risk of bias across studies	22	Present results of any assessment of risk of bias across studies (see Item 15).	9
Additional analysis	23	Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression [see Item 16]).	13-14
DISCUSSION			
Summary of evidence	24	Summarize the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g., healthcare providers, users, and policy makers).	15-17
Limitations	25	Discuss limitations at study and outcome level (e.g., risk of bias), and at review-level (e.g., incomplete retrieval of identified research, reporting bias).	18
Conclusions	26	Provide a general interpretation of the results in the context of other evidence, and implications for future research.	19
FUNDING			
Funding	27	Describe sources of funding for the systematic review and other support (e.g., supply of data); role of funders for the systematic review.	20

Appendix 12: Study Characteristics: East Asia and Pacific Region

First Author, Year	Data Collection Year	Country	Country Income Group	Setting	Age	Sample size	% Male	Stroke cases	Case Ascertainment
Wang, 1983	1981	China	Upper Middle Income	Urban	All ages	10941	48.2	1188	SSQ, NE
Viriyavejakul, 1985	NR	Thailand	Upper Middle Income	Urban	Adults	1317	NR	690	SSQ, NE
Li, 1985	1983	China	Upper Middle Income	Urban	All ages	63195	49.59	620	SSQ, NE, CI
Xueming, 1989	1985	China	Upper Middle Income	Rural	All Ages	246812	NR	253	SSQ, NE
Xue, 1991	1986	China	Upper Middle Income	Urban and Rural	All ages	5814851	50.05	245	SSQ, NE
Li, 1995	1990	China	Upper Middle Income	Urban	All Ages	101866	52.28	411	SSQ, NE, MR
Viriyavejakul, 1998	1994-96	Thailand	Upper Middle Income	Urban and Rural	≥ 60	3036	NR	1120	SSQ, NE
Le, 1999	1994-95	Vietnam	Lower Middle Income	Urban and Rural	All	52649	50	428	SSQ, NE
Misbach, 2001	1997-98	Indonesia	Lower Middle Income	Urban and Rural	21-92	1408	NR	3977	SSQ, NE
Ferri, 2001	2003	China	Upper Middle Income	Rural	≥60	1002	44.6	1600	SSQ, NE
Antonio, 2005	2003-04	Philippines	Lower Middle Income	Urban and Rural	≥20	4753	NR	1400	SSQ, NE
Zhang, 2006	2004-05	China	Upper Middle Income	Rural	≥35	29497	50.54	2360	SSQ, NE,MR

He, 2006	2001-02	China	Upper Middle Income	Urban	65-95	2334	40.36	16195	SSQ, NE, CI
Zhang, 2007	2004-05	China	Upper Middle Income	Rural	≥35	29970	50.46	2479	SSQ, NE, CI
Sun, 2007	2004-05	China	Upper Middle Income	Rural	≥ 35	29970	50.46	2970	SSQ, NE, CI
Van Minh, 2008	2005	Vietnam	Upper Middle Income	Urban and Rural	25-64	4220	50.7	781	SSQ
Van Minh, 2008	2005	Indonesia	Lower Middle Income	Urban and Rural	25-64	1951	50.90	461	SSQ
Van Minh,2008	2005	Thailand	Upper Middle Income	Urban and Rural	25-64	2147	49.23	1024	SSQ, NE
Yi, 2009	2002	China	Upper Middle Income	Urban and Rural	≥15	17 857	44.64	789	SSQ, NE, MR
Dong, 2010	2004-06	China	Upper Middle Income	Rural	≥65	4541	50.25	7730	SSQ, NE
Ferri, 2011	2003	China	Upper Middle Income	Urban	≥ 65	1160	43.1	9300	SSQ, NE
Hanchaiphiboolkul, 2011	2004-06	Thailand	Upper Middle Income	Urban and Rural	45-80	19997	34	1880	SSQ, NE
Sy, 2012	2008	Philipines	Lower Middle Income	Urban and Rural	≥20	7215	46.1	1200	SSQ
He,2012	2008-10	China	Upper Middle Income	Rural	≥40	58308	34.92	3700	SSQ, NE, MR
Wang, 2012	2009	China	Upper Middle Income	Rural	≥50	934	50.54	3747	SSQ, NE
Wu, 2013	2010	China	Upper Middle Income	Urban and Rural	≥ 50	13157	48.1	3100	SSQ, NE

*NR- Not Reported, SSQ- Stroke Screening Questionnaire, Neurological Examination, MR- Medical records, CI- Clinical Investigations

Appendix 13: Study Characteristics: Europe and Central Asian Region

First Author, Year	Data Collection Year	Country	Country Income Group	Setting	Age	Sample size	% Male	Stroke cases	Case Ascertainment
Mircea, 2007	2006	Romania	Upper Middle Income	Urban and Rural	18-85	3124	39	3297	SSQ, NE
Oncel, 2014	2010-11	Turkey	Upper Middle Income	Urban	≥45	2441	48.5	942	SSQ, NE, CI, MR

* NR- Not Reported, SSQ- Stroke Screening Questionnaire, Neurological Examination, MR- Medical records, CI- Clinical Investigation

Appendix 14: Study Characteristics: Middle East and North African Region

First Author, Year	Data Collection Year	Country	Country Income Group	Setting	Age	Sample size	% Male	Stroke cases	Case Ascertainment
Attia, 1993	1985	Tunisia	Upper Middle Income	Urban and Rural	All ages	34874	51.46	120	SSQ, NE

Kandil, 2006	1992-93	Egypt	Lower Middle Income	Urban and Rural	All ages	25000	NR	508	SSQ, NE, CI
Maziak, 2007	2004	Syria	Lower Middle Income	Urban	18-65	2038	45.2	1079	SSQ
El Tallawy, 2010	2005-09	Egypt	Lower Middle Income	Urban and Rural	All ages	62583	NR	560	SSQ, NE, CI
Khedr, 2013	2010-10	Egypt	Lower Middle Income	Urban and Rural	All ages	5920	51.8	963	SSQ, NE, CI
Farghaly, 2013	2005-09	Egypt	Upper Middle Income	Urban	All Ages	62583	51.4	554	SSQ, NE, CI
El Tallawy, 2013	2009-12	Egypt	Lower Middle Income	Urban	≥20 s	32285	49.4	620	SSQ, NE
Khedr, 2014	2011-13	Egypt	Upper Middle Income	Urban and Rural	All ages	8027	51.97	922	SSQ, NE, CI
Engels, 2014	2008-09	Morocco	Lower Middle Income	Urban and Rural	≥15	44742	48.7	284	SSQ, NE, CI

*NR- Not Reported, SSQ- Stroke Screening Questionnaire, Neurological Examination, MR- Medical records, CI- Clinical Investigations

Appendix 15: Study Characteristics: Latin America and Caribbean Region

First Author, Year	Data Collection Year	Country	Country Income Group	Setting	Age	Sample size	% Male	Stroke cases	Case Ascertainment
Cruz, 1985	1982	Ecuador	Upper Middle Income	Rural	All ages	1113	NR	360	SSQ, NE
Gracia,1988	1986	Panama	Upper Middle Income	Urban	All ages	955	NR	750	SSQ, NE
Jaillard,1995	1988	Peru	Upper Middle Income	Urban	≥15	3246	45.9	620	SSQ, NE, CI

Pradilla,1995	1983-92	Colombia	Upper Middle Income	Urban and Rural	All ages	16032	NR	699	SSQ, NE
Uribe,1997	1992-93	Colombia	Upper Middle Income	Urban	All ages	13588	47.6	559	SSQ, NE
Takeuchi,1999	1995-96	Colombia	Upper Middle Income	Urban and Rural	All ages	998	NR	680	SSQ, NE
Nicoletti,2000	1994-96	Bolivia	Lower Middle Income	Rural	All ages	9955		174	SSQ, NE
Pradilla,2002	1995-96	Colombia	Upper Middle Income	Urban and Rural	All ages	1454	44.6	1720	SSQ, NE
Cruz-Alcala,2002	2000	Mexico	Upper Middle Income	Urban	All Ages	9082	48	451	SSQ, NE
Pradilla,2002	1995-96	Colombia	Upper Middle Income	Rural	All Ages	544	42.6	1838	SSQ, NE
Medina,2003	2001	Honduras	Lower Middle Income	Urban	All ages	1573	47	572	SSQ, NE, CI
Pradilla,2003	1995-96	Colombia	Upper Middle Income	Urban and Rural	All ages	8910	NR	1990	SSQ, NE
Del Brutto,2004	2003	Ecuador	Upper Middle Income	Rural	≥15	1568	46.43	638	SSQ, NE, CI
Melcon,2006	1991-92	Argentina	Upper Middle Income	Urban	All Ages	17049	46.75	868	SSQ, NE, MR,
Diaz-Cabezas,2006	2004-05	Colombia	Upper Middle Income	Urban and Rural	7-89	787	32	1017	SSQ, NE
Thompson-Cerna, 2007	2004-05	Honduras	Lower Middle Income	Rural	All ages	5608	47.7	360	SSQ, NE, CI
Pereira,2009	2007	Brazil	Upper Middle Income	Urban and Rural	≥60	4154	45	2937	SSQ, NE, CI
Ferguson,2010	2007-08	Jamaica	Upper Middle Income	Urban and Rural	15-74	2521	31.1	1370	SSQ, MR

Llibre,2010	2003-06	Cuba	Upper Middle Income	Urban	≥65	2944	35	7778	SSQ, NE, CI
Ferri,2011	2003	Dominican R.	Upper Middle Income	Urban	≥ 65	2008	34.1	8400	SSQ, NE
Ferri,2011	2003	Peru	Upper Middle Income	Urban	≥ 65	1376	35.7	6800	SSQ, NE
Ferri,2011	2003	Venezuela	Upper Middle Income	Urban	≥ 65	1949	36.6	6200	SSQ, NE
Ferri,2011	2003	Mexico	Upper Middle Income	Urban	≥ 65	10003	36.6	6500	SSQ, NE
Abe,2011	2008	Brazil	Upper Middle Income	Urban	≥35	3661	38.30	6637	SSQ, NE, MR
Cantu-Brito,2011	2008-09	Mexico	Upper Middle Income	Urban and Rural	≥35	2437	43.3	770	SSQ, NE, CI
Quet,2011	2007	Mexico	Upper Middle Income	Rural	All ages	4008		150	SSQ, NE
Ferri,2011	2003	Peru	Upper Middle Income	Rural	≥ 60	551	46.6	2700	SSQ, NE
Ferri,2011	2033	Mexico	Upper Middle Income	Rural	≥60	999	39.8	6500	SSQ, NE
Copstein,2012	2009	Brazil	Upper Middle Income	Urban	≥20	3391	44.1	8405	SSQ, NE
Del Brutto,2014	2012	Ecuador	Upper Middle Income	Rural	≥40	642	41	3115	SSQ, NE, CI
Fernandes,2014	2011	Brazil	Upper Middle Income	Urban and Rural	≥ 35	5925		4152	SSQ, NE

*NR- Not Reported, SSQ- Stroke Screening Questionnaire, Neurological Examination, MR- Medical records, CI- Clinical Investigations

Appendix 16: Study Characteristics: South Asian Region

First Author, Year	Data Collection Year	Country	Country Income Group	Setting	Age	Sample size	% Male	Stroke cases	Case Ascertainment
Abraham, 1970	1968-69	India	Lower Middle Income	Urban and Rural	All ages	258576	50.82	57	SSQ, NE
Gourie-Devi, 1987	1982-84	India	Lower Middle Income	Urban	All ages	57660	82	52	SSQ, NE, MR
Bharuacha, 1988	1985	India	Lower Middle Income	Urban	All Ages	14010	NR	842.3	SSQ, NE
Koul, 1990	1986	India	Lower Middle Income	Rural	≥15	63645	53	143	SSQ, NE,CI
Das, 1996	1989-90	India	Lower Middle Income	Rural	All ages	37286	48.43	126	SSQ, NE
Banerjee, 2001	1998-99	India	Lower Middle Income	Urban	All ages	50291	52.12	147	SSQ, NE, CI
Saha, 2003	1992-93	India	Lower Middle Income	Rural	All ages	20842	52.95	147	SSQ, NE
Gourie-Devi, 2004	1993-95	India	Lower Middle Income	Urban and Rural	All ages	102557	51	150	SSQ, NE
Das, 2006	2003-04	India	Lower Middle Income	Urban	All ages	52377	NR	487	SSQ, NE, MR
Jafar, 2006	2001-02	Pakistan	Lower Middle Income	Urban	≥35	500	50	4800	SSQ, NE
Das, 2007	2003-05	India	Lower Middle Income	Urban	All ages	52377	52.7	472	SSQ, NE, CI
Das, 2008	2003-04	India	Lower Middle Income	Urban	≥ 60	5430	51.05	3351	SSQ, NE, CI
Xu, 2008	2000-01	China	Upper Middle	Urban and	≥35	29340	49.8	1544	SSQ, NE, MR

			Income	Rural					
Van Minh, 2008	2005	India	Lower Middle Income	Rural	25-64	2080	49.95	1971	SSQ
Van Minh, 2008	2005	Bangladesh	Low Income	Urban and Rural	25-64	8098	45.16	1445	SSQ
Kamal, 2009	2008-09	Pakistan	Lower Middle Income	Urban	≥35	545	50.6	19100	SSQ, NE
Raina, 2010	2009	India	Lower Middle Income	Urban	≥15	684	51.2	1169	SSQ, NE, MR
Khanam, 2011	2003-04	Bangladesh	Low Income	Rural	≥ 60	452	45.1	900	SSQ, NE
Mohammad, 2011	NR	Bangladesh	Low Income	Urban and Rural	≥ 40	15627	NR	300	SSQ, NE
Ferri, 2011	2003	India	Lower Middle Income	Rural	≥60	999	45.5	1100	SSQ, NE
Ferri, 2011	2003	India	Lower Middle Income	Urban	≥ 65	1005	42.4	1900	SSQ, NE

*NR- Not Reported, SSQ- Stroke Screening Questionnaire, Neurological Examination, MR- Medical records, CI- Clinical Investigations

Appendix 17: Study Characteristics: Sub-Saharan African Region

First Author, Year	Data Collection Year	Country	Country Income Group	Setting	Age	Sample size	% Male	Stroke cases	Case Ascertainment
Osuntokun, 1982	1982	Nigeria	Lower Middle Income	Rural	All	903	NR	443	SSQ, NE
Osuntokun,1987	1982	Nigeria	Lower Middle Income	Rural	All ages	18954	48.97	58	SSQ, NE, MR
Longe, 1988	1986	Nigeria	Lower Middle Income	Rural	All ages	2925	49.88	68	SSQ, NE
Tekle-Haimanot,	1986-88	Ethiopia	Low Income	Rural	All	60820	NR	15	SSQ, NE

1990					Ages				
Balogou, 2001	1989-95	Togo	Low Income	Rural	All ages	23422	NR	231	SSQ, NE
Connor, 2004	2001-02	South Africa	Upper Middle Income	Rural	≥15	42378	47.29	243	SSQ, NE, MR
Danesi, 2007	2005-06	Nigeria	Lower Middle Income	Urban	All ages	13127	55.6	114	SSQ, NE
Cossi, 2012	2008-09	Benin	Low Income	Urban	≥15	15155	41.37	462	SSQ, NE, MR
Ngoungou, 2012	NR	Gabon	Upper Middle Income	Urban and Rural	≥40	736	42.53	2174	SSQ, MR
Dewhurst, 2013	2009-10	Tanzania	Low Income	Rural	≥70	2232	43.7	2420	SSQ, NE
Onwuchekwa, 2014	2008	Nigeria	Lower Middle Income	Rural	≥18	1057	44	851	SSQ, NE
Enwereji, 2014	2011	Nigeria	Lower Middle Income	Rural	All ages	6150	49.06	163	SSQ, NE, CI

*NR- Not Reported, SSQ- Stroke Screening Questionnaire, Neurological Examination, MR- Medical records, CI- Clinical Investigations

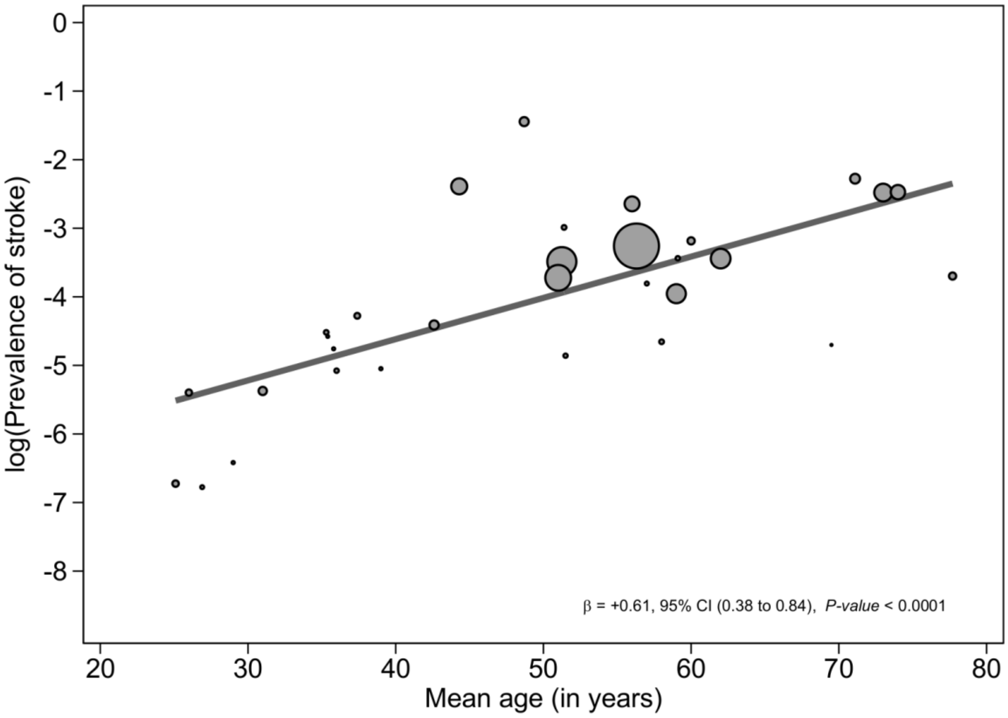
Appendix 18: Risk of bias assessment for included stroke studies

First Author	Publication Year	Country	Selection Sampling)	Selection (Sample size)	Detection (Outcome exposure)	Confounder (Controlled)	Detection (Outcome Assessment)
Abraham	1970	India	A	A	B	A	B
Osuntokun	1982	Nigeria	A	B	B	A	B
Wang	1983	China	A	B	B	B	B
Viriyavejakul	1985	Thailand	A	B	A	A	B
Li	1985	China	A	B	B	A	A
Cruz	1985	Ecuador	A	B	B	B	B
Gourie-Devi	1987	India	A	A	A	A	A
Osuntokun	1987	Nigeria	A	B	B	A	A
Gracia	1988	Panama	A	A	A	B	B
Bharuacha	1988	India	A	A	A	B	B
Longe	1988	Nigeria	A	A	B	A	B
Xueming	1989	China	A	A	B	A	B
Koul	1990	India	A	A	A	A	A
Tekle-Haimanot	1990	Ethiopia	A	A	B	A	B
Xue	1991	China	A	A	B	A	B
Attia	1993	Tunisia	A	A	A	A	B
Li	1995	China	A	A	B	A	A
Jaillard	1995	Peru	A	A	A	A	A
Pradilla	1995	Colombia	A	A	A	A	B
Das	1996	India	A	A	A	A	B
Uribe	1997	Colombia	A	A	A	B	B
Viriyavejakul	1998	Thailand	A	B	A	A	B
Le	1999	Vietnam	A	A	A	A	B
Takeuchi	1999	Colombia	A	A	A	B	B
Nicoletti	2000	Bolivia	A	B	A	A	B
Misbach	2001	Indonesia	B	B	A	A	B
Banerjee	2001	India	A	A	A	A	A
Balogou	2001	Togo	A	A	B	A	B
Pradilla	2002	Colombia	A	A	B	A	B
Cruz-Alcala	2002	Mexico	A	B	A	B	B
Pradilla	2002	Colombia	A	A	B	B	B
Medina	2003	Honduras	A	B	B	A	A
Pradilla	2003	Colombia	A	A	A	A	B
Saha	2003	India	A	A	A	A	B
Del Brutto	2004	Ecuador	A	A	B	A	A
Gourie-Devi	2004	India	A	A	A	A	B
Connor	2004	South Africa	A	A	A	A	A
Antonio	2005	Philipines	A	A	A	A	B
Zhang	2006	China	A	A	B	A	B
He	2006	China	A	A	B	B	A
Melcon	2006	Argentina	A	A	A	B	A
Diaz-Cabezas	2006	Colombia	A	A	A	B	B
Kandil	2006	Egypt	A	A	A	A	A
Das	2006	India	B	A	A	A	A
Jafar	2006	Pakistan	A	A	A	A	B
Zhang	2007	China	A	B	B	A	A
Sun	2007	China	A	A	A	A	A

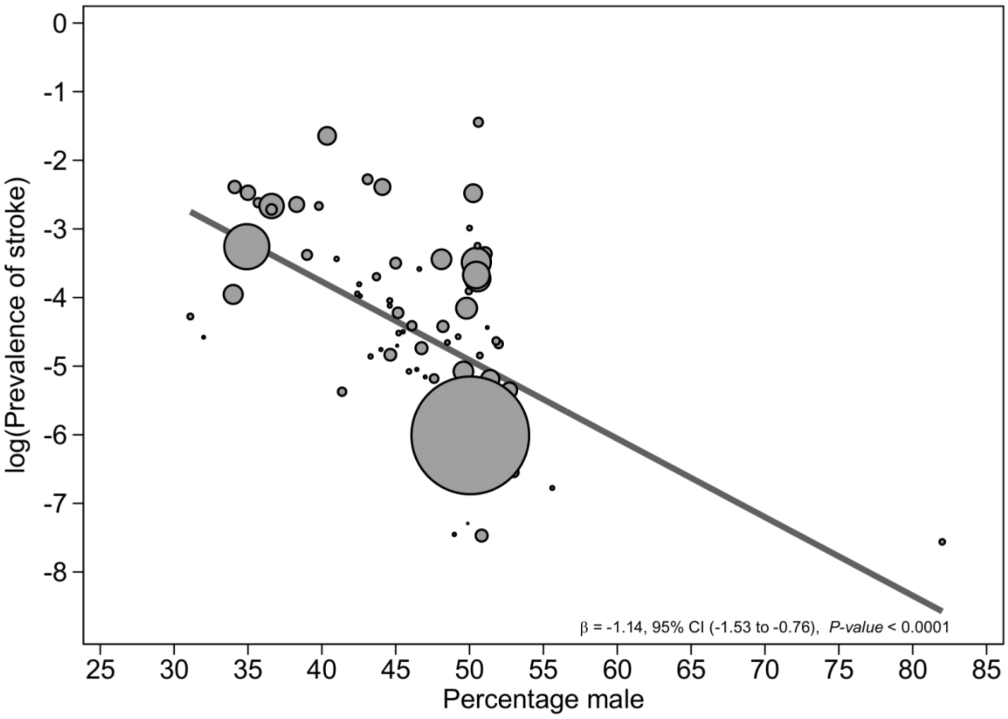
Mircea	2007	Romania	A	A	A	A	B	
Thompson-Cerna	2007	Honduras	A	B	A	A	A	
Maziak	2007	Syria	A	A	B	A	C	
Das	2007	India	B	A	A	A	A	
Danesi	2007	Nigeria	A	A	B	A	B	
Van Minh	2008	Vietnam	A	A	A	A	A	
Van Minh	2008	Indonesia	A	A	A	A	C	
Van Minh	2008	Thailand	A	A	A	A	C	
Das	2008	India	A	A	A	A	A	
Xu	2008	China	A	A	A	A	A	
Van Minh	2008	India	A	A	A	A	C	
Van Minh	2008	Bangladesh	A	A	A	A	C	
Yi	2009	China	A	A	A	A	B	
Pereira	2009	Brazil	A	A	A	A	A	
Kamal	2009	Pakistan	A	B	A	A	B	
Dong	2010	China	A	A	A	A	A	
Ferguson	2010	Jamaica	A	A	A	A	A	
Llibre	2010	Cuba	A	A	A	A	A	
El Tallawy	2010	Egypt	A	A	A	B	A	
Raina	2010	India	A	A	A	B	A	
Ferri	2011	China	A	A	A	A	B	
Ferri	2011	China	A	A	A	A	B	
Hanchaiphiboolkul	2011	Thailand	A	A	A	A	B	
Ferri	2011	Dom. Rep	A		A	B	B	
Ferri	2011	Peru	A	A	A	B	B	
Ferri	2011	Venezuela	A	A	A	B	B	
Ferri	2011	Mexico	A	A	A	B	B	
Abe	2011	Brazil	A	A	A	A	A	
Cantu-Brito	2011	Mexico	A	A	A	A	A	
Quet	2011	Mexico	A	B	A	B	B	
Ferri	2011	Peru	A	A	A	B	B	
Ferri	2011	Mexico	A	A	A	B	B	
Khanam	2011	Bangladesh	A	B	A	B	B	
Mohammad	2011	Bangladesh	A	A	A	A	B	
Ferri	2011	India	A	A	A	A	B	
Ferri	2011	India	A	A	B	B	B	
Sy	2012	Philipines	A	B	A	A	C	
He	2012	China	A	A	A	A	A	
Wang	2012	China	A	A	A	A	B	
Copstein	2012	Brazil	A	A	A	A	B	
Cossi	2012	Benin	A	A	A	A	A	
Ngoungou	2012	Gabon	A	A	A	A	A	
Wu	2013	China	A	A	A	A	B	
Khedr	2013	Egypt	A	A	A	A	A	
Farghaly	2013	Egypt	A	A	A	A	A	
El Tallawy	2013	Egypt	A	A	A	B	B	
Dewhurst	2013	Tanzania	A	A	B	A	B	
Oncel	2014	Turkey	A	A	A	A	A	
Del Brutto	2014	Ecuador	A	A	A	A	A	
Fernandes	2014	Brazil	A	A	A	A	B	
Khedr	2014	Egypt	A	A	A	A	A	

Engels	2014	Morocco	A	A	A	A	A
Onwuchekwa	2014	Nigeria	A	A	A	A	B
Enwereji	2014	Nigeria	A	A	B	A	A

Appendix 19: Scatter of association of mean age with prevalence of stroke estimates



Appendix 20: Scatter of association of percentage male with prevalence of stroke estimates



Appendix 21: Study Collaboration Agreement

APRIL 29, 2014

AGREEMENT

Between

Department of Preventive and Social Medicine, College of Health Sciences, University of Port Harcourt, East/West Road PMB 5323 Choba, Rivers State, Nigeria

AND

Population Evidence and Technology Group, Health Sciences division, Warwick Medical School, University of Warwick, Coventry, CV4 7AL, United Kingdom

This research agreement is between Preventive and Social Medicine group (First Party), represented by **Dr. Best Ordinioha,** Head of department, AND the Population Evidence and Technology Group, (Second Party), represented by **Dr. Kandala Ngianga-Bakwin.** This agreement describes the nature of collaboration in the study of cardiovascular risk factors in an oil polluted environment, and forms part of the PhD thesis for **Mr. Martinsixtus Ezejimofor** at the University of Warwick.

The study intends to perform a cross-sectional (comparative) analysis to examine the prevalence of cardiovascular risk factors among 2000 participants in selected local government areas in Rivers State.

Responsibilities of the 1st Party:

1. PSM group will lead the entry of the study team into the selected communities. This will include meeting with relevant stakeholders and provision of local knowledge relevant to the study.
2. PSM group will assists in data collection and monitoring field workers
3. PSM group will assists in training of field workers and proper disbursement of incentives to study participants through her resident medical practitioners
4. PSM group is not responsible for costs except for that which will be agreed in writing.

Responsibilities of the 2nd Party:

1. PET group (led by Mr. Martinsixtus Ezejimofor) will provide all study materials and equipment relevant to the study

2. PET group (led by Mr. Martinsixtus Ezejimofor) will find and recruit fieldworkers in all the study locations
3. PET group (led by Mr. Martinsixtus Ezejimofor) will train fieldworkers and provide incentives for the study participants
4. PET group (led by Mr. Martinsixtus Ezejimofor) will store and manage all patients-related information and data including analysis and dissemination
5. PET group (led by Mr. Martinsixtus Ezejimofor) will fund all the expenses related to study.

Benefits

1. The PSM group (Dr. Best Ordinioha, Dr. Arthur Onwuchekwa, and Dr. Omosivie Maduka) will be included as co-authors in all the publications that will come out from this study.

Agreed and Approved

Dr. Best Ordinioha (1st Party)

On Behalf of Preventive and Social Medicine group

………………………………………………

Dr. Kandala Ngianga-Bakwin (2nd Party)

On Behalf of Population Evidence Technology group

…………………………………………………………

Appendix 22: Ethical Approval Certificate University of Warwick

5th December 2013

Warwick
Medical School

PRIVATE
Martinsixtus Ezejimofor
Health Sciences
WMS
University of Warwick
Coventry
CV4 7AL

Dear Martinsixtus,

Study Title and BSREC Reference: *Prevalence of hypertension and associated risk factors for cardiovascular disease in oil-polluted environment a case study of Niger delta*, REGO-2013-448

Thank you for submitting your revisions to the above-named project to the University of Warwick Biomedical and Scientific Research Ethics Sub-Committee for Chair's Approval.

I am pleased to confirm that I am satisfied that you have met all of the conditions and your application meets the required standard, which means that full approval is granted and your study may commence.

I take this opportunity to wish you success with the study and to remind you any substantial amendments require approval from the committee before they can be made. Please keep a copy of the signed version of this letter with your study documentation.

Yours sincerely,

p.p Graham Hewitt

David Davies
Chair
Biomedical and Scientific
Research Ethics Sub-Committee

Biomedical and Scientific
Research Ethics Subcommittee
A010 Medical School Building
Warwick Medical School,
Coventry, CV4 7AL.
Tel: 02476-151875
Email: BSREC@Warwick.ac.uk

THE UNIVERSITY OF
WARWICK

Appendix 23: Ethical Approval Certificate University of Port Harcourt

UNIVERSITY OF PORT HARCOURT

OFFICE OF THE DEPUTY VICE-CHANCELLOR (RESEARCH & DEVELOPMENT)

RESEARCH ETHICS COMMITTEE

MEMORANDUM

From: Secretary Ref: UPH/DVC(R&D)/REC/04 Date: May 15th, 2014.	To: Martinsixtus Ezejimofor C. Division of Health Sciences Warwick Medical School University of Warwick Coventry CV4 7AL United Kingdom

APPROVAL OF RESEARCH PROPOSAL

Having addressed the issues raised by the Research Ethics Committee on your proposal titled: **Cardiovascular risk factors in an oil-polluted environment**, the Research Ethics Committee at its statutory meeting held on Thursday May 15th, 2014 gave approval to your research proposal.

We hope you will keep strictly to the corrected proposal based on which this approval was given.

The Committee expects you to give a feedback at the end of the research work.

You may now continue with your research work.

Let me on behalf of the committee congratulate and wish you a fruitful research experience.

Yours truly,

Office of the Deputy Vice-Chancellor (Research & Development)

16 MAY 2014

University of Port Harcourt

Appendix 24: Approval for Use of facilities

PORT HARCOURT
RIVERS STATE NIGERIA
Rivers of possibilities

16th May, 2014

Dr. Omosivie Maduka
Department of Preventive and Social Medicine,
University of Port-Harcourt Teaching Hospital,
Port-Harcourt

RE: REQUEST FOR PERMISSION TO CARRY OUT A RESEARCH STUDY ON CARDIOVASCULAR RISK FACTORS IN AN OIL POLLUTED ENVIRONMENT

With reference to your letter on the above subject matter dated 6th May, 2014, we wish to convey the approval of the Rivers State Primary Health Care Management Board permitting you to screen for cardiovascular disorders in adults. You have also been granted permission based on your request to administer questionnaires at MPHC Ebubu in Eleme LGA, MPHC Kpite in Tai LGA, PHC Usokun and MPHC Degema in Degema LGA, lasting a period of six weeks per Local Government Area.

Letters have been sent to this effect to the Medical Officers of Health of the respective LGAs and the Medical Officers in-charge of the Primary Health Centres. You are advised to follow up on these letters. A high ethical standard should be maintained during and after the study with particular regard to patient/client rights and confidentiality.

You are required to furnish the Director, Planning Research and Statistics, RSPHCMB with information on your findings at the end of the research. Failing to comply with this feedback policy of the Rivers State Primary Health Care Management Board at the end of the study may adversely affect other researchers in future.

We wish you success in this project.

DR. ANIKARA S. ATAMUNOTORU
For: Executive Secretary

Government Of Rivers State Of Nigeria,
Office of the Executive Secretary
Primary Health Care Management Board.
Website: www.rspcmb.org.ng

Administrative Headquarters
Plot 27/29 Dr. Sam Wobo Street,
Off Sani Abacha Road, GRA Phase 3,
Port Harcourt, Rivers State.

Appendix 25: General study Questionnaire Tool

CONSENT FORM

Study Number: REGO-2013-448

Participant's identification number (PIN) for this study:

Project title: A cross-sectional study of cardiovascular risk factors in an oil-polluted environment a case study of Niger Delta

Name of researcher: Martinsixtus Ezejimofor

Please tick all boxes

1.	I confirm that I have read and understand the information sheet dated…………………................... for the above study. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily.	
2.	I understand that my participation is voluntary and that I am free to withdraw at any time without giving any reason	
3.	I confirm that the procedures regarding confidentiality have been clearly explained and I cannot be identified by any published work.	
4.	I understand that other researchers at the University of Warwick will have access to this data only if they agree to preserve the confidentiality of the data and if they agree to the terms I have specified in this form.	
5.	I agree to take part in the above named study.	

____________________ __________________ __________________

Name of participant Signature Date

Participant's thumb print

____________________ __________________ __________________

Name of researcher Signature Date

SOCIO-DEMOGRAPHIC CHARACTERISTICS

1	**Gender (record as observed)**	**0.Male** **1.Female**	
2	What is your date of birth?	Day__ Month __ Year____	
3	How old are you? (YEARS)		
4	What is the name of your tribe? NO CODE		
5	What is the name of your community? NO CODE		
6	How long have you lived in the community? MONTHS/YEARS		
7	What is your marital status	1.Single 2.Married 3. Divorced 4.Widowed 5.Partners	
8	What is your employment status?	1. Government 2. Private 3.Retired 4.Not Working	
9	Do you work in the city?	0. No 1. Yes	
10	What is your occupation?		
11	Taking the past year, can you tell me what the average earnings of the household have been?	Per Week	
		Per Month	
		Per Year	
12	What is your education level?	0.Uneducated 1.Pre-college 2.College 3.Higher education	

13	What is the main source of your drinking water?	1.Tap water–Indoor 2.Tap water-outdoor 3.Dug Well 4.Rainwater 5.Tanker Truck 6.Cart with Tank 7.Surface water 8.Bottled water 9.Sachet water	
14	Where is the water source located?	1.Indoor 2.Outside	
15	Do you do anything to make the water safer to drink?	0.No 1.Yes	
16	What do you usually do to make the water safer to drink?	1.Boil 2.Add Chlorine 3.Use Water Filter 4.Solar Disinfection 5.Stand and Settle 6.Nothing	
17	What type of fuel does your household mainly use for cooking?	1.Electricity 2.Gas 3.Kerosene 4.Charcoal 5.Wood 6.Sawdust 7.No food cooked	
18	Is the cooking usually done in the house, in a separate building, or outdoors?	1.In-house 2.Separate house 3.Outdoors	
19	What kind of conveyance do you own?	0.None 1.Bicycle 2.Motorcycle 3.Car or truck 4.Boat	
20	Do you own agricultural land?	0.No 1.Yes	
21	What is the size of the land?		

Health Related Information

22	Do you have any long standing illness or disease such as diabetes, kidney disease or heart problem?	0.No 1.Yes	
23	If yes what is the illness or disease?		
24	Are you taking any medicine?	0.No 1.Yes	
25	Has your blood pressure ever been measured?	0.No 1.Yes	
26	When was the last time your blood pressure was taken?	Past one week ≤ 1 month >1 month >3 month	
27	Have you ever been told by doctor that you have high blood pressure or hypertension?	0.No 1.Yes	
28	If **yes,** did your doctor prescribe any blood pressure medicines?	0.No 1.Yes	
29	Has any member of your family had high blood pressure? (Check all that apply)?	0. Nobody 1.Father **2.**Mother 3.Brother **4.**Sister	
30	During the past two weeks, have you been treated for high blood pressure with drugs (medication) prescribed by a doctor or other health worker/chemist?	0. No 1.Yes	
31	Have you ever noticed that your face or mouth was shifted to one side (paralyzed) for more than 24 h?	0. No 1.Yes	
32	Have you ever had loss of sensation or abnormal sensation affecting your arms and legs, lasting for more than 24 h?	0. No 1.Yes	
33	Have you ever had paralysis of one side of your body (arm or leg) lasting for more than 24 h?	0. No	

		1.Yes	
34	Have ever been diagnosed of stroke or currently taking any stroke medication?	0. No 1.Yes	
35	Can you tell me the major risk factors for cardiovascular diseases such as stroke? (list all)	0.None 1.Age 2.Hereditary 3.Hypertension 4.Salt intake 5.Fatty-food/Cholesterol 6.Excess weight 7.Stress 8.Lack of exercise 9.High blood sugar 10.Poor diet 11.Smoking 12.Alcohol intake 13. Lack of money 14 Pollution 15. Lack of education	
36	Hypertension is a silent disease	0.No 1.Yes	
	Hypertension is a life threatening condition	0.No 1.Yes	
	Lowering BP improves a person's health	0.No 1.Yes	
	What is your BP reading	0.No 1.Yes	
	BP is high when reading is ≥ 140/90	0.No 1.Yes	
	Treatment is throughout life	0.No 1.Yes	
37	What can you do to lower your BP? (List all)		
38	Has a doctor or other health worker advised you to do any of the following? (List all that apply)	1.Exercise 2.Measure your BP 3.Reduce salt intake 4.Reduce Fatty-food 5.Reduce weight 6.Think less -Stress 7.Reduce carbohydrate 8.Eat fruits 9.Stop smoking 10.Reduce alcohol intake	

		11.Go for BP checks 12.**No advice**	
39	Have you ever had trouble sleeping in the night in the last one month?	0.No 1.Yes	
40	How many hours of sleep do you have on each night in the past one month?		

BEHAVIORAL INFORMATION

	Tobacco smoking behavior		
41	What is you smoking status (tobacco products, such as cigarettes, cigars or pipes)?	0.None smoker 1.Current smoker 3.Ex-Smoker	
42	Which of the following do you currently smoke daily?	1.Manufactured cigarettes 2.Hand-rolled cigarettes 3.Pipes full of tobacco 4.Cigars 5.Rolled tobacco leaves 6.Powered snuff	
43	On average, how many do you smoke each day?		
44	How long ago did you stop smoking daily?	Years/Months/Weeks	
	ALCOHOL CONSUMPTION BEHAVIOUR		
45	Have you ever consumed a drink that contains alcohol such as beer, wine, spirit, fermented cider or palm wine?	0.No 1.Yes	
46	Have you consumed alcohol within the past 12 months?	0.No 1.Yes	
47	In the past 12 months, how frequently have you had at least one drink?	5 or more days a week 1-4 days per week 1-3 days a month	

		Less than once a month	
48	When you drink alcohol, on average, how many unit drinks do you have during one day?	Number (show cup measure)	
49	During each of the past 7 days, how many units of alcoholic drink did you have each day?	Number (show cup measure)	
DIETARY BEHAVIOUR			
50	In a typical week, on how many days do you eat fruit?	Number of days **Don't Know**	
51	How many portions or size (in gram) of fruit do you eat on one of those days?	The portions or size (in gram) **Don't Know**	
52	How many portions or size (in gram) of vegetables do you eat on one of those days?	The portions or size (in gram) **Don't Know**	
53	How would you rate your consumption of fatty foods?	**1.** I avoid animal fats/oil or bleaching palm oil	
		2. I do not pay attention to the amount of fats and oils in my food	
		3. I use a lot of fats and always bleach palm oil while cooking	
54	How would you rate your consumption of **salt?**	**1.** I avoid adding table salt in my meals	
		2. I do not pay attention to the amount of salt in my food	
		3. I always add table salt directly to my food while eating	
PHYSICAL ACTIVITIES			
55	During the past 1 month, how often did you usually get physical exercise (such as walking, gardening, and exercising,	**1.** Every day	
		2. 3 to 6 times a week	

	swimming, tennis)?	**3.** Less than 3 times a week	
56	On the days that you exercised, haw many total minutes did you usually spend exercising?	**1.** Less than 30 minutes	
		2. 30 minutes	
		3. 30 minutes or more	
57	Does your work involve mostly sitting or standing, with walking for no more than 30 minutes at a time?	0.No 1.Yes	
58	IF NO, does your work involve vigorous activity, like [heavy lifting, digging or construction work, farming, fishing] for at least 30 minutes at a time?	0.No 1.Yes	
59	How many days a week do you work l?	Every day 1-3 times a week More than 4 days a week	
60	How much time would you spend walking or bicycling to- from work?	Hours ☐ Minutes ☐☐	

ANTHROPOMETRIC AND BLOOD PRESSURE MEASUREMENTS

ANTHROPOMETRIC MEASUREMENTS		
61	Height	
62	Weight	
63	Waist circumference	
64	Hip circumference	
Blood pressure measurements		

65	Reading 1	Systolic BP	
		Diastolic BP	
66	Reading 2	Systolic BP	
		Diastolic BP	
67	Reading 3	Systolic BP	
		Diastolic BP	
	Average	Systolic BP	
		Diastolic BP	

BIOCHEMICAL MEASUREMENT			
	Total cholesterol and HDL cholesterol		
68	During the last 12 hours have you had anything to eat or drink, other than water?	Yes/ No	
69	Total cholesterol		
70	HDL cholesterol		
71	Fasting glucose		
72	Full Blood Assay		

Time interview ended ________:_________

Research Assistant's signature……………………….

Appendix 26: Stroke-Specific Questionnaire Tool

S/NO Enter four Digit No. (see questionnaire)	**NAME** of Household Member 15 years and above	**AGE**	**SEX**	Are you on stroke medication currently	Do you suffer from headache even when you don't have fever?	Do you suffer from severe headaches, chiefly on one side of the head, which come on from time to time?	In association with these headaches, do you suffer from nausea or vomiting?	Have you ever noticed that your face or mouth was shifted to one side (paralyzed) for more than 24 h?	Have you ever had episodes where you lose contact with your surroundings for some minutes?	Have you ever had any episode of shaking of your hands or legs for a brief period and which you could not control?	Have you ever had loss of sensation or abnormal sensation affecting your arms and legs, lasting for more than 24 h?	Have you ever had paralysis of one side of your body (arm or leg) lasting for more than 24 h?	Have you ever had convulsions that occurred when you had a fever?	Have you ever had convulsions that occurred when you did not have a fever?	Do your arms shake currently?	Have you noticed that you have become slower when walking?	Do you shuffle your feet or take tiny steps when you walk?	Have you ever had any weaknesses or paralysis in both legs?	Positive /Negative for stroke? **(For office use only)**
		In Years	M/F	1 = Yes 2 = No 3 = DNK 9 = NK	1 = Yes 2 = No 3 = DNK 9 = NK	1 = Yes 2 = No 3 = DNK 8 = NA 9 = NK	1 = Yes 2 = No 3 = DNK 8 = NA 9 = NK	1 = Yes 2 = No 3 = DNK 9 = NK	1 = Yes 2 = Possible 3 = Never 4 = DNK 9 = NK	1 = Yes 2 = No 3 = DNK 9 = NK	1 = Yes 2 = No 3 = DNK 9 = NK	1 = Yes 2 = No 3 = DNK 9 = NK	1 = Yes 2 = No 3 = DNK 9 = NK	1 = Yes 2 = No 3 = DNK 9 = NK	1 = Yes 2 = No 3 = DNK 9 = NK	1 = Yes 2 = No 3 = DNK 9 = NK	1 = Yes 2 = No 3 = DNK 9 = NK	1 = Yes 2 = No 3 = DNK 9 = NK	Yes -1 NO - 2
31.1	***31.2***	***31.3***	***31.4***	***31.5***	***31.6***	***31.7***	***31.8***	***31.9***	***31.10***	***31.11***	***31.12***	***31.13***	***31.14***	***31.15***	***31.16***	***31.17***	***31.18***	***31.19***	***31.20***
																			1 2
																			1 2
																			1 2
																			1 2
																			1 2
																			1 2
																			1 2
																			1 2
																			1 2