APPLICATION OF DISEASE MAPPING TO A GLOBAL PUBLIC HEALTH ISSUE IN LOW- AND MIDDLE-INCOME COUNTRIES: A CASE STUDY OF HYPERTENSION

A Thesis submitted to Warwick Medical School in partial fulfilment for the award of Doctor of Philosophy in Medicine

By

Ahmed Mohammed Sarki

JANUARY, 2017

THE UNIVERSITY OF WARWICK

WARWICK MEDICAL SCHOOL

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ACKNOWLEDGEMENT

I will like to begin by expressing my gratitude to Almighty Allah for granting me the life, sound health, and wisdom to complete this research.

I will like to express my profound appreciation to my amazing and indefatigable Supervisory team in particular Professor Kandala, Professor Stranges, and Dr. Uthman who have stood by me relentlessly in ensuring that this research becomes a success. No amount of words can express my gratitude and appreciation to these embodiments of knowledge.

I will also like to acknowledge the contribution of the Division of Health Sciences at Warwick Medical School who have sponsored me to attend various courses and workshops which impacted me with the skills necessary to conduct this research.

My appreciation also goes to the University of Warwick for admitting me into the PhD in Medicine program. I have learnt so much in such a little time and I am confident to state that, my Warwick experience is one that can never be forgotten.

I will like to give credit to the amazing individuals who supported me financially, particularly; Alhaji Abdulrazaq Tayibu, Alhaji Mohammed Bashir, Alhaji Shehu Madaki and Alhaji Shehu Ibrahim Demba.

My acknowledgement cannot be complete if I don't extend my gratitude to my family for their endearing support over the last 3 years. I will like to specifically thank my parents, my siblings, and my beloved Rabiat Nura Abba.

Lastly, I will like to appreciate the contribution of my friends and colleagues, for the most part; Chidozie Nduka, Bashir Mohammed, Justine Musiime, Kyuka Ibrahim, Toyin Ogboye, and many others that I couldn't mention due to limited space. These individuals are the most amazing bunch of friends one can wish to have.

DEDICATION

In loving memory of Hendrick Kandala

LIST OF ACRONYMS AND ABBREVIATIONS

AFR – African Region

AMR – Americas Region

AOR – Adjusted Odds Ratio

BHS – British Hypertension Society

BMI – Body Mass Index

BP – Blood Pressure

BRHS – British Regional Heart Study

CARMELA – Cardiovascular Risk Factor Multiple Evaluation in Latin America Study

CIs – Confidence Intervals

CVDs – Cardiovascular Diseases

DALYs – Disability-adjusted life-years

DBP – Diastolic Blood Pressure

DHS – Demographic and Health Surveys

EMBASE – Excerpta Medica database

EMR – Eastern Mediterranean Region

EUR – European Region

FAO – Food and Agriculture Organization of the United Nations

GDP – Gross Domestic Product

GNI – Gross National Income

HIV/AIDS – Human Immunodeficiency Virus/Acquired Immune Deficiency Syndrome

IMF – International Monetary Fund

INSTAT – Institute of Statistics of Albania

JNC – Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure

Kg/m^2 – Kilogram per metre square

LMICs – Low-and Middle-income countries

McMC – Markov chain Monte Carlo simulation technique

MEASURE DHS – Monitoring and Evaluation to Assess and Use Results, Demographic and Health Surveys

MEDLINE – Medical Literature Analysis and Retrieval Systems Online

Mesh – Medical Subject Heading

mmHg – millimetres of mercury

NCDs – Noncommunicable Diseases

NICE – National Institute for Health Care Excellence

NHP – National Hypertension Project

OR – Odds Ratio

PHCS – Primary Health Care Strengthening

POR – Posterior Odds Ratio

PPP – Purchasing Power Parity

PRISMA – Preferred Reporting Items for Systematic Reviews and Meta-analyses

PROSPERO – Prospective register for systematic reviews

PURE – Prospective Urban-Rural Epidemiological Study

SBP – Systolic Blood Pressure

SD – Standard Deviation

UK – United Kingdom

UNICEF – United Nations Children's Fund

USA – United States of America

USAID – United States Agency for International Development

UNFPA – United Nations Population Fund

WHO – World Health Organization

YLD – Years of healthy life lost due to disability

YLL – Years of life lost due to premature mortality

DECLARATION

I hereby wish to declare that this Thesis is my own work except where I stated otherwise. All sentences or passages quoted in this thesis from other people's work have been specifically acknowledged by clear cross-referencing to author, year of publication, and page(s). Similarly, any illustrations which are not the work of the author of this Thesis have been used with the explicit permission of the originator WHERE POSSIBLE and are specifically acknowledged.

ABSTRACT

Background

Hypertension is a global public health problem. It is the number one risk factor for mortality and the third leading cause of disability-adjusted life-years (DALYs) worldwide. The burden of the disease is more severe in low- and middle-income countries, where prevalence estimates are projected to increase by 30% over the next decade. This is not surprising owing to the on-going epidemiological transition taking place in these countries, where the interplay between social factors and disease is highly pertinent. However, evidence on the burden of hypertension and its determinants in low- and middle-income countries are limited. The overall aim of this research is to examine the prevalence and status of hypertension in low- and middle-income countries. The definition of hypertension used in this research is blood pressure measurement of ≥140 /90 mmHg (SBP/DBP), the use of antihypertensive medication, or self-reported physician diagnosis of hypertension.

Objectives

- To estimate the overall prevalence of hypertension in low- and middle-income countries.
- To examine the socio-demographic determinants of hypertension in low- and middle-income settings.
- To examine the geographic variation of hypertension prevalence in selected low-and middle-income countries.
- To interpret the findings and discuss their implications for practice/policy and future research.

Methods

A systematic review and meta-analysis was conducted to provide overall and regional estimates of hypertension prevalence across low- and middle-income countries, and to examine patterns of the disease across different socio-demographic characteristics in these settings. Studies reporting hypertension prevalence in low- and middle-

income countries were sought from electronic databases and grey literature. The data from these studies were analyzed using random-effects meta-analyses and sub-group analyses.

Secondary data analyses of DHS datasets were also conducted to estimate hypertension prevalence and examine its geographic variation in selected low- and middle-income countries with hypertension data, while accounting for a number socio-demographic characteristics. The secondary data analyses entailed logistic regression and Bayesian geo-additive analyses. Odds ratios with 95% confidence intervals were reported for the logistic regression analyses, whereas posterior odds ratios with 95% credible intervals were reported for the Bayesian geo-additive analyses.

Results

The systematic review included 242 studies, comprising 1,494,609 adults from 45 countries. The overall prevalence of hypertension was 32.3% (95% confidence interval [CI] 29.4–35.3) with the Latin America and Caribbean region reporting the highest prevalence (39.1%, 95% CI 33.1–45.2). Prevalence was also highest in upper-middle income countries (37.8%, 95% CI 35.0–40.6) and lowest in low-income countries (23.1%, 95% CI 20.1–26.2). Prevalence among adults ≥65 years was substantially higher than adults <65 years; however, there was no significant sex-difference overall (31.9% vs 30.8%, $p=0.6$). Prevalence was generally higher among the non-educated compared to educated people (49.0% vs. 24.9%, $p<0.05$), among overweight/obese persons compared to normal weight (46.4% vs. 26.3%, $p<0.05$), and among urban settlers compared to rural (32.7% vs 25.2%, $p=0.0005$). Meta-regression showed that combined overweight/obesity ($p<0.05$) and being uneducated ($p<0.05$) significantly accounted for between-study heterogeneity in hypertension rates

The secondary analysis comprised data on 93,247 respondents in 10 selected countries (Albania, Armenia, Azerbaijan, Ukraine, Uzbekistan, Egypt, Morocco, Lesotho, Senegal and Maldives). The prevalence of hypertension was lowest in

Morocco (5.4%) and highest in Albania (22.7%). Age was the most consistent predictor of hypertension. Being employed was protective in the Eastern European countries (Albania, Armenia, Azerbaijan, Ukraine and Uzbekistan) ($p<0.05$ for each) and in African countries such as Egypt and Senegal ($p<0.05$ for each). Education was protective in Egypt, Senegal and Maldives ($p<0.05$ for each), but may be a strong determinant in Lesotho given the extremely high literacy rates in the country.

Examining the geographic variation of hypertension revealed that Tirana and Elbasan districts had the highest burden of hypertension compared to other districts in Albania; Sharkia and Kalyoubia districts had the highest burden of hypertension compared to other districts in Egypt; while Quthing and Maseru districts had the highest burden of hypertension in Lesotho.

Conclusion

Overall, the findings provide contemporary and up-to-date estimates that reflect the significant burden of hypertension in low- and middle-income countries and evidence that hypertension remains a major public health issue in these settings. The findings also suggest that addressing the wider social determinants of hypertension, such as illiteracy and unemployment, may reduce overall prevalence of the disease in low- and middle-income countries.

CHAPTER ONE: INTRODUCTION

1.1 INTRODUCTION

The major causes of mortality in the world today are non-communicable diseases (NCDs), and collectively, these health conditions are responsible for more than 36 million deaths annually [World Health Organisation (WHO), 2014]. They are characterised by their long duration and slow progression (WHO, 2011a), examples include; cardiovascular diseases (CVDs), chronic respiratory diseases, cancers, and diabetes (WHO, 2014).

NCDs pose a global threat, and the burden of death and disability attributable to these diseases are rising in almost every country of the globe due to the changing patterns in lifestyle, negative effects of globalization, poor dietary habits, rapid urbanization, and trends of ageing in populations (Beaglehole *et al.*, 2011; Hosseinpoor *et al.*, 2012). Despite being thought of as diseases of the most affluent nations, approximately 4 out of every 5 NCD deaths occur in low- and middle-income countries (LMICs) (WHO, 2014).

The encumbrance of NCDs in LMICs goes beyond a global health issue to an economic and developmental issue as they lead to increase in poverty, increase in healthcare expenditure, and loss of productivity (Suhrcke *et al.*, 2007; Lee *et al.*, 2010; Mahal *et al.*, 2010; Beaglehole *et al.*, 2011). In relation to the economic impact of NCDs, the World Economic Forum and the Harvard School of Public health in late 2011 forecasted that the global economic burden of NCDs over the next 2 decades would be approximately US$47 trillion (Bloom *et al.*, 2011; Moolani *et al.*, 2012) unless all stakeholders around the world act together towards combatting these diseases.

NCDs share common risk factors (Suhrcke *et al.*, 2007). However, the scope of this research is limited to CVDs and more specifically hypertension, given that the latter is one of the most important risk factors for mortality and burden of disease globally, with very high prevalence in LMICs (WHO, 2014).

CVDs are referred to as a group of diseases of the heart and blood vessels (Bloomfield *et al.*, 2006; Newby *et al.*, 2010) and are reported to be the leading cause of disease, disability, and death globally (Mathers & Loncar, 2006; Gaziano, 2008; WHO, 2014). CVDs account for the most NCD deaths with a mortality rate of approximately 17 million people every year while cancers are responsible for the death of over 7 million people annually, chronic respiratory diseases on the other hand claim 4.2 million lives yearly, whereas 1.3 million people die annually as a result of diabetes (Lim *et al.*, 2012; WHO, 2014).

Furthermore, WHO (2005) highlighted that CVDs transcend socioeconomic, gender, and geographical boundaries. It has been reported that ≥80% of CVD deaths occur in low-and-middle-income countries and the distribution is almost equal in men and women (WHO, 2013b). For instance, the incidence of ischemic heart disease (IHD) in the Western World is rapidly declining but in Eastern Europe and the Indian subcontinent, incidence of the disease is rising (Bloomfield *et al.*, 2006). In the work of Deaton *et al.*, (2011), the authors highlighted that even in developing countries where the prevalence of CVDs is high, greater burden of the diseases occur in the lower socio-economic group. This signals a shift in the epidemic of CVDs, hence, prompting the need for reliable, cost-effective, and innovative approaches to apply what is already known about these diseases in the developed countries to the developing countries.

The key risk factors of CVDs include: hypertension (high blood pressure), physical inactivity, tobacco smoking, diabetes mellitus, unhealthy diet, family history of CVDs, hyperlipidaemia (high blood lipids), obesity, poverty, hereditary factors, demographic characteristics, age, sex, and haemostatic factors (Zipes *et al.*, 2005; Bloomfield *et al.*, 2006; Longmore *et al.*, 2010; Newby *et al.*, 2010; Neylon *et al.*, 2013; WHO, 2013b; World Heart Federation, 2015).

Significant gaps exist in what is known about CVDs and their risk factors in LMICs either due to inadequate data or paucity of information on regional variations in cardiovascular diseases incidence, prevalence and/or mortality in these countries

(Gupta, 2011; Kandala *et al.,* 2013). There is therefore a need to conduct epidemiological studies that will provide an insight into the geographic variation of the risk factors of CVDs in LMICs. These studies will enable researchers to identify the primordial determinants of the risk factors of CVDs in these countries and also inform resource allocation and public health interventions. In addition, the studies would provide a basis for replicating studies/surveys that are conducted elsewhere, such as the British Regional Heart Study (BRHS) (Walker *et al.*, 2004), Cardiovascular Risk Factor Multiple Evaluation in Latin America Study (CARMELA) (Schargrodsky *et al.*, 2008), International collaborative study of cardiovascular disease in Asia (InterASIA) (He *et al.*, 2004), the Prospective Urban-Rural Epidemiological Study (PURE) (Teo *et al.*, 2009) in many of the LMICs.

This research will focus on examining the geographical variation of the major risk factor for CVDs (hypertension) and its associated determinants in selected low-and middle-income countries which are spread across Sub-Saharan Africa, Eastern Europe, and the Indian sub-continent.

1.2 BACKGROUND

1.2.1 DEFINITION OF THE HEALTH PROBLEM - HYPERTENSION

Hypertension (high blood pressure) is a chronic condition in which blood vessels (arteries) have persistent raised pressure generated by the force of blood pushing against the artery walls as it is pumped by the heart (Newby *et al.*, 2010; WHO, 2013a). High blood pressure increases the risk of damage to the heart and blood vessels in organs such as the kidneys and brain, which leads to heart diseases, stroke, kidney failure, cognitive impairment and other co-morbidities (Kearney *et al.*, 2005; Addo *et al.*, 2007).

Blood pressure occurs within a continuous range, therefore cut off levels are usually defined according to the amount of risk they pose to patients (Newby *et al.*, 2010). According to the National Institute for Health and Care Excellence (NICE) (2011a), there is no natural cut off point above or below which hypertension exists. Newby *et* *al.*, (2010) further postulated that high blood pressure is not a specific disease, but rather a trait that represents quantitative rather than qualitative deviation from the norm, therefore any definition of hypertension is arbitrary.

However, in this research many definitions and classifications of hypertension have been considered including that of the British Hypertension Society (BHS), World Health Organisation-International Society of Hypertension (1999), European Society of Hypertension-European Society of Cardiology (2003), and the Sixth and Seventh report of the United States of Americas' Joint National Committee on Prevention, Detection, Evaluation, and treatment of High Blood Pressure (JNC) in 1997 and 2003 respectively (Chobanian *et al.,* 2003) which are presented in the table below:

Table 1.1: Classification of blood pressure levels

Category	**Systolic Blood Pressure (SBP) (mmHg)**		**Diastolic Blood Pressure (DBP (mmHg)**
Blood Pressure			
Optimal	<120	and	<80
Normal	<130	and	<85
High-normal	130-139	or	85-89
Hypertension			
Level 1 (mild)	140-159	or	90-99
Level 2 (moderate)	160-179	or	100-109
Level 3 (severe)	≥180	and	≥110
Isolated Systolic hypertension			
Level 1	140-159	and	<90
Level 2	≥160	and	<90

Source: Williams, *et al.,* (2004)

For the purpose of this research, the definition of hypertension adopted is blood pressure of ≥140 /90 mmHg (SBP/DBP), self-reported physician diagnosis of hypertension, or being on anti-hypertensive medication- which is also in line with the definitions adopted by Carretero & Oparil (2000), Kearney *et al.,* (2005) and WHO (2013a).

1.2.2 THE GLOBAL EPIDEMIOLOGY AND ASSOCIATED BURDEN OF HYPERTENSION

WHO (2013a) reported that 1 in 3 adults around the world have high blood pressure. However, extensive diagnosis and cost-effective treatments have led to better management and prevention of hypertension sequels in developed countries which also contributed significantly to the reduction of deaths from heart diseases and disability from stroke (WHO, 2011a). On the contrary, a lot of people with hypertension in developing countries are undiagnosed and therefore risk missing out on treatments that could reduce death from heart diseases and disability from stroke and other form of cardiovascular morbidities (Ibrahim & Damasceno, 2012)

Hypertension is widely recognized as a chronic non-communicable disease and it is dubbed by many researchers as a 'silent killer' partly due to its associated high mortality rates and its asymptomatic presentation (Kearney *et al.*, 2005; Ma *et al.*, 2013). It has been established that hypertension is the major risk factor for mortality and the third leading cause of disability-adjusted life-years (DALYs) worldwide (Ezzati *et al.,* 2002; Hendricks *et al.,* 2012).

Specifically, hypertension is estimated to cause over 7 million premature deaths, about 12.8% of all deaths globally and this accounts for 57 million disability adjusted life years (DALYs) (WHO, 2016a). In other words, hypertension accounts for the loss of the equivalent of 57 million years of full health.

Hypertension may portend a considerable impact on the global incidence of cardiovascular disease, given that the disease it is the single most important risk factor for stroke and coronary heart disease, accounting for about 54% and 47% of cases respectively (Lawes *et al.*, 2008; WHO, 2016a). Hence, hypertension is potentially among the major drivers of cardiovascular diseases- the major cause of mortality worldwide (WHO, 2016a). Few studies have explored the relationship between elevated blood pressure and life expectancy in adults. Of note, Franco *et al.* (2005), in a secondary data analysis examined the life expectancy at 50 years of 3128 men and women with high blood pressure, as compared to normotensive men and women from the Framingham Heart Study. The findings revealed that the normotensives lived slightly longer than the hypertensives (5.1 years *versus* 4.9 years).

In the past two decades, the prevalence of hypertension has been higher in low-and middle-income countries compared to high-income countries, and continue to increase rapidly. For instance, in the year 2000, there were approximately twice as many people with hypertension in low-and middle-income countries, compared to high-income countries (639 million *versus* 333 million) (Kearney *et al.*, 2005). Projections at that time estimated a 60% increase in global hypertension prevalence by the year 2025, which would be driven by a considerably larger increase in hypertension prevalence in low-and middle-income countries (80% *versus* 24%) (Kearney *et al.*, 2005). Figure 1.1 below is a graphical illustration of the prevalence of hypertension across country income groups and geographical regions based on estimates for the year 2008. In addition, about one billion people were living with hypertension worldwide during this time, which represented a 40% increase from 600 million affected people in the year 1980 (WHO, 2013d). As shown, the increase in hypertension prevalence during this period was driven by estimates from low-and middle-income countries.

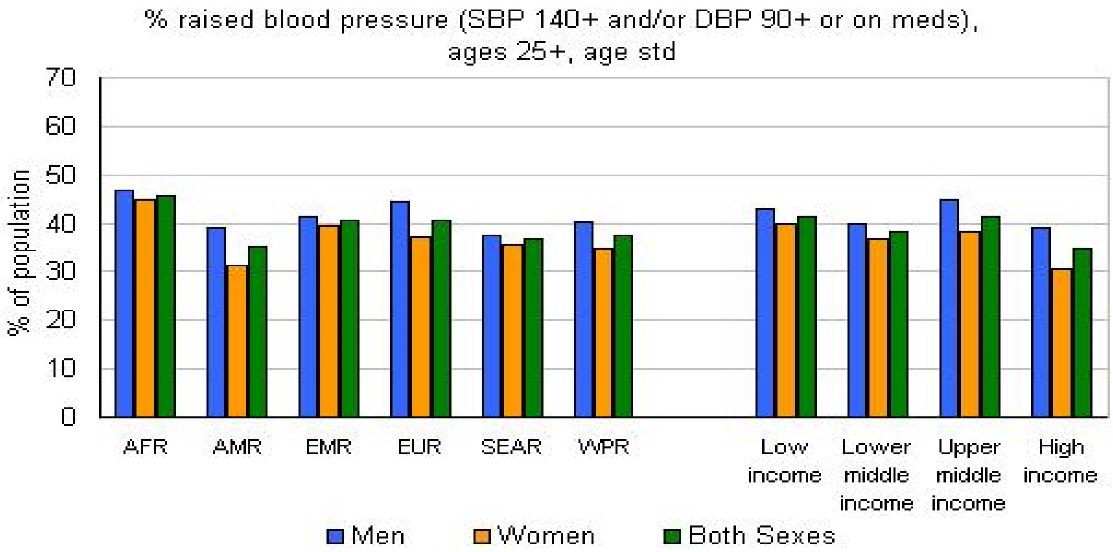


Figure 1.1: Prevalence of hypertension in WHO regions. Source: World Health Organisation (2013b)

With regards to the prevalence of high blood pressure across the WHO regions, the African region (AFR) had the highest prevalence with 46% for both sexes, followed by the Eastern Mediterranean (EMR) and European (EUR) regions with prevalence slightly above 40% for both sexes, whereas the Americas (AMR) region had the lowest prevalence of 35% for both sexes. Of note, the prevalence of hypertension higher among men than women across all the regions, however caution must be applied in interpreting these figures, given that the observed sex differences in hypertension prevalence were only statistically significant in the European and American regions (WHO, 2013d).

The WHO in its 2014 Global Status Report on non-communicable Diseases stipulated that the global prevalence of hypertension in adults 18 years and above was estimated at 22%. Furthermore, the WHO highlighted that, the prevalence of hypertension remained highest in the African region at 30% for all adults and lowest in the Americas at 18%. In addition, the prevalence of high blood pressure by country income group was highest in low-income countries compared to the middle-income and high-income countries (WHO, 2014). These variations in estimate from 2008 to 2014 indicate a shift in prevalence among WHO regions and World Bank income group in which the African region and low-income countries have the highest prevalence estimates of hypertension.

1.2.3 RISK FACTORS FOR HYPERTENSION AND THEIR RELEVANCE TO LOW-AND MIDDLE-INCOME COUNTRIES

Findings from several literature sources have ascribed the increase of the hypertension epidemic in low-and middle-income countries to the following factors: ageing of the population, lifestyle factors (such as smoking, alcohol, physical inactivity, poor dietary habits), socioeconomic determinants (which include wealth, education, household income, and occupational grade), psychosocial factors (such as stress and job strain), medication adherence, and environmental factors (such as urbanisation, pollution, and overcrowding e.t.c). (Messerli *et al.*, 1981; Koplan & Dietz, 1999; Lewington *et al.*, 2002; Gascon *et al.*, 2004; Stranges *et al*., 2004; Ezzati *et al.*, 2006; WHO, 2013d;2013e; Murphy *et al.*, 2016; UNFPA, 2016; World Heart Federation, 2016).

1.2.3.1 AGEING POPULATIONS

Blood pressure increases with age, and the age-related changes in blood pressure are associated with a temporal relationship between ageing and hypertension. For instance, Vasan *et al.* (2002), in a population-based cohort study, revealed a 90% incidence of hypertension in middle-aged men and women who were previously normotensive. One of the biological mechanisms for the age-related increase in blood pressure is explained by the progressive loss of the elastic properties of blood vessels with ageing, which lead to stiffening of the blood vessels and loss of blood pressure regulation.

For more than three decades, it has been widely documented that increasing age is the most consistent independent predictor of hypertension prevalence in low-and middle-income countries (Messerli *et al.*, 1981; Landahl *et al.*, 1986). The average life-expectancy in low-and middle-income countries increased from 47 years in 1960 to 70 years in 2014 (World Bank, 2016). In other words, the resident populations in low-and middle-income countries are, on the average, 23 years older today than they were five decades ago. Of note, this increase in average life-expectancy (in low-and middle-income countries) is much steeper than the 13-year increase (68 years to 81 years) observed in high-income countries during the same period (World Bank, 2016). Therefore, ageing populations may play an important role in the on-going epidemic of hypertension in low-and middle-income countries.

1.2.3.2 LIFESTYLE FACTORS

Lifestyle or behavioural factors increase the risk of developing hypertension. Of note, these factors include unhealthy dietary patterns, physical inactivity, tobacco use, and harmful use of alcohol (WHO, 2013d). Lifestyle factors may interact with ageing in improving the prediction of hypertension, as the latter often accompanies a more prolonged exposure to the former.

Poor dietary behaviours may reflect patterns influenced by social and physical environments (Reddy & Katan, 2004). For instance, the nutritional transition that has accompanied the urbanization of low- and middle-income countries presents an increased substitution of plant-based foods for fast foods that tend to be disproportionately high in sodium and saturated fats. Sodium increases blood pressure by causing the body to retain fluids while constricting the arteries (Zheng *et al.* 2014). Consumption of saturated fats increases the formation of atheromatous plaques, which reduces the calibre of blood vessels, so that the pressure of blood flow along affected vessels is increased. Furthermore, the WHO (2016) affirms that low- and middle-income countries are witnessing the fastest rise in childhood obesity across the world. And although based on evidence from high-income populations, 26% of obese children develop hypertension as adults compared to 6% of normal-weight children (Watson *et al*., 2013). This piece of evidence is important within the context of developing economies, which grow at faster rates than developed countries, and provide an enabling environment for the aggressive marketing of fast foods (World Heart Federation, 2016).

Physical inactivity is an independent risk factor for cardiovascular diseases (Koplan & Dietz, 1999). Generally, physical activity increases blood flow to the endocrine organs, which leads to the release of natural hormones and cytokines that relax blood vessels and lower blood pressure (Koplan & Dietz, 1999). The WHO (2016b) reports that an estimated 3.2 million deaths each year are attributable to insufficient physical activity as nearly one-third of adults aged 15 and above are insufficiently active (28% of males and 34% of females). Interestingly, rapid dramatic reductions in physical activity are also occurring in low- and middle-income countries (Swinburn *et al.* 2004). The current levels of physical inactivity in low- and middle-income countries are partly due to increasing sedentary lifestyle in occupational activities, given rapid technological changes and industrialization that potentially transform the various sectors of developing economies. The current levels of physical activity in low- and middle-income countries may also be explained by increasing motorisation of transportation, which continue to replace walking and bicycle riding in urban cities. In China, for instance, car owners were 80% more likely to be hypertensive, compared to people who walk or use bicycles (Hu & Willet, 2002).

Tobacco use is the most preventable cause of cardiovascular mortality worldwide with majority of the world's cigarette smokers (1.3 billion about a decade ago) resident in low- and middle-income countries (Teo *et al.* 2006). The relationship between tobacco use and hypertension has been widely documented. The harmful effects of tobacco on health include fatty build-ups in arteries (atherosclerosis), impairment of endothelial function, arterial stiffness, increasing heart rate, and increasing myocardial contractility, all of which increase blood pressure (Najem *et al.* 2006; Rosen *et al.* 2006; Jatoi *et al.* 2007; Virdis *et al.* 2010). In a study conducted to evaluate the association between cigarette smoking and hypertension among 28,000 normotensive women, Browan *et al*. (2007) found that cigarette smoking was modestly associated with an increased risk of developing hypertension, and the association was strongest among women who smoked 15 cigarettes per day or more.

Harmful consumption of alcohol increases blood pressure and significantly increases the risk of developing hypertension in the future (Alcohol Concern, 2015). Essentially, alcohol consumption is associated with weight gain, which in turn, is associated with increased blood pressure. Several epidemiological studies have demonstrated a plausible dose-response relationship between the amount of alcohol consumed and the risk of hypertension. For instance, in a meta-analysis of observational studies, the pooled risk of developing hypertension was higher among men who consumed more than 50g/day of alcohol (RR 1.61, 95% CI 1.38-1.87), compared to men who consumed less (RR 1.03, 95% CI 0.94-1.13) (Briasoulis *et al*., 2012). Similarly, the pooled risk of hypertension was slightly increased among women who consumed more than 30g/day of alcohol (RR 1.19, 95% CI 1.07-1.32), but not among women who consumed less (RR 0.87, 95% CI 0.82-0.92) (Briasoulis *et al*., 2012). In addition, Stranges *et al.* (2004) found that the odds of developing hypertension were significantly higher among persons who consumed more than 2 drinks per day, compared to those who consumed less than 2 drinks per day (OR 1.75, 95% CI 1.13-2.72). Unfortunately, these findings are based on evidence from high-income countries, given the dearth of published data on the dose-response relationship between alcohol consumption and hypertension risk in low- and middle-income countries. Nonetheless, harmful alcohol consumption remains a public health problem in low- and middle-income countries. A considerable proportion of people resident in low- and middle-income countries live in poverty with reduced social support, which have consequences for mental health issues, and invite alcohol abuse as a coping mechanism for stress relief. In Brazil, for instance, more than three-quarters of street children are heavy drinkers (WHO, 2004). This portends a greater risk of developing hypertension and cardiovascular health outcomes in their later adulthood.

1.2.3.3 PSYCHOSOCIAL FACTORS

Psychosocial factors comprise of stress and strain among populations. Stress and strain are plausible causes of hypertension when combined with other factors (Sparrenberger *et al.* 2009). The most common psychosocial factors in low-and middle-income countries are job strain (Babu *et al.* 2013) and emotional distress (Brosschot *et al.* 2005). The mechanism underlying the stress-hypertension relationship involves stimulation of the nervous system to produce large amounts of catecholamines that leads to increased blood pressure (Kulkarni *et al.* 1998; McEwen, 1998; Spruill, 2010). However, the process by which stress contribute to sustained raised blood pressure over time is still being investigated, possible reasons include the repeated activation of this system, failure to return to resting levels following stressful events, and failure to adapt to repeated stressors for the development of hypertension (McEwen, 1998).

Job strain on the other hand is characterised by a combination of high workload and few decision-making opportunities in the workplace. Babu *et al.* (2013) conducted a systematic review and meta-analysis comprising over 25,000 workers to determine the relationship between job strain and hypertension and found a statistically significant association (OR 1.29 95% CI 1.14 – 1.47). Again, the included studies were largely from high-income countries, given the dearth of relevant studies from low- and middle-income countries. Nonetheless, high strain jobs are typically associated with lower occupational grades, which are speculated to be more prevalent in low- and middle-income countries, compared to high-income countries.

1.2.3.4 MEDICATION ADHERENCE

Given the chronicity of hypertension, it is not unexpected that sub-optimal adherence to antihypertensive medication constitutes an important public health problem in the treatment and control of hypertension, especially in low- and middle-income countries, where access to these medications are limited by health systems in which patients finance the costs of their health care. A recent systematic review and meta-analysis comprising 92,443 adults in low- and middle-income countries revealed that approximately two-thirds of hypertensive patients do not adhere to their medications (pooled percentage 63.35%; 95% CI 38.78 - 87.91) (Nielsen *et al.* 2016). It is worthy to note that, factors contributing to non-adherence in the study were largely related to socio-economic factors.

1.2.3.5 ENVIRONMENTAL FACTORS

Environmental factors that affect the development of hypertension in low- and middle-income countries include overcrowding and pollution: common aftermaths of rapid urbanisation.

Rapid urbanisation refers to the accelerated increase in the proportion of people living in urban areas and the ways in which societies cope (Godfrey & Julien, 2005). The United Nations projected that by the year 2050, about 64% of populations in the developing regions of the world would be living in urban areas, with many cities in this region such as Jakarta (Indonesia), Manila (Philippines), Mumbai (India), Cairo (Egypt), and Lagos (Nigeria) already having an estimated population of 20 million each (UNFPA, 2016). In low- and middle-income countries, rapid urbanisation does not necessarily translate to increase in life expectancy (Eckert & Kohler, 2014), but contributes to shifts in disease burden (Godfrey & Julien, 2005; Allender *et al.* 2008; Eckert & Kohler, 2014). In these countries, the negative effects of urbanisation are more common among the urban poor as they grapple with health inequalities, extreme poverty, vulnerability, and marginalization (UNFPA, 2016).

Overcrowding or housing instability on the hand is a plausible independent environmental risk factor for hypertension (D'Atri & Ostfeld, 1975; Seedat *et al.,* 1982). An explanation of the link between overcrowding and hypertension is that the latter leads to psychological distress, and strained relationships even within households (emotional distress) among other factors which eventually lead to hypertension (Kopko, 2016).

Another important environmental risk factor that affects the development of hypertension is pollution. Several types of pollution have been linked with hypertension particularly noise pollution (Zawilla *et al.* 2014), air pollution (Chan *et al.* 2015), and oil pollution (Ezejimofor *et al.* 2016). There are a number of epidemiological studies that have shown an association between occupational and environmental noise exposure and hypertension. van Kempen *et al*. (2002) conducted a meta-analysis of 43 epidemiologic studies published between 1970 and

1999 that investigated the relation between occupational and community noise exposure and blood pressure and/or ischemic heart disease. They found a significant associations of occupational (RR 1.14; 95% CI: 1.01–1.29) and traffic noise exposure (RR 1.26; 95% CI: 1.14–1.39) with increased hypertension risk (van Kempen *et al*., 2002). Regarding oil pollution, Ezejimofor *et al.* (2016) conducted a comparative cross-sectional study among over 2,000 residents of the Niger-Delta oil-producing region of Nigeria, stratified by areas of residence (polluted and non-polluted communities). The findings of the study revealed that the adjusted odds of developing hypertension were approximately five-folds higher among participants living in oil-polluted communities, compared to participants living in non-oil polluted communities (aOR 4.85, 95% CI 1.84-12.82).

1.2.3.6 SOCIAL DETERMINANTS

Social determinants of health are characterised by wealth, education, household income, social support, culture, accessibility to health care, psychosocial factors, and residential environments (Clark *et al.* 2009; Havranek *et al.* 2015). These factors determine the conditions in which individuals are born, raised, live, work, and age, as well as the mechanisms put in place to deal with their ill health (Marmot *et al.* 2008).

Disparities in these living conditions lead to varying health status among individuals or populations - health inequalities (Arcaya *et al.* 2015). At the centre of these differences lies an individual's socioeconomic status (SES) where — in its most simplistic definition — refers to the standing of an individual in a community with respect to education, wealth, and profession. Hence, a person of low SES is described as one with little or no formal education, belonging to a lower wealth quintile, or having lower occupational grades. In all countries, individuals of low SES suffer health disadvantage while persons with higher SES tend to have better health (Marmot, 2005). In other words, there is a social gradient in health across and within populations.

Although the mechanisms involved are not clear-cut, they are speculated to include poorer lifestyle, adverse living conditions, psychosocial stress, occupational strain, and limited access to health care resources. The latter is particularly important within the context of low- and middle-income countries where people living in these settings tend to pay out of-pocket for health care (Murphy *et al.* 2016).

Epidemiological studies conducted in low- and middle-income countries have consistently demonstrated the graded association between socioeconomic factors and hypertension risk. For instance, studies show inverse associations of the number of years of formal education completed (Albert *et al*. 2006; Wen-Hui *et al.* 2013), occupational grade (Clark *et al.* 2009) and house-hold income (Harhay *et al.* 2013) with hypertension prevalence.

In addition, there is epidemiological evidence of the impact of urbanisation on the rising prevalence of hypertension across low- and middle-income countries. For example, studies show higher prevalence estimates of hypertension among urban settlers in low- and middle-income countries, compared to rural settlers (Midha *et al.* 2009). Similarly, prevalence estimates of hypertension tend to be higher in upper middle-income countries, compared to the less advanced lower middle-income and low income countries (Addo *et al.* 2007).

The hypothesized mechanisms of the association between social determinants and hypertension and their relationships with other risk factors of hypertension are illustrated in Figure 1.2 (page 19).

1.3 EPIDEMIOLOGICAL TRANSITION

This is a theory proposed by Omran in 1971 that focuses on the complex changes in the pattern of health and diseases and their interactions with economic, social, and demographic determinants as they affect populations (Omran, 1971; 1979). In essence, the theory is concerned with the constant patterns of changes in the primary causes of morbidity and mortality as societies develop. Omran (2005) posits that in many high-income countries, epidemiological transition has paralleled demographic and technological transitions and it is advancing in many low-and middle-income countries because degenerative and man-made diseases are gradually displacing communicable diseases as the primary causes of deaths.

It is also imperative to highlight that epidemiological transition is associated with demographic and nutritional transitions (Popkin & Gordon-Larsen, 2004; Amuna & Zotor, 2008). The demographic transition describes a change in population dynamics highlighting the relationship between mortality and birth rate (Amuna & Zotor, 2008). On the other hand, nutritional transition implies a shift in pattern of diet and physical activity by populations which includes consumption of unhealthy foods (containing high levels of salt, sugar, and fat, with large intakes of "empty calories") as well as lack of regular physical activities (Popkin & Gordon-Larsen, 2004).

As stated earlier, the focus of this research is on examining the major primary risk factor for CVDs (hypertension) and its determinants in some selected low-and middle-income countries. Therefore, it will be important to underline the stages of epidemiological transition as they relate to CVDs so as to determine where LMICs lie. A summary can be found on the following page.

Table 1.1: Modified model of the stages of epidemiologic transition in relation to cardiovascular diseases

Stages of Development	Deaths from CVD, % of Total Deaths	Predominant CVDs and Risk Factors	Regional Examples
Age of pestilence and famine	5-10	Rheumatic heart disease, infections, and nutritional cardiomyopathies	Sub-Saharan Africa, rural India, South America
Age of receding pandemics	10-35	Same as above and hypertensive heart disease and haemorrhagic strokes	China
Age of degenerative diseases	35-65	All forms of strokes, ischemic heart disease at young ages, increasing obesity and diabetes	Urban India, former socialist economies, aboriginal communities
Age of delayed degenerative diseases	<50	Stroke and ischemic heart disease at old age	Western Europe, North America, Australia, New Zealand

Age of health regression and social upheaval	35-55	Re-emergence of deaths from rheumatic heart disease, infections, increased alcoholism, and violence; increase in ischemic and hypertensive diseases in the young	Russia

Source: Yusuf *et al.,* (2001)

From the table above, it can be understood that most of the countries of interest to this research (Albania, Armenia, Azerbaijan, Egypt, Lesotho, Maldives, Morocco, Senegal, Ukraine, and Uzbekistan) are within the first three stages of the epidemiological transition of CVDs.

1.4 STUDY JUSTIFICATION

Hypertension is chosen as the health outcome of interest in this research because of its increasing prevalence in almost every part of the world particularly in low-and middle-income countries. Furthermore, the on-going epidemiological transition which is accompanied by demographic and nutritional transitions in these settings added to the interest of undertaking this research.

As highlighted in many research articles, low-and middle-income countries have weak health infrastructure and limited resources allocated to health care, while they are still struggling with the burden of infectious diseases such as HIV/AIDS, tuberculosis, measles, cholera, polio, and haemorrhagic viral infections. Therefore, with high prevalence of chronic non-communicable diseases such as 'hypertension', the health settings in these countries will have to deal with multiple burdens of diseases and health outcomes.

In many of these countries, though, infectious diseases are to a larger extent under control through the concerted effort and support from the global community, particularly developed countries such as USA, UK, Canada, Germany, Netherlands, Japan and international organisations such as WHO, UNICEF, World Bank, Global

Fund as well as other philanthropic organisations such as the Bill & Melinda Gates Foundation and MacArthur Foundation.

However, unless the social determinants and primordial risk factors of chronic diseases such as ‘hypertension’ are understood, identified, and acted upon within the context of low-resource settings, economic and social development in these countries will be hampered, and indirectly, the burden is going to shift to developed countries which at present are also facing economic challenges. Another important issue of concern, is that many governments and public health planners of developing countries still remain largely unaware of the current magnitude of certain conditions such as ‘hypertension’ and its serious complications in their own countries.

It is on this note that research on chronic diseases prevention and control need to focus on generating country-specific information about risk factors of chronic diseases such as ‘hypertension’, the burden of these diseases, as well as impact of globalization and urbanization on behaviours of the population so as to make compelling arguments to leaders of the low-and middle-income settings for prioritizing chronic diseases prevention and control on their development agenda.

This study will play a major role towards understanding the prevalence and identifying the leading risk factors of hypertension in the countries investigated as well as enabling cross-comparisons of the findings between countries in the same region (e.g. Lesotho and Senegal- which are all located in sub-Saharan Africa) or between countries in different regions (e.g. Albania and Maldives- which are located in Eastern Europe and the Indian sub-continent respectively) so as to provide evidence that will inform potential interventions in these countries.

The study will also inform public health policy, resource allocation, and provide platforms for cost-effective monitoring of trends of hypertension as they occur even at smaller geographic scales within the countries explored and other low-and middle-income countries sharing similar geographical characteristics. The study might also help inform the design of cost-effective interventions to address the burden of hypertension across these countries, which will be tailored to the specific needs of the selected populations.

1.5 RESEARCH QUESTIONS

a) What is the status of hypertension in low-and middle-income countries?

b) What is the prevalence and geographic variation of hypertension in Albania, Armenia, Azerbaijan, Egypt, Lesotho, Maldives, Morocco, Senegal, Ukraine, and Uzbekistan?

c) What are the risk-factors underlying the geographic variation of hypertension in these countries?

1.6 RESEARCH HYPOTHESES

I. There is a significant geographical variation in hypertension prevalence across selected low- and middle-income countries.

II. There is a significant difference in hypertension prevalence among populations residing in low- and middle-income countries with respect to:

   a) Ageing of the population (Messerli *et al.*, 1981; Lewington *et al.*, 2002)

   b) Environmental factors (urbanisation, overcrowding, and pollution) (D'Atri & Ostfeld, 1975; Seedat *et al.,* 1982; Zawilla *et al.* 2014)

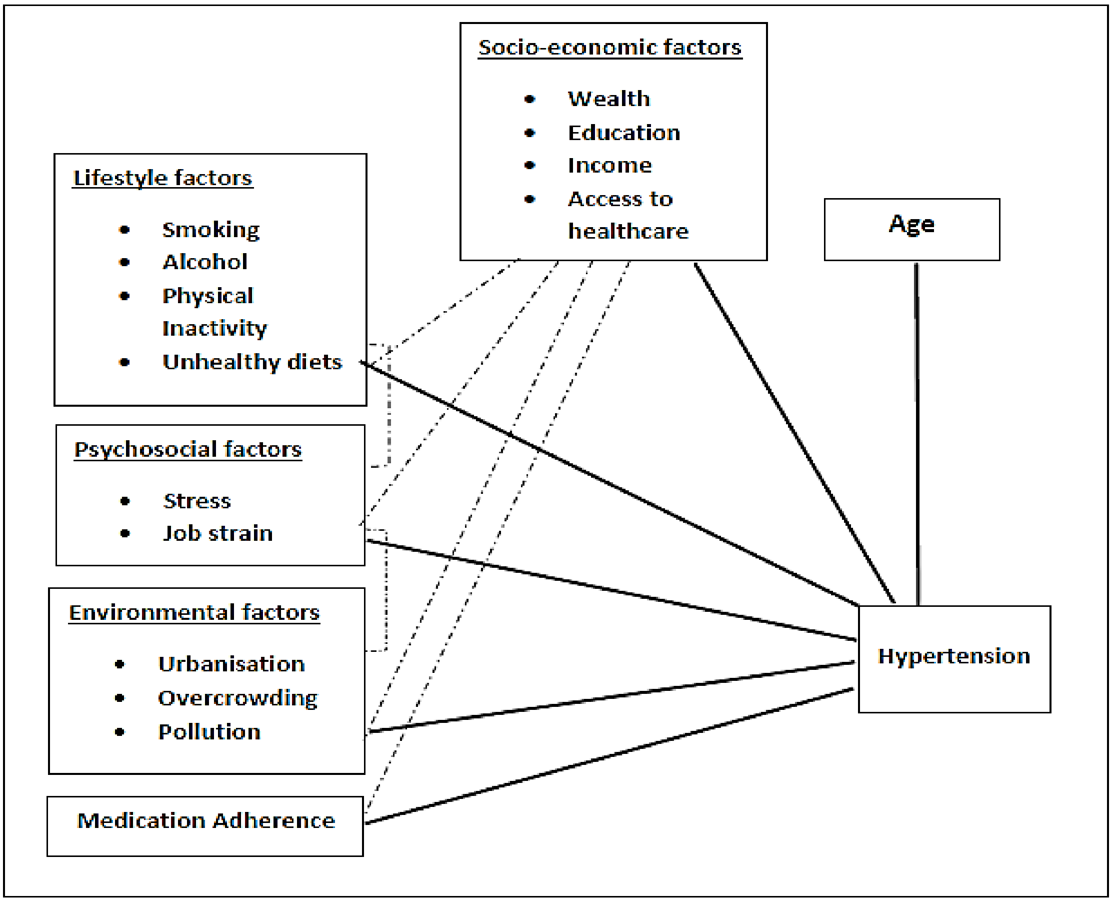
   c) Lifestyle factors [Smoking status (current smokers *vs* non-smokers); Alcohol drinking status (current drinkers *vs* non-drinkers), physical inactivity, and unhealthy dietary patterns] (Reddy & Katan, 2004; Teo *et al.* 2006; Mungal-Singh, 2012; Baan *et al.* 2007)

   d) Socioeconomic factors (educational attainment, wealth status, and household income) (Clark *et al*. 2009; Wen-Hui *et al.* 2013; Murphy *et al.* 2016)

   e) Psychosocial factors (stress, job strain) (Sparrenberger *et al.* 2009; Babu *et al.* 2013)

f) Medication adherence (optimal *vs* sub-optimal) (Gascon *et al.,* 2004; Krousel-Wood *et al.,* 2009; Nielsen *et al.* 2016)

The mechanisms in which these hypotheses are related with hypertension as well as their interrelationships are illustrated in Figure 1.2.



Dotted lines represents interrelationships between the factors; solid lines represents relationships between the risk factors and hypertension

Figure 1.2: The hypothesized mechanisms of the relationship between hypertension and its risk factors

From Figure 1.2 above, it can be observed that all the factors (age, medication adherence, socio-economic, lifestyle, psychosocial, and environmental factors) are directly associated with hypertension. In addition, socio-economic factors are related to other factors including lifestyle factors, psychosocial factors, environmental factors, and medication adherence. Similarly, psychosocial factors and lifestyle factors are associated. This is due to the explanation provided on page 11 that individuals that are exposed to emotional stress or job strain often tend to use smoking or alcohol as coping mechanisms as opposed to seeking medical interventions. Likewise, environmental factors which result from the aftermath of urbanisation such as overcrowding and pollution are associated with psychosocial factors as explained in pages 11-12.

1.7 AIM OF THE RESEARCH

The overall aim of this research is to examine the prevalence and status of hypertension in low- and middle-income countries.

1.7.1 OBJECTIVES

The objectives for this research are:

- To conduct a systematic review and meta-analysis on the prevalence of hypertension in low-and middle-income countries

- To examine the geographic variation of hypertension in low-and middle-income countries by analysing geographical patterns in hypertension prevalence across and within these countries using existing data from the Demographic and Health Surveys (DHS) datasets.

- To determine the potential influence of a wide range of traditional and emerging risk factors for hypertension in these countries, including socio-demographic and major lifestyle characteristics.

- To discuss the findings and their implications for practice/policy and future research.

1.8 STUDY SETTING

The study settings for this research are a number of low-and-middle income countries (LMICs). The World Bank (2015a) often refers to LMICs as developing economies or developing countries, however, the Bank cautioned that countries that fall under this category are not necessary on the same pace of development nor have they reached their final stage of development, hence, the need to understand the term and its application.

The International Monetary Fund (IMF) (2009) in its country composition of the regions highlighted that countries belonging to this category span from many regions of the world, including sub-Saharan and North Africa, South, West, and Central Asia, North and South America, the Caribbean, North and Eastern Europe.

In terms of the economics, World Bank (2015a) stated that countries are divided according to Gross National Income (GNI) per capita, calculated using the World Bank Atlas Method. The groups are: low income, $1,045 or less; lower middle income, >$1,046 - $4,125; upper middle income, >$4,126 - $12,745; and high income, $12,746 or more.

As stated above, this research seeks to examine the geographical variation of hypertension and its associated risk factors in some selected LMICs (i.e. Albania, Armenia, Azerbaijan, Egypt, Lesotho, Maldives, Morocco, Senegal, Ukraine, and Uzbekistan).

1.9 RATIONALE FOR SELECTING THE COUNTRIES INCLUDED IN ANALYSIS

Selection of these countries is driven mainly by the availability of data on hypertension in the Demographic Health Survey datasets and fortuitously the countries selected spread across North, South, and West Africa, Eastern Europe, and the Indian sub-continent. It is worthy to note that these countries reflect a range of different socio-cultural and economic contexts and they also have different patterns of diseases and risk factors. Furthermore, these countries are at different stages of the on-going epidemiological transition; therefore, applying the novel techniques of disease mapping will help us understand the different patterns of hypertension burden and aetiology as well as the geographical variation of the disease in these countries.

1.10 OVERVIEW OF THE THESIS STRUCTURE

This thesis comprises six chapters.

Chapter One sets the stage for the thesis by providing the background of NCDs, hypertension (its epidemiology and risk factors), epidemiological transition, study justification, research questions, aims & objectives, study settings, the rationale for selecting the countries explored in the thesis.

Chapter Two discusses the socio-demographic profile of the ten countries included in the thesis (Albania, Armenia, Azerbaijan, Egypt, Lesotho, Maldives, Morocco, Senegal, Ukraine, and Uzbekistan).

Chapter Three presents the methods employed in producing the thesis, including a systematic review and meta-analysis and secondary data analyses of DHS datasets.

Chapter Four presents the results of the systematic review and meta-analysis and secondary data analyses.

Chapter Five discusses the findings of the systematic review and secondary analyses, their limitations and strengths, and their implications for practice, policy and future research.

Chapter Six summarizes the findings and provides concluding remarks.

CHAPTER TWO: SOCIO-DEMOGRAPHIC PROFILE OF INCLUDED COUNTRIES

This chapter will present the socio-demographic profile of the ten countries (Albania, Armenia, Azerbaijan, Egypt, Lesotho, Maldives, Morocco, Senegal, Ukraine, and Uzbekistan) which will be explored in this research. The socio-demographic profiles of these countries will provide information on the geography, population, age structure, birth and death rates, under-five mortality, maternal mortality, top causes of mortality, disability adjusted life years (DALYs) and economic indices. The socio-demographic differences across the selected countries and their implications for hypertension prevalence will also be highlighted.

2.1 ALBANIA

The Republic of Albania is a country located on the Balkan Peninsula in South-Eastern Europe. It has a surface area of 28,748 square kilometres (km^2). It shares a border with Montenegro to the North-West, Kosovo to the North-East, Macedonia to the North and East, and Greece to the South and South-East. The country's coastline is 487 km long. The climate is considered a continental climate characterized by cold winters and hot summers (Central Intelligence Agency, 2016a). Albania has 12 counties, including its capital Tirana. Below is a map of Albania and its neighbouring countries.

Figure 2.1: Map of Albania, showing the countries it shares borders with. Source: Operation World (2015)

Albania has a population of 3,038,594 (2016 estimate) with a density of about 110 people per km^2. The annual population growth rate is 0.3% (2016 estimate) (World Bank, 2015b). The average life expectancy at birth is 78.3 years (male 75.7 years; female 81.2 years) (2016 estimate) (Central Intelligence Agency, 2016a). Life expectancy is higher in urban areas than in rural areas: men and women in urban areas live approximately 3 years longer than their counterparts in rural areas. More than 98% of the resident population are ethnic Albanians with small groups of Greeks, Macedonians, Vlachs, Bulgarians and Serbs (Institute of Statistics, 2008).

The birth and death rates for Albanians is 13.1 births/1,000 population and 6.7 deaths/1,000 population respectively (2016 estimate). The Infant mortality rate is estimated at 12.3 deaths/1,000 live births. Maternal mortality rate is at 29 deaths/100,000 live births (WHO, 2015a). Albanians have a median age of 32.5 years (male 31.2 years; female 33.8 years) (2016 estimate). The age structure of the country is presented in the population pyramid in Figure 2.2.

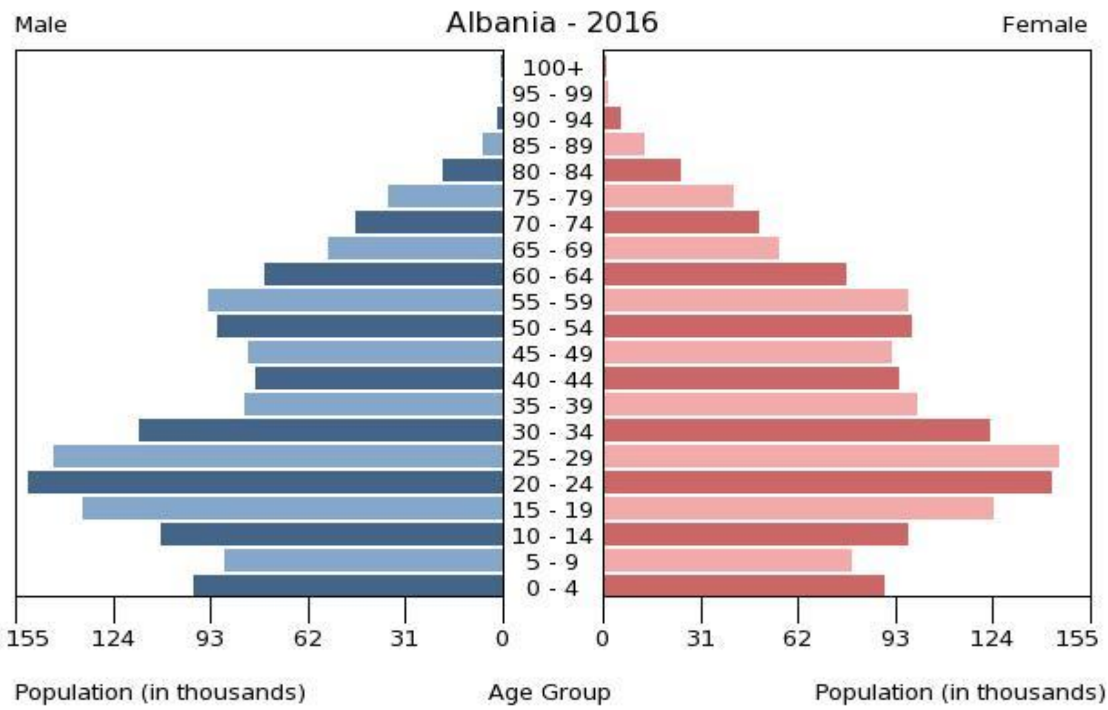


Figure 2.1.2: Albania population pyramid (2016 estimate). Source: Central Intelligence Agency, (2016a)

From the population pyramid above, the age structure of Albania is as follows; **0-14 years, 18.4%** (male 295,022; female 263,141)**; 15-24 years, 18.1%** (male 284,201; female 265,530)**; 25-54 years, 40.7%** (male 589,707; female 648,021)**; 55-64 years 11.2%** (male 168,500; female 172,587); **65 years and over 11.6%** (male 165,076; female 186,809). From the age structure, it can be understood that the 25-54-year age group represents the highest population in the country. Overall, men and women aged 0-54 years make up more than three-quarters of the total population. Table 2.1 summarises the top causes of mortality and DALYs in Albania from the latest available estimates.

Table 2.1: Summary of top causes of mortality and DALYs for Albania

Health Outcome	Top causes
Mortality	Ischaemic heart disease (25.4%); stroke (25.2%); pulmonary cancers (3.5%); chronic obstructive pulmonary disease (2.8%); stomach cancer (2.4%); hypertensive heart disease (1.8%); kidney disease (1.5%); heart disease of other origins (1.4%); and road traffic accidents (1.4%)
DALYs	Cardiovascular diseases and diabetes; neuro-psychiatric conditions; cancers; endocrine, blood and immune disorders; gastrointestinal diseases; genitourinary diseases; skin diseases; and congenital anomalies

Source: WHO, 2016c.

The Gross Domestic Product (GDP) of Albania (2015 estimate) is US $32.6 billion, and the GDP per capita is approximately US $11,900 (2015 estimate). In 2014, approximately 6% of the GDP was spent on health care. The income gap between the rich and the poor is relatively small, with Gini index of 29% (2012 estimate) (a Gini index of 0% represents perfect equality, whereas a Gini index of 100% represents perfect inequality) (World Bank, 2015b). In 2015, about 17% of the resident population was unemployed, and the population living below poverty line was 14%. The percentage of people living in urban areas is 57.4% (with an annual rate of urbanisation of 2.2%) (Central Intelligence Agency, 2016a). Albania is classified by the World Bank as an upper middle-income country (World Bank, 2015b).

2.2 ARMENIA

Armenia is a landlocked mountainous country situated in the southern Caucasus Mountains in southwestern Asia. The country borders Georgia to the North, Iran to the South, Turkey to the West, and Azerbaijan to the East. The area of the country is 29,743 km^2, with more than two-thirds used for agricultural purposes. Armenia has a highland continental climate with cold winters and hot summers. The country is subdivided into 11 regions, including the region of Yerevan, which is the capital city of Armenia (National Statistical Service, 2011). The map of Armenia showing its 11 regions and neighbouring countries is presented below.

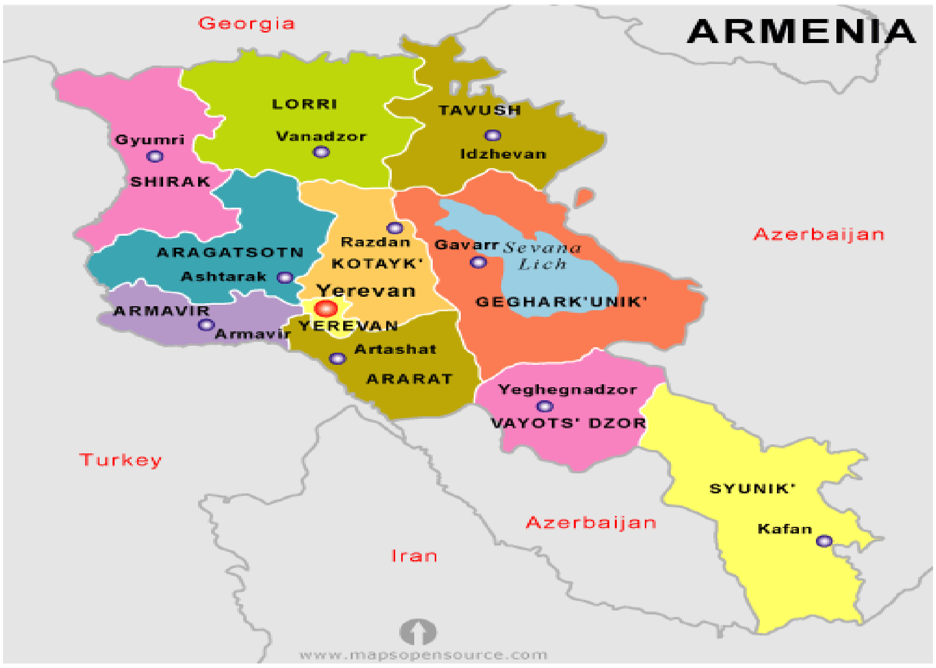


Figure 2.3: Map of Armenia showing 11 regions and surrounding countries. Source: Maps Open Source (2015a)

Armenia has a population of 3,051,250 (2016 estimate). The average life expectancy at birth is 74.6 years (male 71.4 years; female 78.3 years) (2016 estimate) (Central Intelligence Agency, 2016b), and the resident population comprises Armenians (98.1%), Kurds (1.1%), and other ethnic groups (0.7%) The birth and death rates in Armenia is 13.3 births/1,000 population and 9.4 deaths/1,000 population respectively (2016 estimate). The Infant mortality rate is estimated at 13.1 deaths/1,000 live births, and maternal mortality rate is approximately 25 deaths/100,000 live births

(Central Intelligence Agency, 2016b; WHO, 2015b; World Bank, 2015c). Armenians have a median age of 34.6 years (male 32.8 years; female 36.5 years) (2016 estimate). The age structure of Armenia is presented in the population pyramid in Figure 2.4.

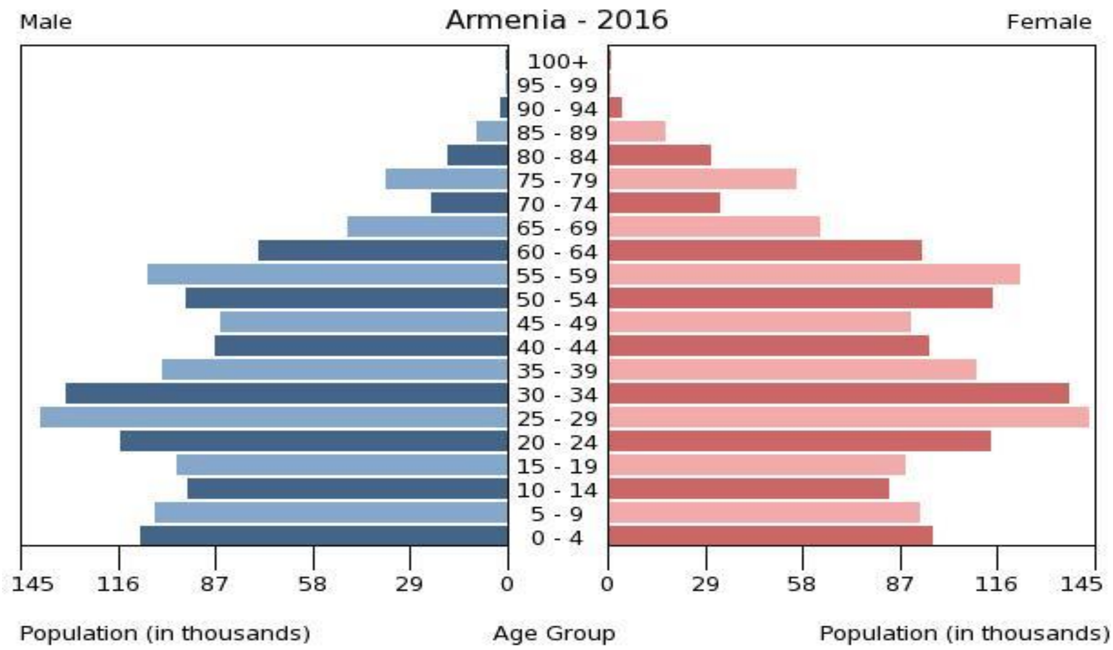


Figure 2.4: Armenia population pyramid (2016 estimate). Source: Central Intelligence Agency, (2016b)

From the population pyramid above, the age structure of Armenia is as follows; **0-14 years, 19.0%** (male 308,701; female 271,028)**; 15-24 years, 13.6%** (male 213,203; female 201,291)**; 25-54 years, 43.5%** (male 640,070; female 685,958)**; 55-64 years 13.0%** (male 180,700; female 214,834)**; 65 years and over 11.0%** (male 134,330; female 201,135). Table 2.2 summarises the top causes of mortality and DALYs in Armenia from the latest available estimates.

Table 2.2: Summary of top causes of mortality and DALYs for Armenia

Health Outcome	Top causes
Mortality	Ischaemic heart disease (36%); stroke (15%); pulmonary cancers (4.5%); chronic obstructive pulmonary disease (4.2%); diabetes mellitus (3.4%); liver cirrhosis (2.3%); hypertensive heart disease (2%); breast cancer (1.9%); stomach cancer (1.9%); colon and rectum cancers (1.7%)
DALYs	Cardiovascular diseases and diabetes; neuro-psychiatric conditions; cancers; endocrine, blood and immune disorders; and congenital anomalies

Source: WHO, 2016d.

The GDP of Armenia (2014 estimate) is US $25.3 billion, the GDP per capita is approximately US $8,500. In 2014, approximately 4.5% of GDP was spent on health care. The distribution of family income (Gini index) is 30.3 (2012 estimate), unemployment rate was 17.8% (2014 estimate) and the population living below poverty is 32% (2013 estimate). The percentage of people living in urban areas are estimated at 62.7% (Central Intelligence Agency, 2016b). Armenia is classified by the World Bank as a lower middle-income country (World Bank, 2015c).

2.3 AZERBAIJAN

Azerbaijan is located in the Asian part of the Eurasian continent and has a favourable geographic position between the Black Sea and the Caspian Sea. Historically, Azerbaijan extends 210,000 km^2 from the Caucasus Mountains in Asia to the mountainous area south and southeast of Lake Urmiya. Nine of the world's 11 climate zones are represented in Azerbaijan; these include dry and semi-arid steppes in the east, subtropical climate in the Southeast, cold climate in the mountains of the North, and temperate climate along the shores of the Caspian Sea (Ministry of Education, 2006; Central Intelligence Agency, 2016c).

The country is rich in oil and gas, iron ore, bauxite, molybdenum, mineral water, and other natural resources. The country consists of 66 administrative regions (Rayons), 13 urban districts, and the Autonomous Republic of Nakhichevan. There are 70 towns, 239 settlements, and 4,272 rural settlements (State Statistical Committee, 2007a). Since the early 1990s, as a result of the conflict with Armenia over Dagligh Garabakh, about 20 % of the land area of the country has been occupied and controlled by Armenia (Central Intelligence Agency, 2016c; Ministry of Education, 2006). The map of Azerbaijan showing the 66 Rayons is presented below.

Figure 2.5: Map of Azerbaijan showing its 66 Rayons. Source: Maps Open Source (2015b)

Azerbaijan has a population of 9,872,765 (2016 estimate) with annual population growth rate of 0.92%. Approximately 54.6% of the population reside in urban areas. The average life expectancy at birth is 72.5 years (male 69.5 years; female 75.8 years) (2016 estimate) (Central Intelligence Agency, 2016c). Azerbaijan is constituted by 91.6% Azerbaijanis, 2% Lezgians, 1.3% Russians, 1.3% Armenians (that live predominantly in the Nagorno-Karabakh region), 1.3% Talysh, and 2.4% of other ethnicities (Central Intelligence Agency, 2016c). The birth and death rates for Azerbaijan is 16.2 births/1,000 population and 7.1 deaths/1,000 population respectively (2016 estimate). The Infant mortality rate is estimated at 24.7 deaths/1,000 live births (2016 estimate), maternal mortality rate on the other hand is approximately at 25 deaths/100,000 live births (2015 estimate) (WHO, 2015c; Central Intelligence Agency, 2016c). Azerbaijanis have a median age of 30.9 years (male 29.3 years; female 32.6 years) (2016 estimate). The age structure of Azerbaijan as highlighted on the country's population pyramid is presented below.

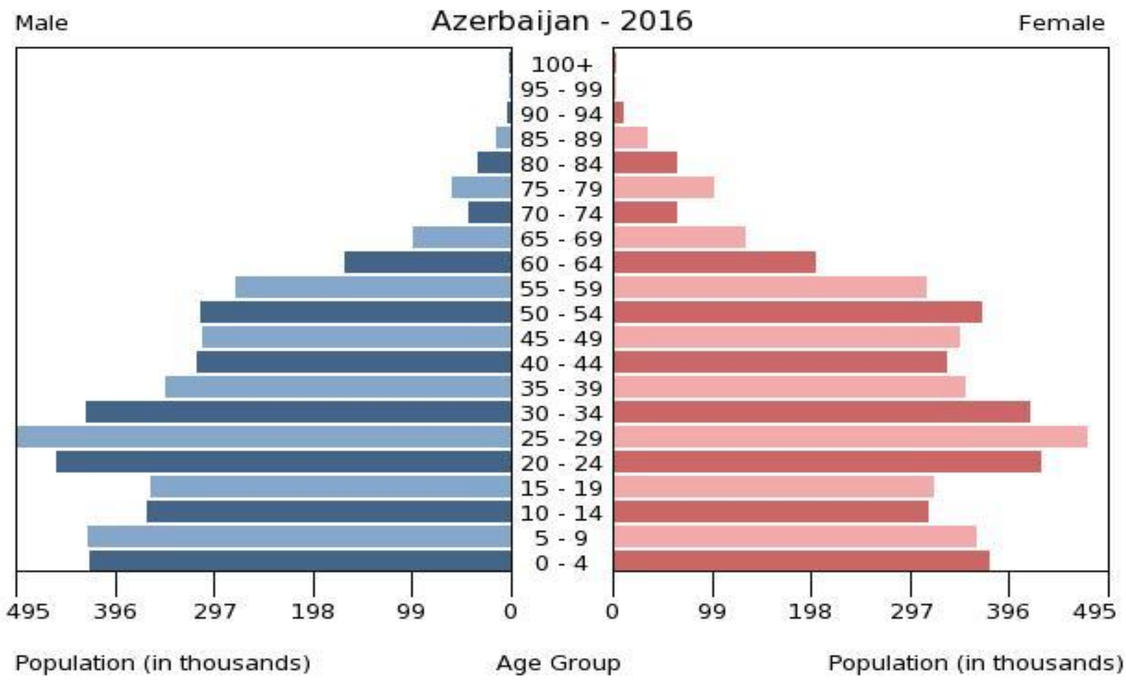


Figure 2.6: Azerbaijan population pyramid (2016 estimate). Source: Central Intelligence Agency, (2016c)

From the population pyramid above, the age structure of Azerbaijan is as follows; **0-14 years**, **22.8%** (male 1,204,976; female 1,047,737); **15-24 years, 15.8%** 566(male 812,537; female 744,538); **25-54 years, 45.3%** (male 2,188,683; female 2,281,242)**; 55-64 years 9.6%** (male 439,566; female 512,118)**; 65 years and over 6.5%** (male 245,144; female 396,224). Table 2.3 summarises the cause of death and DALYs in Azerbaijan from the latest available estimates.

Table 2.3: Summary of top causes of mortality and DALYs for Azerbaijan

Health Outcome	Top causes
Mortality	Ischaemic heart disease (32.9%); stroke (14.9%); cirrhosis of the liver (3.3%); lower respiratory infections (3%); hypertensive heart disease (2.2%); road injury (2%); preterm birth complications (2%); chronic obstructive pulmonary disease (1.9%); diabetes mellitus (1.9%); stomach cancer (1.9%)
DALYs	Cardiovascular diseases and diabetes; neuro-psychiatric conditions; cancers; genitourinary, and skin diseases; oral conditions; and congenital anomalies

Source: WHO 2016e.

The GDP of Azerbaijan (2015 estimate) is US $169.4 billion, the GDP per capita is approximately US $18,000. Approximately 6.0% of GDP. The distribution of family income (Gini index) is 33.7 (2008 estimate), unemployment rate as at 2015 estimate was 5.3% and the population living below poverty is 6% (2012 estimate) The percentage of people living in urban areas are estimated to be 54.6% (Central Intelligence Agency, 2016c). Azerbaijan is classified by the World Bank as an upper middle-income country (World Bank, 2015d).

The GDP of Armenia (2014 estimate) is US $25.3 billion, the GDP per capita is approximately US $8,500. In 2014, approximately 4.5% of GDP was spent on health care. The distribution of family income (Gini index) is 30.3 (2012 estimate), unemployment rate was 17.8% (2014 estimate) and the population living below poverty is 32% (2013 estimate). The percentage of people living in urban areas are estimated at 62.7% (Central Intelligence Agency, 2016b). Armenia is classified by the World Bank as a lower middle-income country (World Bank, 2015c).

2.4 EGYPT

The Arab Republic of Egypt is a country located in Northern Africa. It shares a border with the Mediterranean Sea to the north, Sudan to the South, the Red Sea to the East, and Libya to the West. Among the Arab countries in the world, Egypt has the largest and most densely settled population, with a total area of approximately 1,000,000 km^2 (Central Intelligence Agency, 2016d). Egypt has 27 governorates (administrative divisions) in which 4 governorates (Alexandria, Cairo, Suez and Port Said) have no rural population. The capital of Egypt is Cairo. Egypt operates a republic type of government with a bicameral parliament that consists of a Shura Council sometimes referred to as *'Majlis al-Shura'*. This council, however functions mostly in a consultative role to the executive arm of government (Central Intelligence Agency, 2016d).

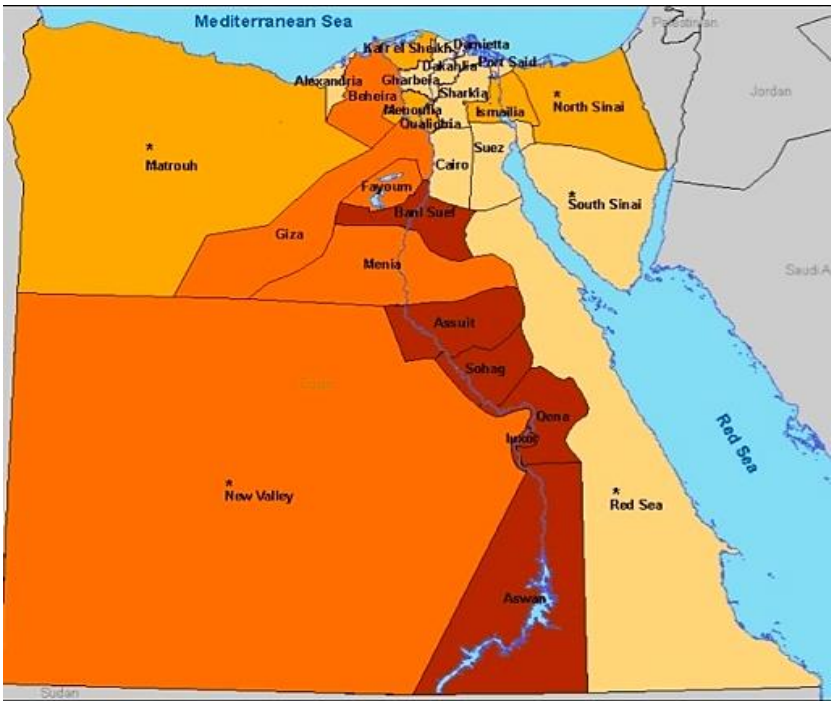


Figure 2.7: Map of Egypt showing the 27 Governorates. Source: FAO (2015)

Egypt has a population of 94,666,993 (2016 estimate) with a density of about 110 people per sq. km. The annual population growth rate is 2.51% (2016 estimate) (Central Intelligence Agency, 2016d). The average life expectancy at birth is 72.7 years (male 71.4 years; female 74.2 years) (2016 estimate) (WHO, 2015d). More than 99.6% of the population are ethnic Egyptians with other inhabitants making up the 0.4% (Central Intelligence Agency, 2016d). The birth and death rates for Egyptians is 30.3 births/1,000 population and 4.7 deaths/1,000 population respectively (2016 estimate). The Infant mortality rate is estimated at 19.7 deaths/1,000 live births, maternal mortality rate on the other hand is approximately 33 deaths/100,000 live births. Egyptians have a median age of 23.8 years (male 23.5 years; female 24.1 years) (2016 estimate) (WHO, 2015d). The age structure of Egypt is presented below.

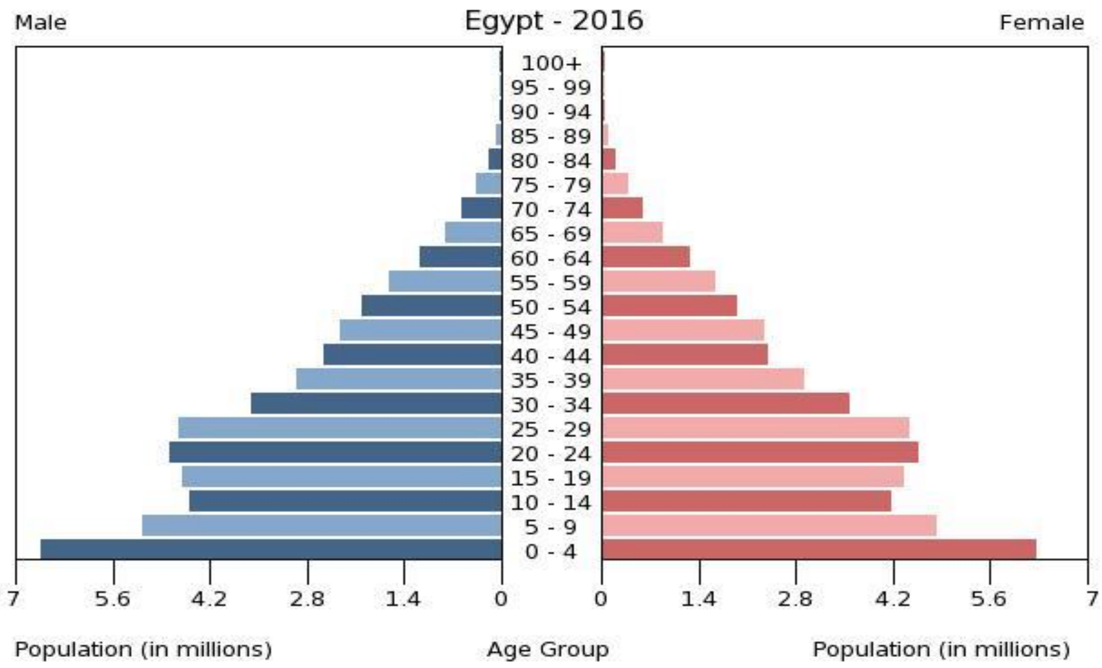


Figure 2.8: Population pyramid of Egypt (2016 estimate). Source: Central Intelligence Agency, (2016d)

The age structure of Egypt is as follows; **0-14 years, 33.2%** (male 16,268,862; female 15,169,039)**; 15-24 years, 19.2%** (male 9,371,819; female 8,839,999)**; 25-54 years, 37.5%** (male 18,020,332; female 17,448,871)**; 55-64 years 5.9%** (male 2,771,399; female 2,826,094)**; 65 years and over 4.2%** (male 1,937,119; female 2,013,459). The age structure of Egypt reveals that the 25-54 years age-group has the highest population in the country, followed by the 0-14 years of the total population. It also highlights that the population aged 55 years and over make up only 11.7% of the total population. The top 10 causes of death and DALYs in Egypt from the latest available estimates (2012) are presented in Table 2.4.

Table 2.4: Summary of top causes of mortality and DALYs for Egypt

Health Outcome	Top causes
Mortality	Ischaemic heart disease (20.5%); stroke (13.3%); cirrhosis of the liver (7.9%); hypertensive heart disease (4.1%); cardiomyopathy, myocarditis (3.3%); liver cancer (3.2%); kidney disease (3%); chronic obstructive pulmonary disease (2.8%); lower respiratory infections (2.7%); endocrine, blood, immune disorders (2.4%)
DALYs	Cardiovascular diseases and diabetes; non-malignant neoplasms; endocrine, blood and immune disorders; oral conditions; congenital anomalies; maternal, neonatal, and nutritional illnesses.

Source: WHO, 2016f

The GDP of Egypt (2016 estimate) is US $1.1 trillion, the GDP per capita is approximately US $11,800. The health expenditure of the country is 5.6% of GDP (2014 estimate). The distribution of family income (Gini index) is 30.8 (2008 estimate), unemployment rate was 12.8% (2015 estimate) and the population living below poverty is 25.2% (2011 estimate). The percentage of people living in urban areas are estimated to be 43.1% of the total population (2015 estimate) (World Bank, 2015e). Egypt is classified by the World Bank as a lower middle-income country.

2.5 LESOTHO

Lesotho is a mountainous kingdom situated in the Southern Africa. The country is divided into 10 administrative districts with a total area of about 30,355 km^2. Less than 10% of the land mass is reserved for agricultural purposes. The map of Lesotho showing its 10 administrative districts is presented in Figure 2.9.

Figure 2.9: Political map of Lesotho showing its 10 administrative districts. Source: Ezilon (2015a)

Lesotho has a population of 1,953,070 people (2016 estimate), the country has a population growth rate of about 0.34% (2014 estimate) (Central Intelligence Agency, 2016e). The average life expectancy at birth is 53 years (male 52.9 years; female 53.1 years) (2016 estimate) (WHO, 2015e; World Bank, 2015f). Sothos comprise 99.7% of the country's population, whereas Europeans, Asians, and others make up the remaining 0.3%. The birth and death rates in Lesotho is 25.1 births/1,000 population and 14.9 deaths/1,000 population respectively (2016 estimate). The Infant mortality rate is estimated at 47.6 deaths/1,000 live births (2016 estimate), and maternal mortality rate is about 487 deaths/100,000 live births (2015 estimate). The excess mortality due to AIDS may account for lower life expectancy, and the high infant mortality and overall mortality rates in Lesotho. About one in four people in the country are affected by HIV (UNAIDS, 2014). The age structure of Lesotho is presented on the population pyramid below.

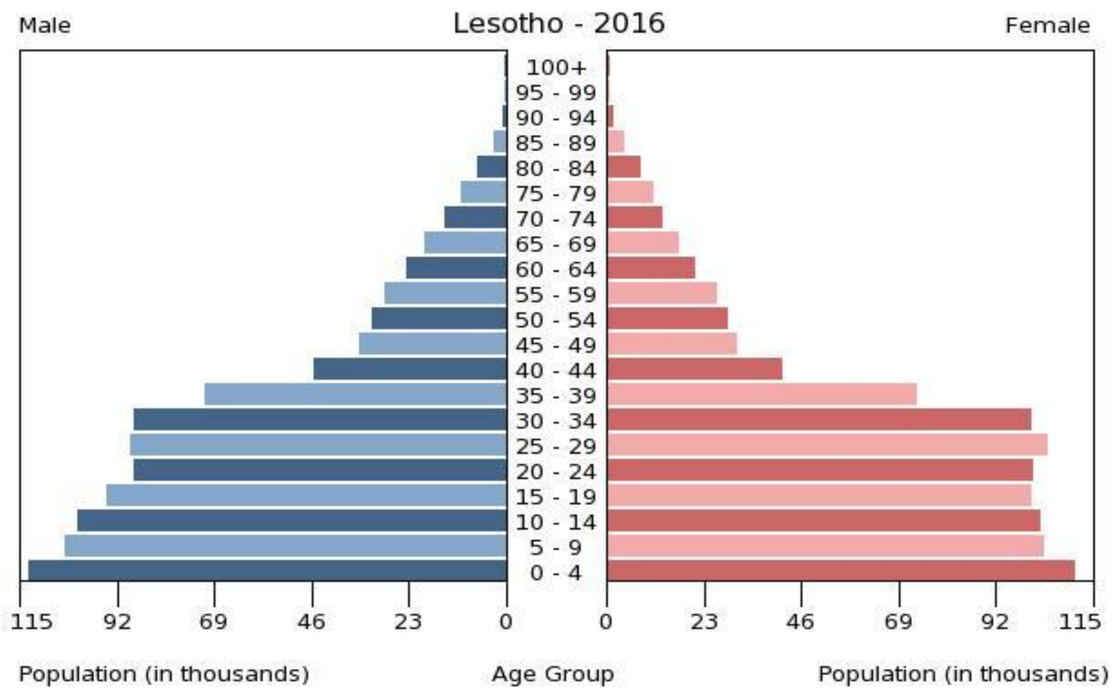


Figure 2.10: Population pyramid of Lesotho (2016 estimate). Source: Central Intelligence Agency, (2016e)

From the population pyramid above, the age structure of Lesotho is as follows; **0-14 years, 32.4%** (male 317,933; female 314,849)**; 15-24 years, 19.6%** (male 181,907; female 200,113)**; 25-54 years, 37.6%** (male 358,643; female 375,313)**; 55-64 years 5.0%** (male 52,016; female 45,549)**; 65 years and over 5.5%** (male 54,466; female 52,281). The median age of Lesotho's population is 24 years, with no difference between males and females (Central Intelligence Agency, 2016e).

The top causes of mortality and DALYs in Lesotho based on the most recent available estimates (2012) are summarised in Table 2.5. Although cardiovascular disease is the second leading cause of death in the country, the disease accounts for a significantly smaller proportion of all-cause mortality, compared to HIV/AIDS-related deaths. The majority of the resident population are young (median age 24 years), suggesting high levels of high-risk social behaviours and increased risk of HIV transmission. However, one cannot rule out the potential for reverse causation: people in Lesotho are less likely to live beyond middle age because of the high rates of HIV/AIDS-related deaths in the country. The younger age demographic profile of Lesotho may account for lower rates of hypertension and other cardiovascular conditions. While it may be more important to address HIV in Lesotho than to address hypertension risk, Lesotho is not spared the effects of the ongoing epidemiological transition in sub-Saharan Africa. In a national survey conducted in Lesotho in 2001, the prevalence of hypertension was estimated to be 37.6% overall (Ministry of Health and Social Welfare, 2001). More recently, in a cross-sectional study investigating hypertension in a primary-care setting in Lesotho, hypertension prevalence was estimated to be 84.2% overall, with 74.3% of patients using anti-hypertensive medications (Thinyane *et al*., 2015). Nonetheless, it is important to acknowledge the small size and hospital-based setting of this study, which may partly explain these estimates (Thinyane *et al*. 2015).

Table 2.5: Summary of top causes of mortality and DALYs for Lesotho

Health Outcome	Top causes
Mortality	HIV/AIDS (41.4%); cardiovascular disease (12%); lower respiratory infections (6%); diarrhoeal disease (3.3%); preterm birth complications (3.2%); birth asphyxia and birth trauma (2.9%); diabetes mellitus (2.8%); interpersonal violence (2.8%)
DALYs	HIV/AIDS; maternal, neonatal, and nutritional; and other infectious diseases (excluding acute respiratory diseases, HIV, tuberculosis, and malaria)

Source: WHO, 2016g

The GDP of Lesotho (2014 estimate) is US $5.77 billion, the GDP per capita is approximately US $3,000. The health expenditure of the country is 10.9% of GDP (2016 estimate). The distribution of family income (Gini index) is 63.2 (1995 estimate), unemployment rate as at 2014 estimate was 28.1% and the population living below poverty is 57.1% (2010 estimate) The percentage of people living in urban areas is estimated to be 27.3% which translates to 71.7% of the population living in either rural or semi-urban areas. Lesotho is classified by the World Bank as lower middle-income country (Central Intelligence Agency 2016e; World Bank, 2015f).

2.6 MALDIVES

The Republic of Maldives is an archipelago in the Indian Ocean located 600 kilometres south of India. It consists of 1,192 small islands that form a chain, about 820 km long and 120 km wide, within an area of 90,000 km^2. Only 196 of the islands are officially inhabited, although another 84 islands are used as resorts, and 14 islands serve industrial purposes. The capital of Malé, with an area of about 2 km^2, accommodates one-third of the country's population of about 300,000. The total land area is estimated to be 300 km^2, of which only 10% are suitable for agriculture (Ministry of Economic Development, 2010; Central Intelligence Agency, 2016f).

For administrative purposes, the 26 natural atolls of the Maldives are classified into 20 groups, each of which is referred to as an administrative atoll. The islands are low lying, with an average elevation of 1.6 meters above sea level. Only a few islands have a land area in excess of 1 km^2. (Ministry of Economic Development, 2010). The map of Maldives showing its Atolls (administrative regions) is presented on the next page.

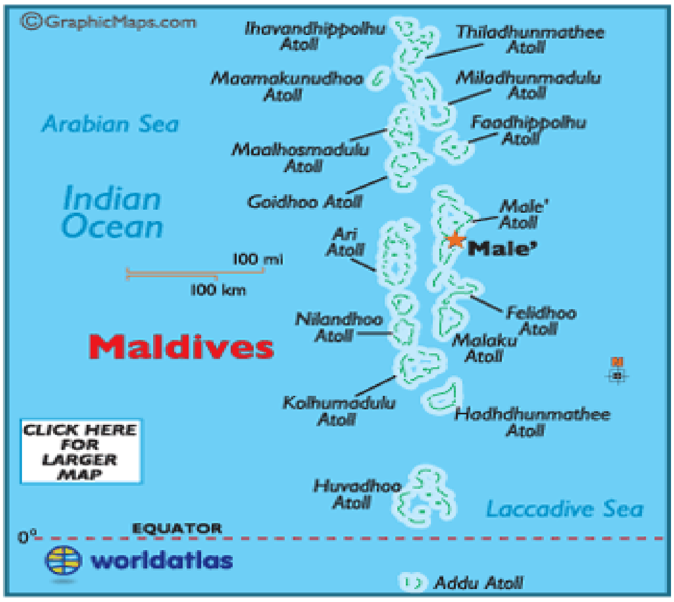


Figure 2.11: Map of Maldives showing its Atolls. Source: World Atlas (2015a)

Maldives has a population of 392,960 people (2016 estimate). The country is characterized by a population growth rate of about -0.07% (2016 estimate) (Central Intelligence Agency, 2016f). The average life expectancy at birth is 75.6 years (male 73.3 years; female 78 years) (2016 estimate) (WHO, 2015f; World Bank, 2015g). The country's composition is made up of South Indians, Sinhalese, and Arabs. The birth and death rates for Maldives is 16 births/1,000 population and 3.9 deaths/1,000 population respectively (2016 estimate). The Infant mortality rate is estimated at 22.9 deaths/1,000 live births (2016 estimate), maternal mortality rate on the other hand is approximately 68 deaths/100,000 live births (2015 estimate) (WHO, 2015f). The median age of Maldivians is 27.8 years (male 27.8 years; female 27.8 years) (Central Intelligence Agency, 2016f). The population pyramid on the next page presents the age structure of the country.

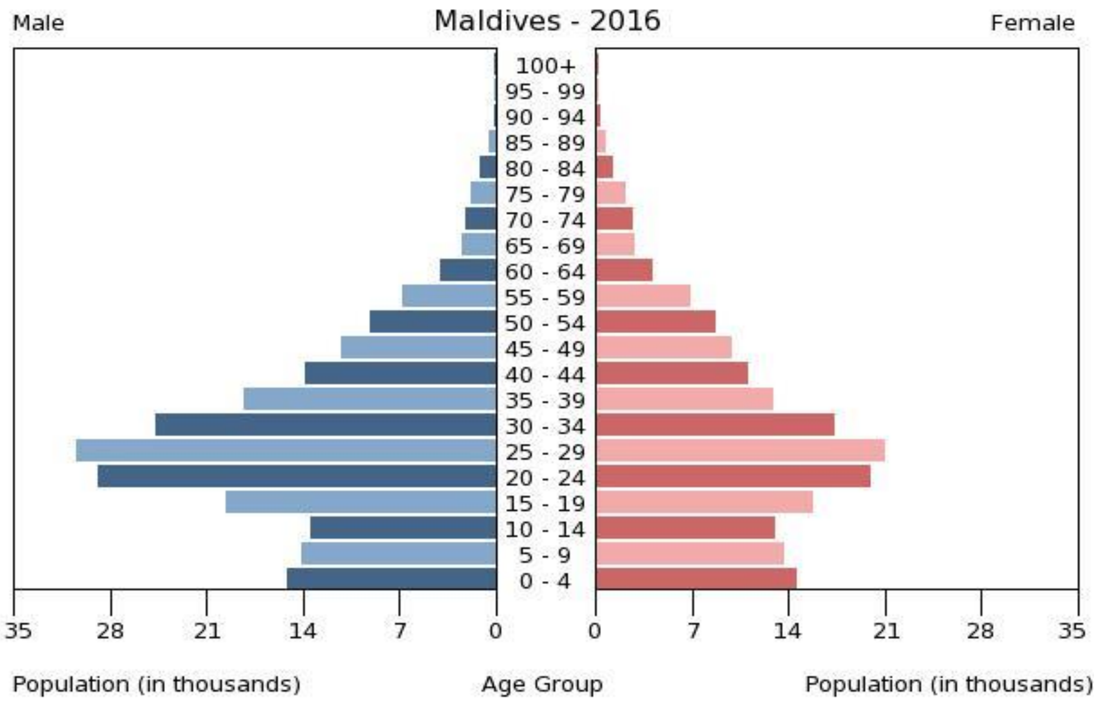


Figure 2.12: Population pyramid of Maldives (2016 estimate). Source: Central Intelligence Agency, (2016f)

From the population pyramid above, the age structure of Egypt is as follows; **0-14 years, 21.2%** (male 42,513; female 40,824)**; 15-24 years, 21.3%** (male 48,319; female 35,360)**; 25-54 years, 47.6%** (male 107,152; female 80,031)**; 55-64 years 5.5%** (male 10,749; female 10,799)**; 65 years and over 4.4%** (male 8,012; female 9,201). It also highlights that the population aged 55 years and over make up only 9.9% of the total population. The top 10 causes of death and DALYs in Maldives from the latest available estimates (2012) are presented in Table 2.6.

Table 2.6: Summary of top causes of mortality and DALYs for Maldives

Health Outcome	Top causes
Mortality	Ischaemic heart disease (15.2%); stroke (13.8%); chronic obstructive pulmonary disease (4.8%); lower respiratory infections (4.4%); kidney diseases (3.5%); endocrine, blood, immune disorders (2.6%); congenital anomalies (2.3%); diabetes mellitus (2.1%); asthma (2%); preterm birth complications (1.6%)
DALYs	Non-malignant neoplasms; endocrine, blood and immune disorders; neuro-psychiatric conditions; cardiovascular disease and diabetes

Source: WHO, 2016h

The GDP of Maldives (2015 estimate) is US $5.19 billion, the GDP per capita is approximately US $14,900. The health expenditure of the country is 13.7% of GDP (2014 estimate). The distribution of family income (Gini index) is 37.4 (2004 estimate), unemployment rate as at 2013 estimate was 11.6% and the population living below poverty is 16% (2008 estimate). The percentage of people living in urban areas are estimated to be 45.5% (Central Intelligence Agency, 2016f). Maldives is classified by the World Bank as an upper middle-income country (World Bank, 2015g).

2.7 MOROCCO

Morocco, officially the Kingdom of Morocco, is the most westbound of the North African countries. It is one of three countries (Spain, France) to have both Atlantic and Mediterranean coastlines. The Arabic name *Al-Mamlakat Al-Maghribiyyah*, which translates to "The Western Kingdom", and *Al-Maghrib*, or the Maghreb, meaning "The West", are commonly used as alternate names. Morocco is a constitutional monarchy with an elected parliament. The political capital is Rabat, although the largest city is Casablanca, other bigger cities include Marrakech, Tangier, Salé, Agadir, Fes, Tetouan, Oujda, Kenitra, Nador, and Meknes (Central Intelligence Agency, 2016g). Below is the political map of Morocco.

Figure 2.13: Political map of Morocco showing its regions. Source: Maps of World (2015a)

The country has a population of 33,655,786 (2016 estimate). The annual population growth rate is 0.99% (2016 estimate) (World Bank, 2015h). The average life expectancy at birth is 76.9 years (male 73.8 years; female 80.1 years) (2016 estimate) (WHO, 2015g). Morocco is made up of 99% Arab-Berbers, while other ethnicities make up 1% of the country. The birth and death rates for Moroccans is 18 births/1,000 population and 4.8 deaths/1,000 population respectively (2016 estimate). The Infant mortality rate is estimated at 22.7 deaths/1,000 live births (2016 estimate), maternal mortality rate on the other hand is approximately at 121 deaths/100,000 live births (2015 estimate) (WHO, 2015g). The median age of Morocco is 28.9 years (male 28.3 years; female 29.5 years) (2016 estimate) (Central Intelligence Agency, 2016g). The age structure of Morocco is presented in the population pyramid below.

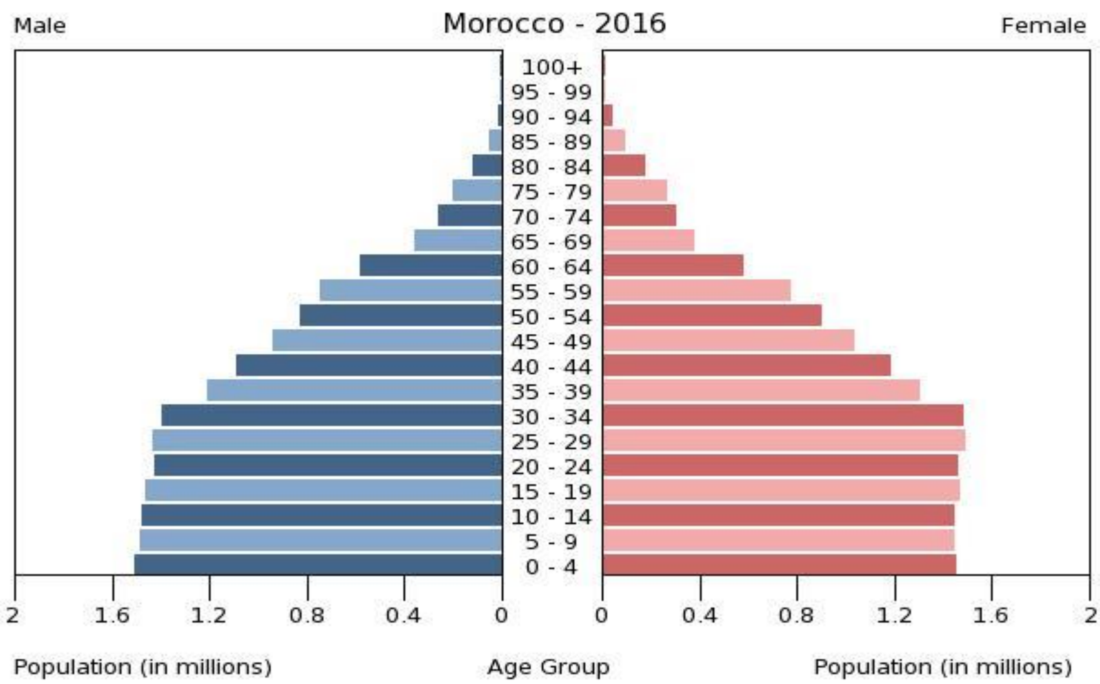


Figure 2.14: Population pyramid of Morocco (2016 estimate). Source: Central Intelligence Agency, (2016g)

From the population pyramid above, the age structure of Morocco is as follows; **0-14 years, 26.1%** (male 4,459,511; female 4,319,538)**; 15-24 years, 17.2%** (male 2,882,145; female 2,913,917)**; 25-54 years, 42.2%** (male 6,874,144; female 7,341,892)**; 55-64 years 7.9%** (male 1,318,302; female 1,337,192)**; 65 years and over 6.6%** (male 995,620; female 1,213,525). The top 10 causes of death and DALYs in Morocco from the latest available estimates (2012) are presented in Table 2.7.

Table 2.7: Summary of top causes of mortality and DALYs for Morocco

Health Outcome	Top causes
Mortality	Stroke (12.8%); diabetes mellitus (11.9%); ischaemic heart disease (11.7%); lower respiratory infections (5.5%); hypertensive heart disease (3.2%); road injury (2.9%); preterm birth complications (2.5%); asthma (2.1%); liver cirrhosis (2.1%); kidney disease (1.9%)
DALYs	Non-malignant neoplasms; endocrine, blood and immune disorders; maternal, neonatal, and nutritional illnesses.

Source: WHO, 2016i

The GDP of Morocco (2014 estimate) is US $254.4 billion, the GDP per capita is approximately US $7,700. The health expenditure of the country is 6.4% of GDP (2012 estimate). The distribution of family income (Gini index) is 40.9 (2007 estimate), unemployment rate as at 2015 estimate was 9.7% and the population living below poverty is 15% (2007 estimate) The percentage of people living in urban areas are estimated to be 59.7% of the total population (2014 estimate). Morocco is classified by the World Bank as a lower middle-income country (World Bank, 2015h).

2.8 SENEGAL

Senegal is located in the extreme West of the African continent. The country shares its borders with the Republic of Mauritania to the North, Mali to the East, Guinea and Guinea Bissau to the South, and the North Atlantic Ocean to the West. Senegal has 14 administrative regions, 117 districts, and 353 rural communities (Central Intelligence Agency, 2016h). The map of Senegal is shown in Figure 2.15.

Figure 2.15: Map of Senegal. Source: World Atlas (2015b)

The country has a population of 14,320,055 with an annual population growth rate of 2.4% (2016 estimates) (Central Intelligence Agency, 2016h). The average life expectancy at birth is 61.7 years (male 59.7 years; female 63.8 years) (2016 estimate) (Central Intelligence Agency, 2016h). The composition of the country is made up of many ethnic groups including Wolof 43.3%, Pular 23.8%, Serer 14.7%, Jola 3.7%, Mandinka 3%, Soninke 1.1%, European and Lebanese 1%, and others 9.4% (Central Intelligence Agency, 2016h).

The birth and death rates in Senegal are 34 births/1,000 population and 8.3 deaths/1,000 population respectively (2016 estimate). The Infant mortality rate is estimated at 50.3 deaths/1,000 live births (2016 estimate) and maternal mortality rate is 315 deaths/100,000 live births (2015 estimate). The median age of Senegal is 18.7 years (male 17.8 years; female 19.6 years) (2016 estimate) (Central Intelligence Agency, 2016h; WHO, 2015h). The age structure of Senegal is presented in the population pyramid in Figure 2.16.

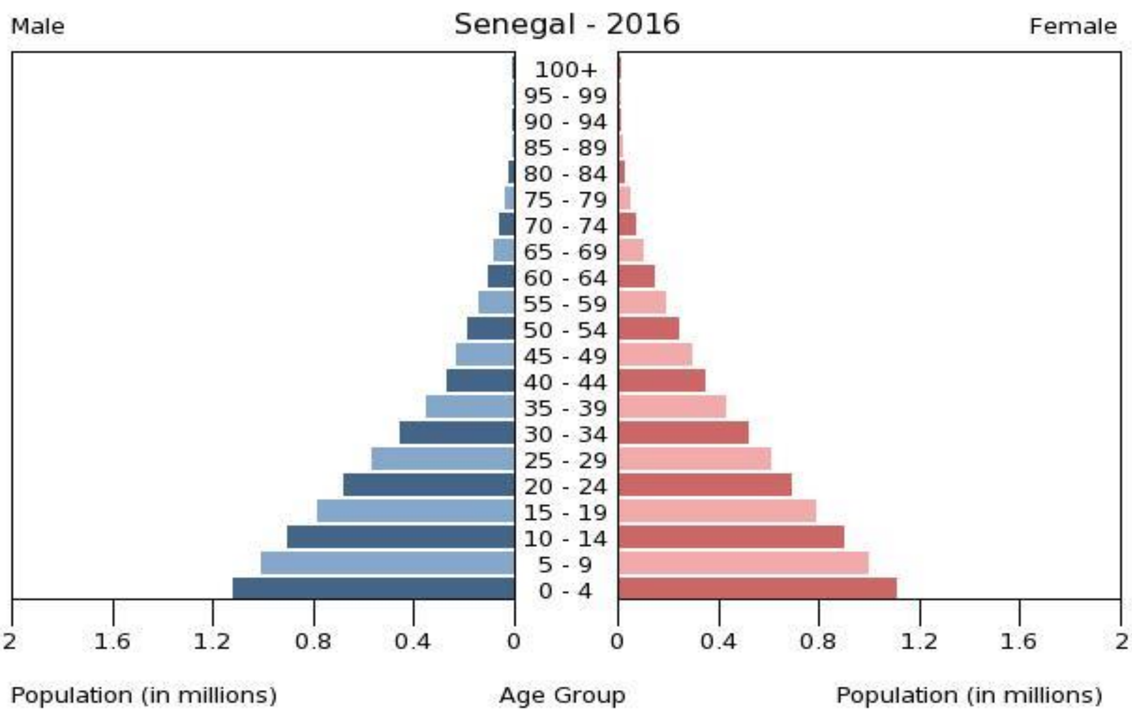


Figure 2.16: Population pyramid of Senegal. Source: Central Intelligence Agency, (2016h)

From the population pyramid, the age structure of Senegal is as follows; **0-14 years, 41.8%** (male 3,011,233; female 2,981,128)**; 15-24 years, 20.4%** (male 1,452,415; female 1,462,989)**; 25-54 years, 30.9%** (male 2,031,035; female 2,398,788)**; 55-64 years 3.9%** (male 242,429; female 317,439)**; 65 years and over 2.9%** (male 189,201; female 233,398).

The top causes of death in Senegal based on the most recent available estimates (2012) are presented in Table 2.8. Although it may be more worthwhile to address respiratory infections in Senegal than to address hypertension and its complications, Senegal (like Lesotho) is not exempt from the effects of the ongoing epidemiological transition in sub-Saharan Africa. In addition, the prevalence of hypertension the country has been increasing over the years from 29.5% in 1988 (Lang et al., 1988) to 43.7% in 2011 (Mbaye et al., 2011).

Table 2.8: Summary of top causes of mortality and DALYs for Senegal

Health Outcome	Top causes
Mortality	Lower respiratory infections (16.1%); malaria (8%); diarrhoeal diseases (6.3%); preterm birth complications (4.5%); stroke (4.4%); birth asphyxia and birth trauma (3.9%); ischaemic heart disease (3.3%); diabetes mellitus (3.1%); meningitis (2.8%); tuberculosis (2.7%)
DALYs	Maternal, neonatal, and nutritional; other infectious diseases (other than acute respiratory diseases, HIV, TB, and malaria); HIV, TB, malaria

Source: WHO, 2016j

The GDP of Senegal (2015 estimate) is US $36.7 billion, the GDP per capita is approximately US $2,500 while the health expenditure of the country is 4.7% of GDP (2014 estimate). The distribution of family income (Gini index) is 40.3 (2011 estimate), unemployment rate as at 2007 estimate was 48% and the population living below poverty is 46.7% (2011 estimate). The percentage of people living in urban areas are estimated to be 43.7% of the total population (2015 estimate) (World Bank, 2015i; Central Intelligence Agency, 2016h). Senegal is classified by the World Bank as a lower middle-income country.

2.9 UKRAINE

Ukraine is located in Eastern Europe and is bordered by the Black Sea and the Sea of Azov in the south, by Russia on the east and north, by Belarus on the north; by Poland, Slovakia, Hungary and Romania on the west, and by Moldova to the south. The territory of Ukraine is 603.5 thousand square kilometres (State Statistical Committee 2007b; Central Intelligence Agency, 2016i).

Ukraine has 27 administrative divisions: 24 regions (oblasts), the Autonomous Republic of Crimea (which is disputed between Russia and Ukraine), and two cities with special status: Kyiv and Sevastopol. The capital of Ukraine is Kyiv. Ukraine extends across the Eastern European plain and includes three vegetation zones: pine and mixed forest, forest-steppe, and steppe (Central Intelligence Agency, 2016i). The political map of Ukraine showing and its neighbouring countries (Poland, Belarus, Russia, Moldova, Romania, Hungary, and Slovakia) is shown on the next page.

Figure 2.17: Political map of Ukraine. Source: Maps of World (2015b)

Ukraine has a population of 44,209,733 (2016 estimate) and an annual population growth rate is -0.4% (2016 estimate) (Central Intelligence Agency, 2016i). The average life expectancy at birth is 71.8 years (male 67.1 years; female 76.9 years) (2016 estimate) (Central Intelligence Agency, 2016i). Ukrainians make up the largest part of the population (77.8 %); Russians are the second largest group (17.3 %); and other ethnic/linguistic groups, each constitute 1% or less of the population (State Statistical Committee, 2003).

The birth and death rates in Ukraine are 10.5 births/1,000 population and 14.4 deaths/1,000 population respectively (2016 estimate). Infant mortality rate is estimated at 8 deaths/1,000 live births (2016 estimate), maternal mortality rate on the other hand is approximately at 24 deaths/100,000 live births (2015 estimate) (WHO, 2015i; Central Intelligence Agency, 2016i). The median age of Ukraine is 40.4 years (male 37.2 years; female 43.5 years) (Central Intelligence Agency, 2016i). The age structure and distribution is presented on the next page.

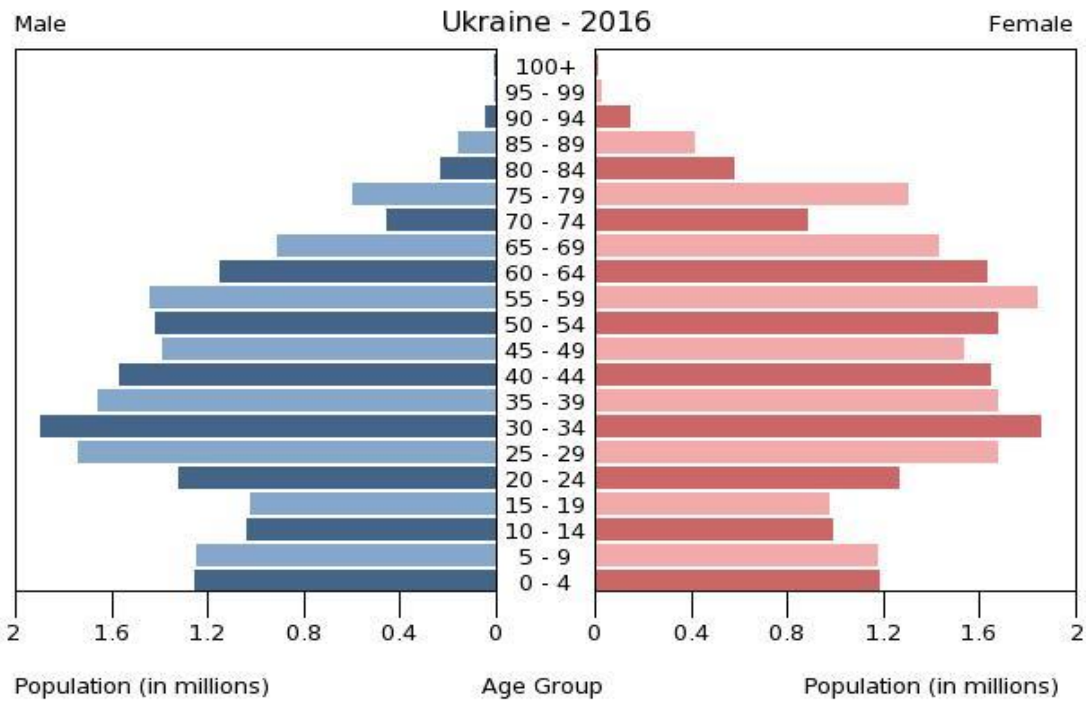


Figure 2.18: Population pyramid of Ukraine. Source: Central Intelligence Agency, (2016i)

Looking at the population pyramid above, the age structure of Ukraine is as follows; **0-14 years, 15.5%** (male 3,528,821; female 3,326,405)**; 15-24 years, 10.3%** (male 2,334,454; female 2,218,718)**; 25-54 years, 44.5%** (male 9,639,404; female 10,020,385)**; 55-64 years 13.7%** (male 2,587,898; female 3,458,016)**; 65 years and over 16.0%** (male 2,375,904; female 4,719,728). Table 2.9 summarises the top causes of mortality and DALYs in Ukraine.

Table 2.9: Summary of top causes of mortality and DALYs for Ukraine

Health Outcome	Top causes
Mortality	Ischaemic heart disease (48%); stroke (17.1%); HIV/AIDS (3%); cirrhosis of the liver (2.5%); pulmonary cancers (2.1%); colon and rectum cancers (1.8%); chronic obstructive pulmonary disease (1.6%)
DALYs	Cardiovascular diseases and diabetes; cancers

Source: WHO, 2016k

The GDP [Purchasing Power Parity (PPP)] of Ukraine (2014 estimate) is US $339.5 billion, the GDP per capita is approximately US $7,500 while the health expenditure of the country is 7.1% of GDP (2014 estimate). The distribution of family income (Gini index) is 24.6 (2013 estimate), unemployment rate as at 2015 estimate was 9.5% and the population living below poverty is 24.1% (2010 estimate). The percentage of people living in urban areas are estimated to be 69.7% of the total population (2015 estimate). Ukraine is classified by the World Bank as a lower middle-income country (World Bank, 2015j).

2.10 UZBEKISTAN

Uzbekistan is a landlocked country located in Central Asia between two major rivers, the Amudarya and the Syrdarya. The territory of Uzbekistan covers 448,900 square kilometres and is bordered by Kazakhstan to the north, Kyrgyzstan and Tajikistan to the south and east, Afghanistan to the south, and Turkmenistan to the west Uzbekistan consists of 12 administrative regions (oblasts), the Autonomous Republic of Karakalpakstan, and Tashkent City. Each region is further broken down into administrative areas called '*Rayons*'. There are 162 rayons, and 118 cities and towns in Uzbekistan (Central Intelligence Agency, 2016j). Below is the political map of Uzbekistan showing its administrative regions.

Figure 2.19: Political map of Uzbekistan showing its administrative regions. Source: Ezilon (2015b)

With a population of 24,473,614 (2016 estimate), Uzbekistan is the third most populous country of the former Soviet Union after Russia and the Ukraine (Central Intelligence Agency, 2016j). Approximately 64% of the population reside in rural areas with only 36.4% of the total population living in urban areas (World Bank, 2015k). The average life expectancy in the country is 73.8 years (male 70.7 years; female 77 years) (2016 estimate). The population density of Uzbekistan is 56 persons/km^2. However, the population is unevenly distributed among the regions. Uzbekistan is a multinational country. It has been estimated that people of more than 130 nationalities live in Uzbekistan. The majority is Uzbeks, constituting more than 80 % of the population, Russians 5.5%, Tajiks 5%, Kazakhs 3%, Tatars 1.5%, and others 2.5% (Central Intelligence Agency, 2016j). The birth and death rates in Uzbekistan are 16.9 births/1,000 population and 5.3 deaths/1,000 population respectively (2016 estimate). The Infant mortality rate is estimated at 18.6 deaths/1,000 live births, maternal mortality rate on the other hand is approximately 36 deaths/100,000 live births (WHO, 2015j; Central Intelligence Agency, 2016j). The median age of Uzbekistan is 28.1 years (male 27.6 years; female 28.7 years) (2016 estimate) (Central Intelligence Agency, 2016j). The age structure of Uzbekistan is presented in the population pyramid below.

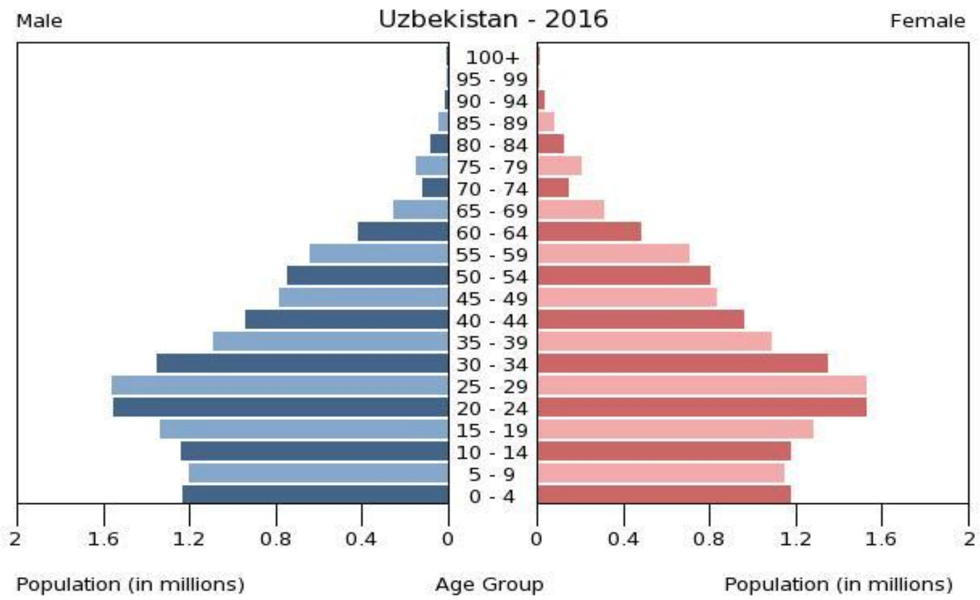


Figure 2.20: Population pyramid of Uzbekistan. Source: Central Intelligence Agency (2016j)

From the population pyramid above, the age structure of Uzbekistan is as follows; **0-14 years, 24.2%** (male 3,658,960; female 3,480,659)**; 15-24** years**, 19.2%** (male 2,874,982; female 2,790,128)**; 25-54 years, 43.5%** (male 6,444,288; female 6,510,741)**; 55-64 years 7.5%** (male 1,049,876; female 1,171,369)**; 65 years and over 5.1%** (male 637,408; female 855,203). The major causes of mortality and DALYs are presented in Table 2.10.

Table 2.10: Summary of top causes of mortality and DALYs for Uzbekistan

Health Outcome	Top causes
Mortality	Ischaemic heart disease (34.2%); stroke (15.9%); liver cirrhosis (4.5%); lower respiratory infections (4.1%); diabetes (2.2%); chronic obstructive pulmonary disease (2%); preterm birth complications (1.9%)
DALYs	Cardiovascular diseases and diabetes; neuro-psychiatric conditions; non-malignant neoplasms; endocrine, blood and immune disorders; genitourinary and skin diseases; oral conditions; and congenital anomalies

Source: WHO; 2016l.

The GDP of Uzbekistan (2015 estimate) is US $187.9 billion, the GDP per capita is approximately US $6,100, while the health expenditure of the country is 5.8% of GDP (2014 estimate). The distribution of family income (Gini index) is 36.8 (2003 estimate), unemployment rate as at 2015 estimate was 4.8 below poverty is 17% (2011 estimate). Uzbekistan is classified by the World Bank 9% and the population living as a lower middle-income country (World Bank, 2015k).

The following section presents a summary of the health and socioeconomic indicators of the selected countries.

2.11 SOCIO-DEMOGRAPHIC DIFFERENCES ACROSS THE SELECTED COUNTRIES AND THEIR IMPLICATIONS FOR HYPERTENSION PREVALENCE

The following table presents a summary for the health and socioeconomic indicators of the selected countries

Table 2.11: Summary of health and socioeconomic indicators for the selected countries

INDICATORS/ COUNTRIES	**Albania**	**Armenia**	**Azerbaijan**	**Egypt**	**Lesotho**	**Maldives**	**Morocco**	**Senegal**	**Ukraine**	**Uzbekistan**
Population (million)	3.0	3.0	9.9	94.7	1.9	0.39	33.6	14.3	44.2	24.5
Average life expectancy (years)	78.3	74.6	72.5	72.7	53	75.6	76.9	61.7	71.8	73.8
Median age (years)	32.5	34.6	30.9	23.8	24	27.8	28.9	18.7	40.4	28.1
Birth rate (births/1000 population)	13.1	13.3	24.7	19.7	47.6	22.9	22.7	50.3	8	18.6
Date rate (deaths/1000 population)	6.7	9.4	7.1	4.7	14.9	3.9	4.8	8.3	14.4	5.3
Infant mortality (deaths/1000 live births)	12.3	13.1	24.7	19.7	47.6	22.9	22.7	50.3	8.0	18.6
Maternal mortality (deaths/100,000 live births)	29	25	25	33	487	68	121	315	24	36
GDP (US$ billion)	32.6	25.3	169.4	1.1*	5.8	5.2	254.4	36.7	339.5	187.9
Average GDP per capita ($)	11,900	8,500	18,000	11,800	3,000	14,900	7,700	2,500	7,500	6,100
Gini Index (%)	29[c]	30.3[c]	33.7[b]	30.8[b]	63.2[a]	37.4[b]	40.9[b]	40.3[c]	24.6[c]	36.8[b]
Health expenditure (as % of GDP, 2016 estimate)	5.9	4.5	6.0	5.6	10.9	13.7	6.4	4.7	7.1	5.8
% of population living in urban areas	57.4	62.7	54.6	43.1	27.3	45.5	59.7	43.7	69.7	36.4
Population living below poverty line (%)	14[c]	32[c]	6.0[c]	25.2[c]	57.1[c]	16.0[b]	15[b]	46.7[c]	69.7[c]	17.0[c]
Unemployment (%)	17.3[c]	17.8[c]	5.3[c]	12.8[c]	28.1[c]	11.6[c]	9.7[c]	48.0[b]	9.5[c]	4.8[c]

Key: *=trillion, a=1990-2000 estimates, b=2001-2010 estimates, c=2011-2016 estimates

Source: Central Intelligence Agency, 2016 a-j; World Bank, 2015 b-k

From Table 2.1, it can be observed that the population of the countries range from 390,000 thousand people in Maldives to 94.7 million in Egypt. Hence, Egypt is most likely to be densely populated compared to Maldives and the other selected countries, so that the resident population of Egypt may be more susceptible to the effects of overcrowding, environmental pollution and other environmental risk factors of hypertension when compared with the resident population of Maldives and the other selected countries (D'Atri & Ostfeld, 1975; Seedat *et al.,* 1982).

The average life expectancy ranges from 53 years in Lesotho to 78 years in Albania. Changes in life expectancy of a country correlate with epidemiological transition, which in turn, correlates with hypertension prevalence and other non-communicable diseases (Corruccini & Kaul, 1983). Lesotho is at a much earlier stage of epidemiological transition, compared to Albania, so it is expected that hypertension prevalence would be lower in Lesotho, compared to Albania.

The median age ranged from 18.7 years in Senegal to 40.4 years in Ukraine. This suggests that Ukraine is more likely to have an ageing population, compared to the resident population of Senegal. Therefore, hypertension prevalence would likely be higher in Ukraine than in Senegal, given the temporal relationship between ageing and hypertension (Messerli et al., 1981; Landahl et al., 1986). The population pyramids for all the 10 countries demonstrates significant differences in the distribution of the populations by age, for instance the percentage of populations aged ≥55 years and above were higher in the Eastern European countries (Albania, Armenia, Azerbaijan, Ukraine and Uzbekistan) compared to countries in Africa (Egypt, Morocco, Senegal, and Lesotho) or the Indian sub-continent (The Maldives). Given the relationship between population ageing and hypertension prevalence, these differences suggest that variation in unadjusted hypertension rates between the countries are to be expected, with prevalence estimates that are more likely to be higher among populations resident in the Eastern European countries.

The average GDP per capita varies from US$2,500 in Senegal to US$18,000 in Azerbaijan. There is also a variation in the Gini index which informs us about the level of income inequality existing in these countries. The African countries had the highest Gini index (Lesotho 63.2%, Morocco 40.9%, and Senegal 40.3%) compared to countries in Eastern Europe suggesting that income inequalities are higher among African populations. However, populations living below poverty line are higher in Ukraine (69.7%), Lesotho (57.1%), and Senegal (46.7%) compared to other countries explored in this research. Hence, the psycho-social burden, and therefore hypertension prevalence in these countries that experience such high levels of socio-economic deprivation are likely to be higher than in countries with lower levels of socio-economic deprivation.

The next chapter will present the methodology and methods of the research.

CHAPTER THREE: METHODS

This chapter is presented in two sections. The first section will describe the methods for the systematic review and meta-analysis, and the second section will describe the methods for the secondary data analysis.

3.1 SECTION A

3.1.1 METHODOLOGY

A systematic review and meta-analysis was conducted to estimate the pooled prevalence of hypertension across low- and middle-income countries. A meta-analysis was appropriate to provide a more comprehensive, consistent, precise and higher-level evidence compared to individual primary studies (Hemingway & Brereton, 2009). In combining the different estimates of hypertension prevalence from individual primary studies, a systematic review with meta-analysis is more robust than a narrative synthesis to make conclusive inferences that aid decision making (Higgins & Green, 2011).

3.1.2 PROTOCOL FOR CONDUCTING THE SYSTEMATIC REVIEW AND META-ANALYSIS COMPONENT

The protocol for this review has been registered in the PROSPERO International prospective register of systematic reviews with reference number- PROSPERO 2013: CRD42013006162 and has been attached in appendix I.

3.1.2.1 REVIEW OBJECTIVES

- To determine the prevalence of hypertension in low-and middle-income countries
- To examine the patterns of hypertension across different socio-demographic characteristics (geographical region, age, gender, educational attainment, wealth status, place of residence, BMI category, and employment status)

3.1.2.2 SEARCH STRATEGY

A comprehensive literature search of Ovid MEDLINE, EMBASE, SCIELO, electronic databases and the World Health Organization Global Cardiovascular Infobase, was conducted from inception to August 2015. The search was conducted using medical subject heading (MeSH) terms and keywords: “hypertension” OR “blood pressure” OR ‘hypertens*’ AND ‘population-based’ OR ‘aetiology’ OR ‘etiology’ OR ‘prevalence’ OR ‘epidemiolog*’ AND “low-and middle-income countries” OR “developing countries” (see appendix II for the complete search strategy). Bibliographies of reviews were also scrutinized for additional studies. Reference lists of identified studies have been cross-checked for potentially relevant studies. Grey literature was sought in order to reduce the risk of reporting bias, and this entailed targeted web-based searches (e.g. Google Scholar), contacting authors of unpublished studies archived on various online research platforms (e.g. ResearchGate, Academia.eu), and databases indexing conference papers and conference proceedings (e.g. Web of Science, ProQuest). No restriction was applied on the year of publication.

3.1.2.3 INCLUSION CRITERIA

Types of participants/Population

Adult population (as defined by the authors of the original studies included) living in low-and middle-income countries with diagnosed hypertension or on anti-hypertensive medication or self-reported hypertension.

Types of studies

All population-based studies (cross-sectional studies, cohort studies, randomised controlled trials) that reported the prevalence of hypertension will be included.

Types of outcomes

Prevalence of hypertension using standard methods of measurements:

- ≥140/90 mmHg (Systolic/Diastolic blood pressure) or
- On anti-hypertensive medication or
- Self-reported health professional diagnosis of hypertension
- Studies that reported overall prevalence as well as those that reported sex and age-specific prevalence of hypertension will be included.

3.1.2.4 EXCLUSION CRITERIA

Studies will not be included in the review if they fall into any of the following categories:

- Studies where standard methods for measurement of hypertension was not clearly described
- Studies in which the definition of hypertension was not ≥140/90 mmHg (Systolic/Diastolic blood pressure)
- Studies where the population or source of population could not be identified
- Hospital-based studies, policy reports, or expert reviews
- Studies addressing specific populations, e.g. hypertension in pregnancy, or hypertension in adolescents
- Studies conducted in high-income countries

A summary of the eligibility criteria can be found in the box below.

Box 1: Eligibility criteria

	Inclusion	**Exclusion**
Population	Adults (18 years and above)	Pregnant women, adolescents, and children
Outcome	Hypertension prevalence reported or deducible from subgroup estimates Hypertension assessed as: BP greater or equal to 140/90mmHg, use of antihypertensive drugs, self-reported physician-diagnosed cases	Hypertension prevalence not reported Pulmonary hypertension Hypertension assessed as: BP greater or equal to 160/95mmHg, other assessment criteria
Study design	All population-based studies, regardless of the design: cross-sectional studies, cohort studies, randomised controlled trials	Hospital-based studies Policy reports Expert reviews
Study location	Low- and middle-income countries	High-income countries
Language	English	Studies published in other languages

3.1.2.5 DATA EXTRACTION (SELECTION AND CODING)

The titles and abstracts of studies retrieved using the search strategy from the databases and additional sources were screened independently by the researcher, a collaborator (Dr. Nduka), and one of the researcher’s supervisors (Dr. Uthman) to identify studies that met the inclusion criteria outlined for the review.

Data from the included studies were also extracted independently by Dr. Uthman and Dr. Nduka using a standardised protocol and a piloted data-extraction form (appendix III), and any discrepancies were resolved by consensus with more senior colleagues (Prof Kandala and Prof Stranges). The data extracted included: year of publication, country of origin, study design, sample size, sampling strategy, study period, place of residence (rural/urban), gender distribution, age group, mean age, body mass index (BMI) category, hypertension prevalence, diagnostic criteria for hypertension, blood pressure apparatus used, comorbidities of hypertension e.g. diabetes, stroke, heart disease. Countries were grouped according to World Bank (2015a) regions and country income groups. With the exception of mean age, all variables were categorical. Overweight /obesity was defined as BMI≥25kg/m^2. Hypertension was defined as blood pressure measurement of at least 140/90 mmHg or the use of antihypertensive medication or self-reported physician diagnoses. Where subgroup estimates of hypertension prevalence were provided, the total hypertension prevalence was calculated manually from these estimates.

3.1.2.6 RISK OF BIAS (QUALITY ASSESSMENT)

Methodological quality entailed assessing the risk of bias for each study using a domain-based tool adapted from the Newcastle-Ottawa Scale (Wells *et al.,* 2014) (see appendix IV). The risk of bias in a study 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. It is worthy to note that non-response bias was not assessed in this review and this stems from the limitation of the tool used in assessing the risk of bias in our included studies. However, all the studies included in the review had high response rates which suggests limiting the likelihood of the effect of non-response bias in this review (Groves, 2006). Overall, the risk of bias assessment was conducted by myself and Dr. Nduka.

3.1.2.7 STATISTICAL ANALYSES

For the meta-analysis, the raw proportions of participants with hypertension from each study were first stabilized using the Freeman-Tukey variant of the arcsine square root transformed proportion (Miller, 1978). Due to anticipated differences in the prevalence estimates of hypertension across individual studies, the transformed proportions were subsequently pooled using the random-effects method, in which case, the pooled prevalence of hypertension represents the mean prevalence in a random distribution of individual (prevalence) estimates (DerSimonian & Laird, 1986; Higgins & Green, 2011). A fixed-effect method, in contrast, assumes that there is one true prevalence of hypertension that is common to all the individual studies in a fixed-effects meta-analysis, in which case, the pooled prevalence of hypertension is an estimate of this true prevalence (Higgins & Green, 2011).

Heterogeneity between studies was assessed 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 a value of 50% was interpreted as representing moderate heterogeneity (Higgins *et al.* 2002; 2003).

Subgroup analyses were performed to account for differences in hypertension prevalence by geographical region, country income group, place of residence, age groups, gender, educational status, employment status, smoking status, drinking status and BMI category. Meta-regression analyses were also performed on these covariates to identify factors that may be associated with hypertension in LMICs (Thompson & Sharp, 1999). In order to ascertain for any secular trends in hypertension prevalence in LMICs, meta-regression analysis was performed on the year of publication.

The meta-analysis results were reported as pooled hypertension prevalence with 95% confidence intervals (CIs). All P values were exact (except where $P<0.0001$) and two-tailed; $P<0.05$ was considered statistically significant. Analyses were conducted using Stata version 12 for Windows (Stata Corp, College Station, Texas) using the 'metaprop' routine (Nyaga *et al.,* 2014). This systematic review and meta-analysis was reported according to the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) guidelines (Liberati *et al.,* 2009). PRISMA checklist is provided in appendix V.

3.2 SECTION B

3.2.1 METHODOLOGY

Secondary data analyses using existing data from the Demographic and Health Surveys (DHS) datasets were conducted to map the geographical patterns of hypertension prevalence across selected low- and middle-income countries. DHS datasets are a well-established source of reliable population-level data in low- and middle-income countries, with a substantial focus on health. The DHS datasets also provide data for more low- and middle-income countries than other datasets such as the WHO Study on global AGEing and adult health (SAGE) and the Prospective Urban and Rural Epidemiological study (PURE).

The Demographic Health Survey program was established in 1984 by the United States Agency for International Development (USAID). The Survey was conceptualized as a follow-up to two International projects on family planning and human fertility viz; the Contraceptive Prevalence Survey and World Fertility Survey (Rutstein & Rojas, 2006). Upon commissioning in 1984, the first DHS project was awarded to Westinghouse Health Systems (which later became part of OCR Macro) and in 2009, ICF International- a venture capital firm also acquired OCR Macro (ICF International, 2013). Therefore, the surveys are now conducted by ICF International in conjunction with the Ministries of Health of about 89 low-and middle-income countries worldwide.

DHS are nationwide-representative household surveys that provide information on a variety of public health issues: anaemia, child health, domestic violence, education, environmental health, family planning, female genital cutting, fertility and fertility preferences, HIV/AIDS, household and respondent characteristics, infant and child mortality, malaria, maternal health, nutrition, maternal mortality, tobacco use, unmet need, wealth, women empowerment and other population health indicators (MEASURE DHS, 2013).

The surveys are conducted in overlapping five-year phases: DHS-I spanned from 1984 to 1990; DHS-II from 1988 to 1993; and DHS-III from 1992 to 1998 (Rutstein & Rojas, 2006). In 1997, DHS was folded into a new multi-project MEASURE (Monitoring and Evaluation to Assess and Use Results) program as MEASURE DHS. The objectives of the DHS program are:

- To provide decision makers in participating countries with improved information and analyses useful for informed policy choices
- To improve coordination and partnerships in data collection at the international and country levels
- To develop skills and resources necessary to conduct high-quality demographic and health surveys in participating countries
- To improve data collection and analysis tools and methodology
- To improve data dissemination and utilization

Between 1984 and 2006, more than 130 nationally representative household-based surveys were conducted and completed under the auspices of DHS project in 70 countries, at present the project has covered 89 countries with over 260 surveys completed (MEASURE DHS, 2013). However, it is imperative to note that the countries receiving USAID assistance are the primary participants in the DHS program. Several other international donors such as UNICEF, UNFPA or the World Bank have funded the DHS program in some countries not supported by USAID (Rutstein & Rojas, 2006).

3.2.2 DHS DATASETS USED IN THE STUDY

Only ten of the 89 countries with ongoing DHS surveys had data on hypertension prevalence (Table 3.1), hence the limited number of datasets examined in this study. In addition, the cost implications of translating datasets published in other languages further precluded datasets from Latin America/Caribbean, Middle-East, and East-Asia/Pacific regions.

Table 3.1: Summary of DHS datasets with information on number of participants included for analysis

Countries	DHS Data	Overall Sample Size	Sample Included in Analysis
Albania	2008-09	10,597	6,472
Armenia	2010	7,506	1,813
Azerbaijan	2006	11,002	11,002
Egypt	2008	16,527	12,008
Lesotho	2009	10,941	10,941
Maldives	2009	11,098	8,546
Morocco	2003-04	16,798 [A]	4,716
Senegal	2010-11	20,617	20,617
Ukraine	2007	10,019	9,336
Uzbekistan	2002	7,796	7,796
Total		**122,901**	**93,247**

A = All Women Sample

3.2.3 STUDY OUTCOME AND MEASUREMENT

In all the 10 surveys, the questionnaires issued to the respondents included questions to determine if the participants had been diagnosed as hypertensive and if they were taking any medication to control raised blood pressure. In some of the countries, blood pressure measurements were measured according to established protocol using sphygmomanometer and stethoscopes, whereas in other countries, automated digital oscillometric BP measuring devices were used.

On the average, two to four measurements of systolic and diastolic BP in millimetre mercury (mmHg) were made with an interval of at least 10-15 minutes between measurements. In all the countries, the average of the 2nd and 3rd measurements or 3rd and 4th measurements were used to classify individuals according to hypertension status. The respondents were classified hypertensive if their systolic BP measurement ≥140 mmHg or if their diastolic BP measurement was ≥90 mmHg. This cut-off is consistent with the definition of hypertension adopted in this study as discussed previously (section 1.1) (Chobanian *et al.*, 2003). Participants who used anti-hypertensive medication and participants with self-reported physician diagnoses of hypertension were also considered to be hypertensive in this study (Chobanian *et al.*, 2003). Hence, for this study, a participant was labelled hypertensive if they met one or more of these three criteria.

3.2.4 OTHER VARIABLES

All datasets in the selected countries provided information on spatial and non-spatial factors that may affect hypertension prevalence in low- and middle-income countries. Spatial factors emphasize the importance of geographical location (e.g. administrative provinces and districts) and place of residence (urban and rural settings). Of note, geographical location can be considered as a proxy for unmeasured factors such as availability and access to health services and health-seeking behavior (Elliot & Wartenberg, 2004; Kandala *et al.,* 2013; Kandala & Stranges, 2014). For instance, there are enormous variations in the stages of epidemiological transition, socio-economic and demographic indices between and within LMICs. For example, rural sub-Saharan Africa is at a much earlier stage of the economic and health transition than urban settings (Salomon & Murray, 2002). Within countries in sub-Saharan Africa, evidence has shown distinctive spatial patterns in hypertension prevalence, beyond the effects of individual-level factors, which suggest potential influences of economic disadvantages, availability and access to health services, and remoteness of certain communities on hypertension prevalence (Kandala *et al.,* 2013).

Non-spatial factors, on the other hand, include non-geographical variables such as age, gender, lifestyle factors (e.g. smoking status and alcohol intake), wealth, educational status, and comorbidities of hypertension (e.g. type 2 diabetes, stroke and heart disease). In order to identify hot spots of hypertension prevalence in LMICs, and to strategically inform national and local policies aimed at the prevention and management of highly prevalent conditions such as hypertension in these settings, the integration of spatial and non-spatial factors is of paramount importance (Elliot & Wartenberg, 2004).

3.2.5 DATA ANALYSIS

This section describes the methods entailed in analysing the DHS datasets. All data were analysed using BayesX version 2.9, Stata version 12 for Windows, and MapInfo® Professional version 12.0 (a widely-used and reliable mapping and geographic analysis software package). All null hypotheses were tested against two-sided alternative hypotheses at 5% significance level.

3.2.5.1 DESCRIPTIVE ANALYSIS

The descriptive statistics entailed exploratory analyses of the characteristics of the study population and stratified by hypertension status, age and gender. The means of the continuous variables (age, BMI, height, waist circumference) were compared between, and where necessary, across strata, using the independent samples t-test (Kirkwood & Sterne, 2003). The proportions of the categorical variables (age group, gender, lifestyle factors, place of residence, education status, and wealth status) were compared between, and where necessary, across strata, using Pearson's chi-square (X^2) test (Kirkwood & Sterne, 2003).

Of note, age group was categorised based on 10-year intervals (15-24, 25-34, 35-44, 45-54, and ≥55). This choice of age distribution is arbitrary as there is no evidence that links specific age-intervals with hypertension risk. However, it is clear that there is a linear relationship between age and hypertension risk (Landahl *et al.* 1986; Chrysant & Chrysant, 2014), so that a 10-year time-interval may be more robust in accounting for the age-related increase in the lifetime risk of hypertension compared to wider time-intervals.

The prevalence of hypertension was also obtained in each of the selected countries and stratified by age and gender.

3.2.5.2 REGRESSION ANALYSIS

Univariable logistic regression models were fitted to identify spatial and non-spatial predictors of hypertension in LMICs. Each simple regression model included the dependent variable (hypertension) and an independent variable (a spatial or a non-spatial factor). Analyses were presented using odds ratios with 95% confidence intervals.

Multivariable logistic regression models were also fitted while adjusting for potential confounders. In this model, the dependent variable (hypertension) was regressed on all spatial and non-spatial independent variables. The measure of effect was presented as adjusted odds ratios with 95% confidence intervals.

3.2.5.3 REGRESSION DIAGNOSTICS

Regression diagnostics were performed and entailed assessing the goodness-of-fit of the regression models using the Hosmer-Lemeshow test and the ***'estat gof'*** routine in Stata (Hosmer & Lemeshow, 1980; Archer & Lemeshow, 2006). The Hosmer-Lemeshow goodness-of-fit test divides subjects into deciles based on predicted probabilities, then computes a X^2 from observed and expected parameters. Furthermore, a *P* value is computed from the X^2 distribution to test the fit of the logistic model. If the Hosmer-Lemeshow goodness-of-fit test statistic is greater than 0.05, we fail to reject the null hypothesis and conclude that there is no difference between observed and model-predicted values, implying that the model's estimates fit the data at an acceptable level. In other words, well-fitting models show non-significance on the goodness-of-fit test, indicating model prediction that is not significantly different from observed values. The degree of multicollinearity (linear relationship among independent variables) was assessed using the ***'collin'*** routine in Stata (Long & Freese, 2014). It is imperative to note that only the independent variables can be used with the ***collin*** routine. Results of the collinearity diagnostics usually presents the following; variance inflation factor (VIF), square root VIF, tolerance (1/VIF), condition index, and condition number. As a general rule of thumb, VIF values above 10, Mean VIF values above 6, or condition number of 10 and above suggests high degrees of multicollinearity (Long & Freese, 2014).

3.2.5.4 MULTIVARIATE BAYESIAN GEO-ADDITIVE ANALYSIS AND DISEASE MAPPING

Multivariate Bayesian geo-additive analysis is used to map the geographical (or spatial) distribution of a disease (hypertension in this case), while accounting for individual-level (or non-spatial) factors, in order to identify disease hot spots (Fahrmeir & Lang, 2001). The Bayesian approach is more appropriate for this purpose and preferred to a multivariable logistic regression analysis for several reasons.

First, a multivariable logistic regression approach would assume that the random components of a contextual variable such as province or district are mutually exclusive, even though, in practice, this assumption may not hold true. Hence, in mapping the geographical distribution of a disease at the district level, a multivariable regression analysis is likely to result in specification errors. A multivariate Bayesian geo-additive model, on the other hand, is robust to such specification errors, which is important to account for unmeasured factors as opposed to treating these factors as proxies for observed variables (Kandala, 2006).

Secondly, in predicting the likelihood of a disease, a logistic regression model is more likely to be influenced by sample size and less likely to handle missing data as effectively as a Bayesian geo-additive model. A multivariate Bayesian geo-additive analysis handles missing data more effectively than a logistic regression analysis by computing a 'dummy' variable and imputing a value that represents the calculated probability of having this missing datum (Fahrmeir & Lang, 2001). This is important in predicting the likelihood of hypertension because without proper handling of missing data, the results obtained from participants with complete data may differ significantly from the ones where data is missing.

Thirdly, the sample design used in the DHS is a stratified multistage cluster sampling design, often with over-sampling of smaller domains such as urban areas or certain regions of a country. The complex nature of the sampling employed in these surveys means that the derived data are strata-disproportionate and clustered at enumeration area. The availability of geographical information system at the level of primary sampling unit (PSU) (i.e. enumeration areas) enables the analysis of hypertension prevalence within each country using multivariate geo-statistical models to account for dependence of prevalence of neighbouring areas. Alternatively, depending on the availability of GIS information, the data were aggregated at an appropriate administrative boundary to enable lattice spatial modelling (Kandala *et al.,* 2013; Kandala & Stranges, 2014).

The geographical patterns of hypertension and possibly nonlinear effects of other factors were explored within a simultaneous, coherent regression framework, using a multivariate geo-additive, semi-parametric mixed model that simultaneously controls for spatial dependence and complex sampling design (Brezger *et al.,* 2005; Kandala *et al.,* 2009). In summary, a logit model for the binary outcome variable y_i for the individual *i* in this framework can be written as

$$\Pr(y_i = 1 | \eta_i) = \exp(\eta_i) / (1 + \exp(\eta_i))$$

with a geo-additive semi-parametric predictor specified as

$$\eta_i = f_1(x_{i1}) + f_2(x_{i2}) + .. + f_p(x_{ip}) + f_{spat}(s_i) + w_i'\gamma + \varepsilon_i$$

where *x* refers to continuous covariates **(age)**, *w* to other discrete variables (such as education, urban-rural residence etc.) and *s* refer to spatial variables that affect the outcome. The *f* functions are nonlinear smoothed effects. $f_{spat}(s_i)$ is the effect of the spatial covariate s_i {*1,...,S*} (for example, districts or provinces). Given the complexity of the model specification, Bayesian procedures will be used to estimate the model parameters instead of maximum likelihood methods. P-spline priors will be assigned to the functions $f_1,..,..,f_p$, while a Markov random field prior will be used for $f_{spat}(s_i)$ (Brezger *et al.,* 2005; Kandala *et al.,* 2009).

Bayesian inference is based on posterior distributions and is carried out using (Markov chain Monte Carlo) McMC simulation techniques so that samples are drawn from full conditionals of single parameters or block parameters given the estimate. Let α denote the vector of all unknown parameters in the model (i.e. x = (f, f_{spat})) and τ represent the vector of all variance components. Then, under usual conditional independence assumptions, for the binomial probit model, Bayesian inference can be based on the posterior given by the equation:

$$P(\alpha|y) \propto \prod_{i=1}^{n} Li\,(y_i, \eta_i)\ \prod_{j=1}^{p}\{p(\beta_j|\tau_j^2)p(\tau_j^2)\}p(f_{str}|\,\tau_{str}^2)p(f_{unstr}|\tau_{unstr}^2)\prod_{j=1}^{r} p(\gamma_j)p(\sigma^2)$$

where β_j, $j = 1; \ldots, p$, are the vectors of regression coefficients corresponding to the functions fj. The full conditionals for the parameter vectors $\beta_1,\ldots,..,\beta_p$ as well as the full conditionals for f_{str}, f_{unstr} and fixed effects parameters y have known distributions. For the variance components τ^2_j, $j = 1,\ldots, p, str, unstr$, and σ^2 the full conditionals are inverse gamma distributions. Thus, a Gibbs sampler can be used for McMC simulation, drawing successively from the full conditionals for $\beta_1,..,..,\beta_p$, f_{str}, f_{unstr}, τ^2_j, $j= 1; \ldots ; p; str, unstr$, *and* σ^2. Furthermore, effective sampling from the Gaussian full conditionals of nonlinear functions will be guaranteed by using Cholesky decompositions for band matrices (Fahrmeir & Lang, 2001; Kandala, 2006).

This multivariate Bayesian geo-additive regression analysis, which permits Bayesian inference based on Markov chain Monte Carlo (McMC) simulation techniques, was carried out using BayesX software package version 2.9 (Brezger *et al.*, 2005). The standard measure of effect was the posterior odds ratios (POR) with the corresponding 95% credible intervals. The estimated posterior ORs, and in essence, the maps, were adjusted for age and other variables in the dataset, and reported with the corresponding posterior probabilities at 80% and 95% nominal levels. The multivariate Bayesian geo-additive regression technique was also used to evaluate the significance of the posterior OR for the fixed, nonlinear and spatial effects, reflecting the patterns of hypertension prevalence on the maps.

It is worth noting that Bayesian analyses conducted in this study were limited to the countries with the highest prevalence from each region such that Albania, Egypt, and Lesotho were selected from countries of Eastern Europe, North Africa, and Sub-Saharan African regions respectively.

Disease mapping explores the geographical distribution of diseases within a population (Elliott *et al.,* 2000). There are two distinct characteristics of disease mapping. The first one is the geographic distribution of diseases, which makes the relative location of events important, enabling the application of geographical information systems with a component of spatial statistics. The second characteristic is that disease mapping enables analysis of disease incidence or prevalence from geographical information or geo-referenced disease data, such as Demographic Health Surveys (Lawson, 2009).

Maps showing variation of diseases can help in elucidating the aetiology of the diseases; they can also be used for understanding the occurrence of diseases in small-areas; and they play an important role in monitoring the health of a community and in tackling epidemics (Elliott *et al.*, 2000; Lawson & Williams, 2001). Disease mapping is employed in this research for examining country- and district/province-level geographic variation in hypertension prevalence using DHS datasets, as well as examining the potential influence of a wide range of traditional and emerging risk factors for hypertension in these countries, including socio-demographic and major lifestyle factors as well as cardiovascular co-morbidities.

After conducting the above analyses and geocoding, the results were presented at district/province levels using choropeth or shaded area mapping techniques (Lai *et al.*, 2009), where the colour red represents districts or provinces with the highest posterior ORs and green represents districts or provinces with the lowest posterior ORs. Similarly, for the maps with the corresponding posterior probabilities at 80% and 95% nominal levels, white indicates a negative spatial effect (associated with reduced risk of hypertension), black a positive effect (an increased risk) and grey a non-significant effect.

These maps provide a summary and visual presentation of the findings of this research which can be used for surveillance purposes, identification of high risk groups, and also for researchers to investigate the relationship between hypertension prevalence and explanatory covariates. To reiterate, these maps can be used by policy makers towards health resource allocation.

3.2.5.5 ETHICAL ISSUES

No ethical approval was required, as the DHS datasets are publicly available. However, permission to use the datasets was sought and obtained from MEASURE DHS – an online repository of ready-to-use data for 89 countries from over 260 surveys.

It is worth mentioning that ethical approvals for conducting the demographic and health surveys were granted by the Health Ministries of all the 10 countries i.e. Albania, Armenia, Azerbaijan, Egypt, Lesotho, Maldives, Morocco, Senegal, Ukraine, and Uzbekistan. It is also worth emphasizing that written informed consents were obtained from the participants in each DHS survey.

CHAPTER FOUR: RESULTS

This chapter presents the results of this research and it is divided into two sections. The first section (Section A) presents the results of the systematic review and meta-analysis. The second section (Section B) presents the results of the secondary data analysis. The findings presented in section A have been published: Sarki A., *et al*. (2015) Prevalence of hypertension in low- and middle-income countries: A systematic review and meta-analysis. *Medicine* 94(50): e1959.

4.1 SECTION A- SYSTEMATIC REVIEW AND META-ANALYSIS

4.1.1 STUDY SELECTION

Figure 4.1 is a PRISMA flow diagram showing study selection. The literature search yielded 3226 records from the database search and an additional 89 records from grey literature search. Of note, the grey literature search included theses, conference abstracts and additional full-text articles. Upon screening, 763 duplicate records were removed, and an additional 2148 articles were excluded by their titles and abstracts, leaving 404 full-text articles assessed for eligibility. One hundred sixty-two (162) full-text articles were subsequently excluded for not meeting the eligibility criteria, leaving 242 full-text articles that were included in the systematic review and meta-analysis.

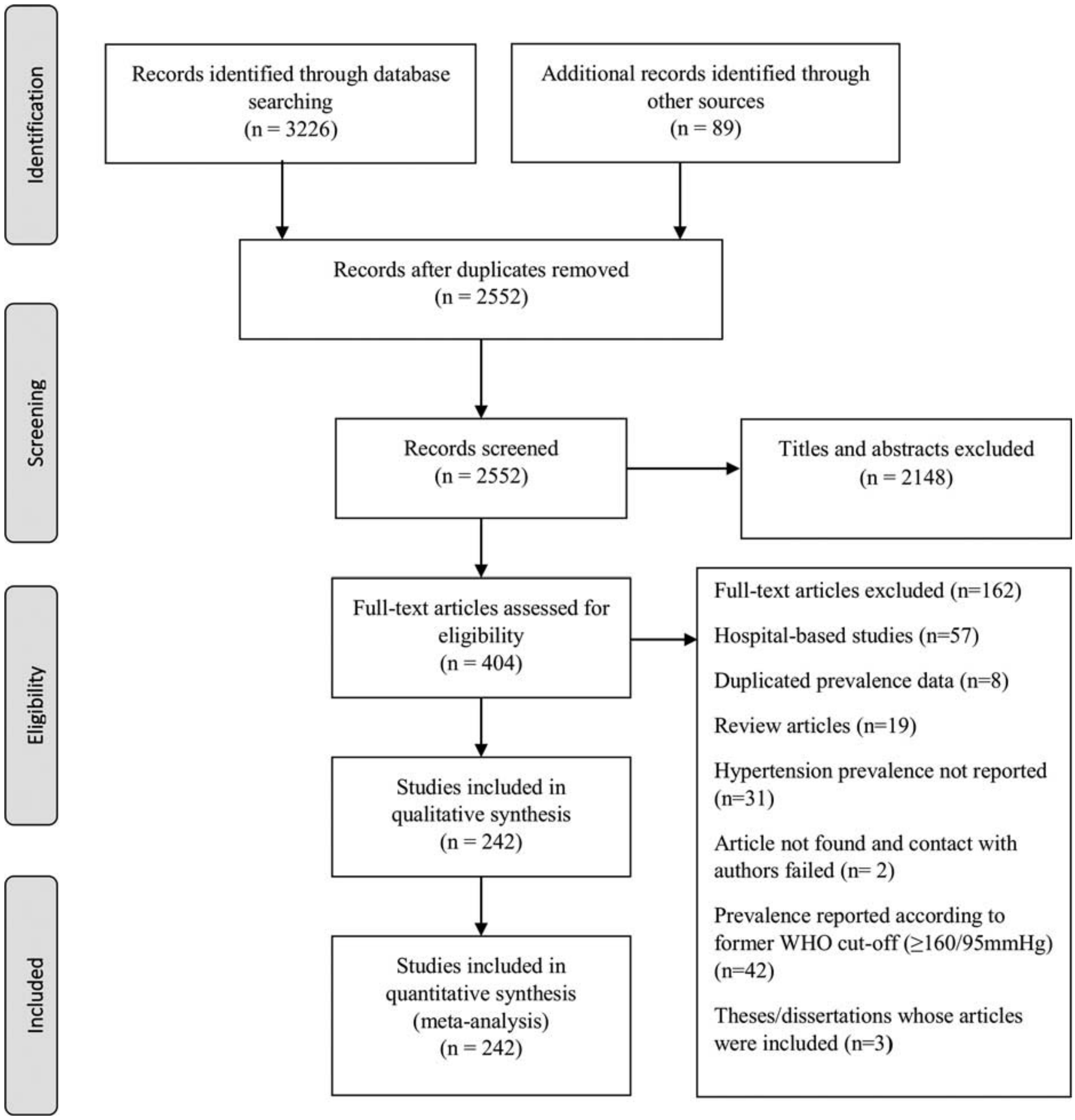


Figure 4.1: PRISMA flow diagram showing study selection

4.1.2 DESCRIPTIVE CHARACTERISTICS OF THE INCLUDED STUDIES

The included studies comprised a total of 1,494,609 participants (52% females) from 45 countries (see Table 4.1). Most of the studies were conducted in India (n=50 studies; 20.7%), followed by Brazil (n=26; 10.7%), Nigeria (n=17; 11%), and China (n=9; 6%). Although a third of the included studies (n=74; 30.6%) originated from sub-Saharan African countries, all six regions, including East Asia and Pacific, Europe and Central Asia, Latin America and Caribbean, Middle East and North Africa, South Asia, and sub-Saharan Africa were represented in this review. All included studies were observational (predominantly cross-sectional) and population-based. Overall, the mean age (± standard deviation) of the study population was 45.9 ± 12.1 years; about one in five participants were smokers; 23.1% were current drinkers; about half of the total study population were obese or overweight; and more than a quarter were non-educated. These characteristics are summarised by region in Table 4.2 and Supplementary Tables 1 to 6 in the Appendix.

Table 4.1: Included countries grouped by World Bank regions

East Asia and Pacific	Europe and Central Asia	Latin America and Caribbean	Middle East and North Africa	South Asia	Sub-Saharan Africa
China	Albania	Brazil	Egypt	India	Burkina Faso
Federated States of Micronesia	Armenia	Cuba	Iran	Nepal	Cameroon
Malaysia	Azerbaijan	Dominican Republic	Morocco	Pakistan	Ethiopia
Thailand	Romania	Haiti	Yemen	Sri Lanka	Ghana
Vietnam	Turkey	Mexico	Lebanon	Bangladesh	Kenya
	Ukraine	Panama			Malawi
	Uzbekistan	Peru			Mozambique
	Kazakhstan	Venezuela			Namibia
					Nigeria
					Senegal
					South Africa
					Sudan
					Tanzania
					Uganda

Table 4.2: Characteristics of included studies by regions

Characteristics	East Asia and Pacific	Europe and Central Asia	Latin America and Caribbean	Middle East and North Africa	South Asia	Sub-Saharan Africa
Mean age ±SD (y)	51.7 ±9.1	35.7± 11.4	50.5 ± 11.6	49.3 ± 12.1	42.3 ± 11.0	41.0 ±13.1
Males (%) (95% CI)	49.1 (37.2–60.4)	37.9 (38.6–46.5)	43.4 (38.9–47.1)	44.0 (40.0–47.3)	48.9 (40.7–56.1)	44.2 (42.0–46.0)
Smokers (%) (95% CI)	30.8 (22.0–40.0)	20.3 (7.7–37.0)	21.0 (17.8–24.2)	7.0 (1.4–14.7)	27.0 (15.0–40.3)	10.7 (7.2–15.5)
Alcohol users (%) (95% CI)	26.2 (21.4–31.0)	24.0 (23.1–25.0)	19.8 (13.0–28.7)	2.6 (2.5–2.9)	33.0 (17.6–48.8)	32.8 (24.5–41.7)
Overweight/obese (%) (95% CI)	29.0 (18.4–41.0)	52.3 (24.9–79.1)	46.8 (41.0–53.9)	56.8 (40.6–73.2)	32.0 (26.9–38.0)	30.4 (24.2–36.3)
Non-educated (%) (95% CI)	32.1 (19.0–46.9)	15.7 (14.7–16.7)	23.6 (13.9–37.0)	23.2 (22.8–24.3)	38.0 (31.0–45.2)	28.1 (19.4–36.7)

CI=confidence intervals, SD=standard deviation, y=years

4.1.3 RISK OF BIAS OF INCLUDED STUDIES

The methodological quality of this review entailed assessing the risk of bias for each included study using a domain-based tool adapted from the Newcastle-Ottawa scale (Wells *et al.,* 2014). The risk of bias in each study was classified as low, moderate, high or unclear across the following domains: selection of participants (selection bias), sample size justification (selection bias), outcome measurement (detection bias), and confounding adjustment. Based on confounding adjustment, 227 studies (94%) adjusted for at least one major potential confounder. Summary of risk of bias assessment for each study is shown in appendix VII.

4.1.4 OVERALL PREVALENCE OF HYPERTENSION IN LOW- AND MIDDLE-INCOME COUNTRIES

All 242 studies reported crude prevalence estimates of hypertension and were included in the meta-analysis. Overall, the pooled prevalence of hypertension was 32.3% (95% CI 29.4–35.3), with estimates ranging from 2.5% (95% CI 1.9–3.2) in rural India (Gupta & Sharma, 1994) to 90% (95% CI 89.9–90.2) in Vietnam (Thuy *et al.,* 2010)(See Figure 4.4).

The overall I^2 statistic was 99.9%, indicating a large amount of heterogeneity in the prevalence estimates of hypertension across the included studies. As determined by meta-regression analysis, the observed heterogeneity was explained by differences between studies in mean age, BMI categories, educational status, and employment status ($P < 0.05$ for each) (Figures 4.3 to 4.5). Differences in smoking status (P=0.988), alcohol use (P=0.150), gender (P=0.763), place of residence (P=0.338) did not account for the observed heterogeneity in the meta-analysis.

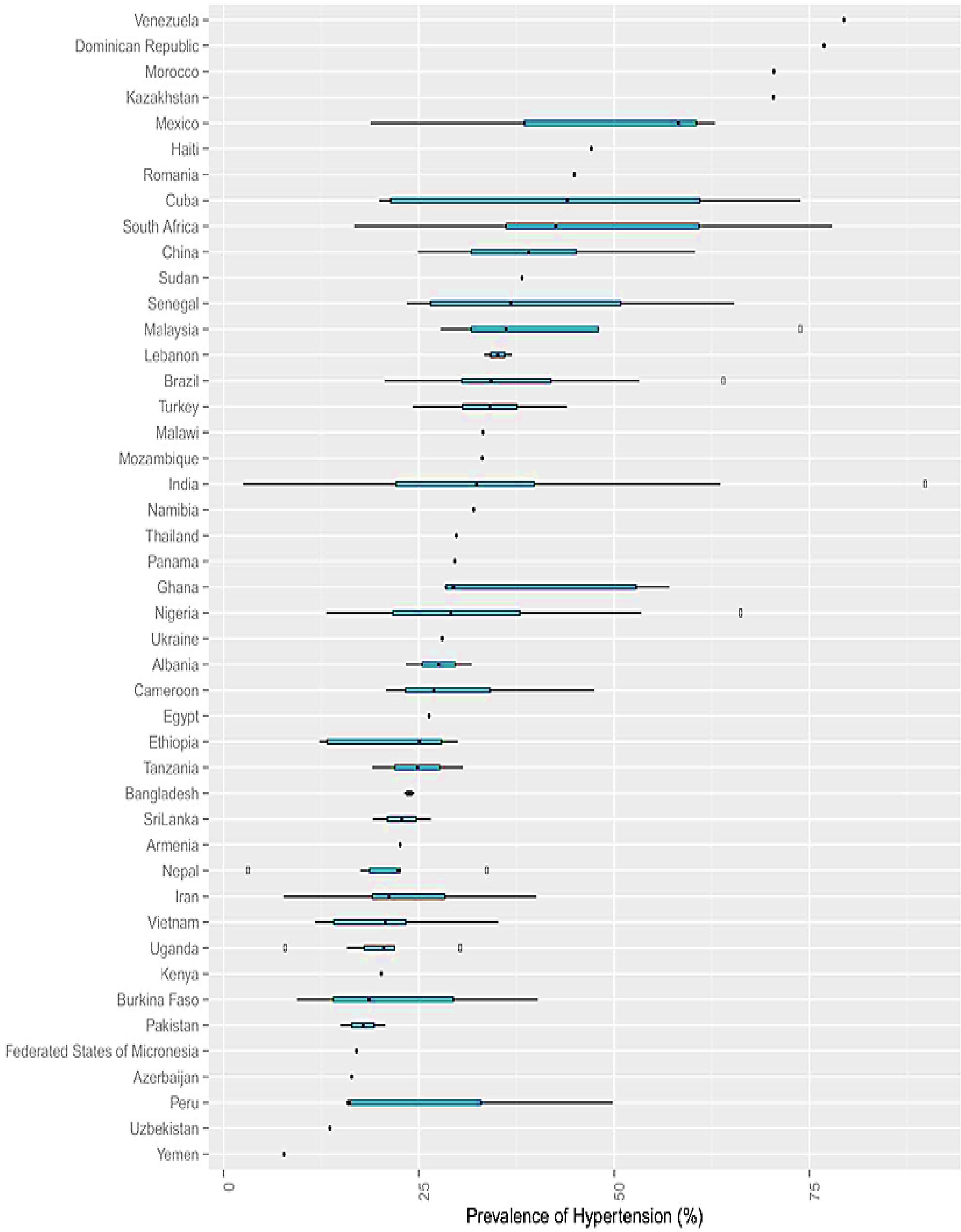


Figure 4.2: Country-specific hypertension prevalence from the countries included in the systematic review and meta-analysis

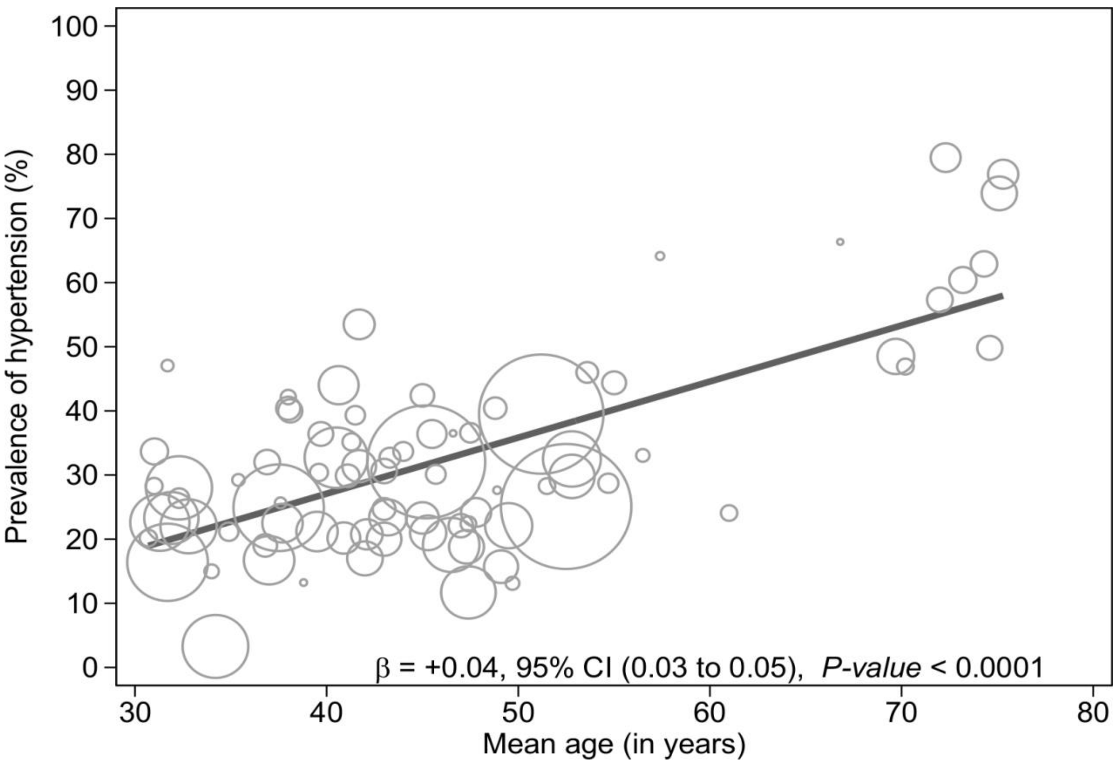


Figure 4.3: Bubble plot showing mean age (in years) accounting for significant heterogeneity in hypertension prevalence estimates between studies

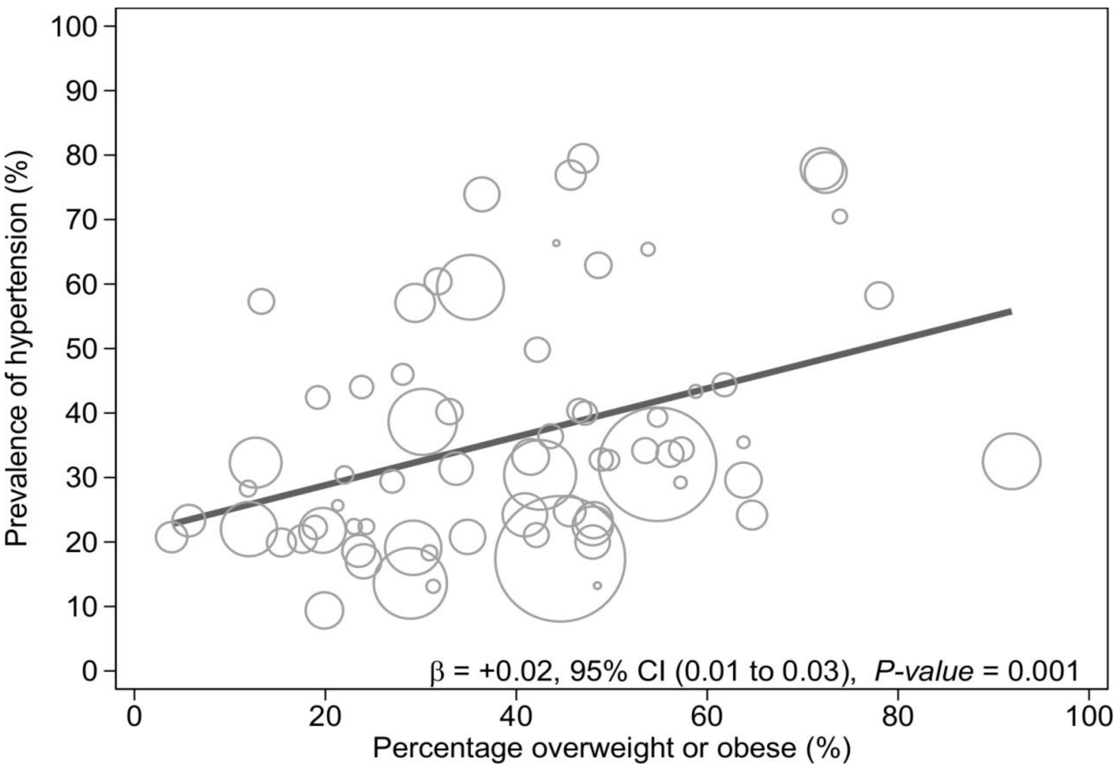


Figure 4.4: Bubble plot showing combined overweight/obesity accounting for significant heterogeneity in hypertension prevalence estimates between studies

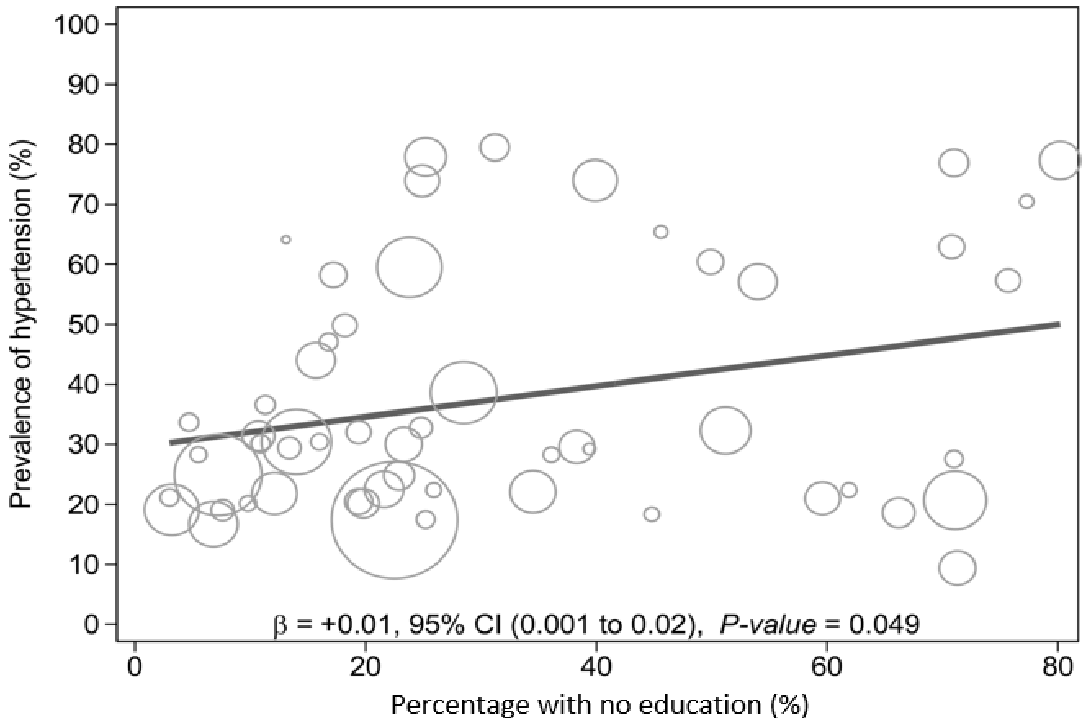


Figure 4.5: Bubble plot showing educational status accounting for significant heterogeneity in hypertension prevalence estimates between studies

4.1.5 POOLED PREVALENCE OF HYPERTENSION PREVALENCE BY GEOGRAPHICAL REGION

The results of the subgroup analysis of hypertension prevalence by geographical region are presented in Figure 4.2 and Supplementary Figures 1 - 5. The region with the highest prevalence of hypertension was Latin America and Caribbean (39.1% [95% CI 33.1–45.2]), whereas, the Middle East and North Africa region had the lowest rate (26.9% [95% CI 19.3–35.3]).

4.1.6 POOLED PREVALENCE BY COUNTRY INCOME GROUP

Upper-middle income countries had a higher prevalence of hypertension (37.8% [95% CI 35.0–40.6]), compared to lower-middle income (31.1% [95% CI 26.1–36.4]) and low-income countries (23.1% [95% CI 20.1–26.2]) (Figure 4.2, Supplementary Figures 7–9).

4.1.7 POOLED PREVALENCE BY PLACE OF RESIDENCE

Hypertension prevalence was higher among populations in urban settings (32.7% [95% CI 30.4–35. 0]), compared to populations in rural settings (25.2% [95% CI 20.9–29.8]) (Figure 4.2, Supplementary Figures 10 and 11).

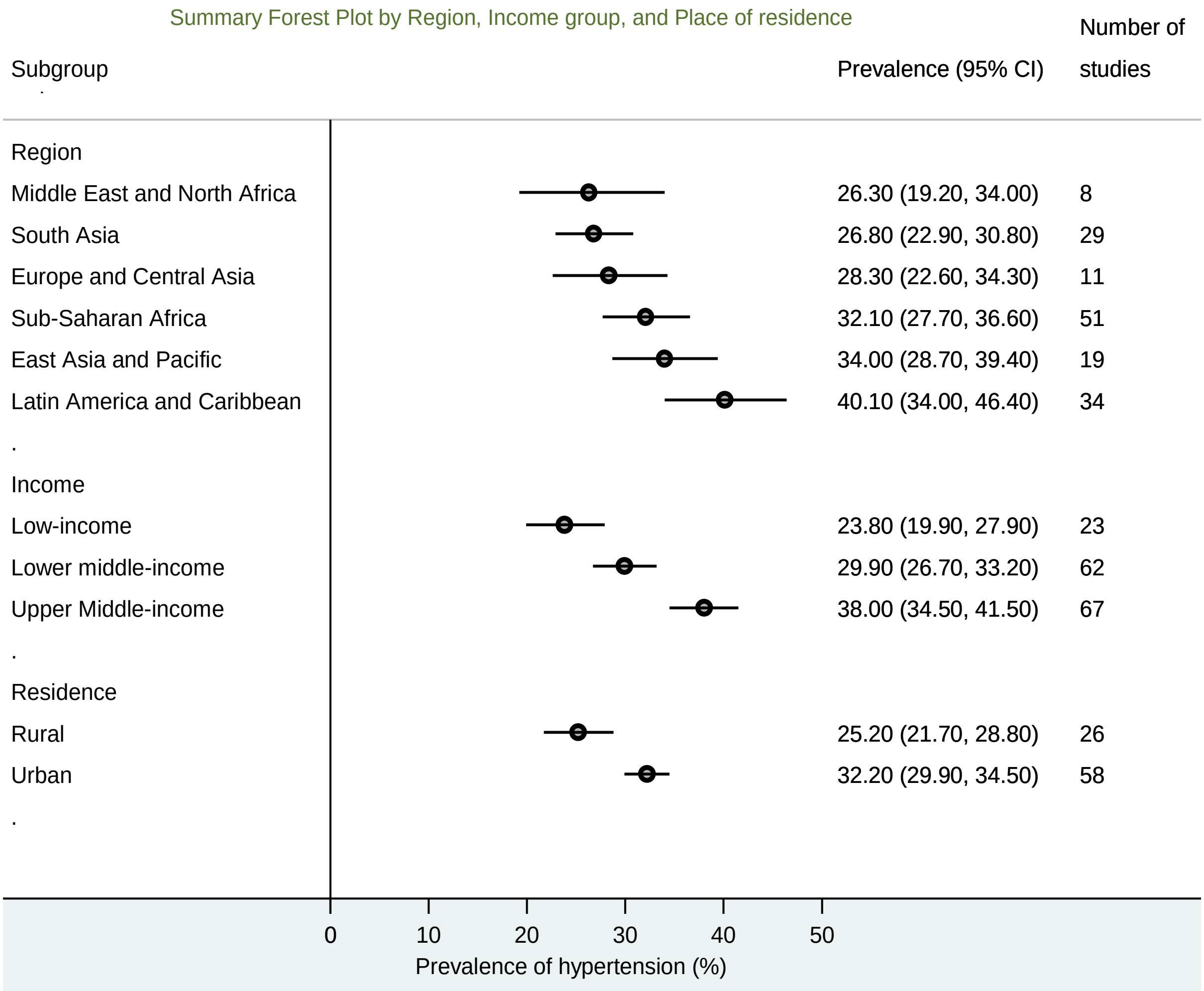


Figure 4.6: Forest plot showing prevalence estimates of hypertension by region, country income group, and place of residence

4.1.8 POOLED PREVALENCE OF HYPERTENSION BY PARTICIPANTS' SOCIO-DEMOGRAPHIC CHARACTERISTICS

Patterns of hypertension across different socio-demographic characteristics for each region were summarised in Table 4.3. In all regions except the Middle East and North Africa region, where no data on hypertension prevalence was reported for the elderly (≥ 65 years), the proportion of hypertension was substantially higher among adults ≥ 65 years, compared to adults < 65 years. Overall, the prevalence of hypertension was high among adults above 65 years, compared to those younger than 65 years (66% versus 29%, $P < 0.05$)

Although prevalence of hypertension in men overall (33%) was slightly higher compared with women (31.2%), this difference was not statistically significant overall ($P = 0.76$). Additionally, no significant sex-deference in hypertension prevalence was observed by region.

There were higher proportions of hypertension among non-smokers compared to smokers in Europe and Central Asia, Latin America and Caribbean, and Middle East and North Africa regions, whereas the proportions of hypertension were higher amongst smokers compared to non-smokers in East Asia and Pacific, South Asia, and Sub-Saharan Africa regions. Overall, hypertension prevalence was significantly higher among non-smokers, compared to smokers (32% versus 29%, $P < 0.05$).

Alcohol use data was not reported in any study originating from countries in the Middle East and North Africa or the East Asia and Pacific regions. With the exception of the sub-Saharan Africa region, hypertension rates were comparable between non-drinkers and current drinkers: non-drinkers had a substantially higher proportion of hypertension compared to current drinkers in sub-Saharan Africa (32.0% vs 21.7%). Overall, hypertension prevalence was significantly higher among non-drinkers, compared to drinkers (30.5% versus 23.5%, $P < 0.05$).

Importantly, hypertension rates were consistently higher among overweight/obese participants, compared to normal weight persons across all regions, and overall (48% vs 27%, $P < 0.05$).

With respect to study setting, prevalence estimates of hypertension were higher in urban communities, compared to participants in rural settings in the Latin America and Caribbean region, East Asia and Pacific, South Asia, and Sub-Saharan Africa. Overall, hypertension prevalence was also higher among urban settlers, compared to rural settlers (36% versus 32%, $P < 0.05$).

Hypertension rates were generally higher among the non-educated, compared to participants with a primary education (50.2% versus 36.3%, $P < 0.005$) and participants with a secondary or tertiary education (50.2% versus 25%, $P < 0.05$).

Hypertension rates were also higher among unemployed people, compared to employed people (36% versus 31%) ($P < 0.05$).

Table 4.3: Prevalence estimates of hypertension across socio-demographic characteristics by region and overall

Characteristics	East Asia and Pacific	Europe and Central Asia	Latin America and Caribbean	Middle East and North Africa	South Asia	Sub-Saharan Africa	Overall
Region	35.7 (32.2–39.4)	31.5 (25.4–37.9)	39.1 (33.1–45.2)	26.9 (19.3–35.3)	29.4 (22.3–37.0)	31.1 (27.6–34.6)	32.3 (29.4-35.3)
Age group							
18-64 y	23.9 (17.4–30.9)*	39.0 (26.0–52.8)*	30.3 (25.1–35.8)*	32.4 (18.7–47.9)	26.1 (20.3–32.3)*	24.4 (20.0–36.0)*	29.4 (21.2-39.3)*
Elderly (≥65 y)	76.5 (61.0–81.0)	78.6 (71.2–85.1)	58.9 (52.7–65.0)	-	53.2 (33.9–72.0)	61.0 (49.3–72.1)	65.6 (53.6-75.0)
Gender							
Male	35.5 (28.2-43.1)	28.5 (22.8-34.5)	36.3 (31.2-41.7)	28.3 (20.1-37.2)	35.4 (17.9-55.2)	33.8 (28.7-39.2)	33.0 (24.8-41.8)
Female	30.6 (21.3-40.7)	27.0 (20.6-33.9)	39.6 (34.1-45.2)	27.1 (18.7-36.4)	29.4 (24.3-34.8)	33.4 (27.3-39.7)	31.2 (24.4-38.5)
Smoker status							
Non-smoker	20.0 (18.1-22.0)*	30.7 (16.4-47.2)*	40.2 (35.0-45.4)	48.0 (7.7-89.9)*	27.7 (15.4-41.9)*	25.7 (22.6-29.0)	32.1 (19.2-45.9)*
Smoker	32.0 (28.7-35.4)	20.9 (9.6-35.0)	38.3 (30.5-46.4)	23.1 (11.3-37.4)	36.0 (27.8-44.6)	23.9 (18.1-30.3)	29.0 (21.0-38.2)
Alcohol use							
Non-drinkers	-	28.4 (13.7-45.9)	35.9 (29.5-42.7)	-	28.0 (18.8-38.2)	32.0 (20.9-44.2)*	30.5 (16.6-34.2)*
Current drinkers	-	29.2 (14.8-46.2)	34.8 (29.9-39.8)	-	32.1 (18.7-47.1)	21.7 (14.6-29.6)	23.5 (15.6-27.6)
Study setting							
Rural	47.5 (25.5-70.1)*	29.8 (3.3-68.4)*	42.8 (26.1-60.4) *	15.8 (8.2-25.4)	28.0 (19.2-37.8)*	29.9 (22.6-37.9)*	32.3 (17.5-50.0)*
Urban	51.2 (32.8-69.5)	26.4 (4.9-56.9)	51.2 (30.1-72.0)	15.4 (8.3-24.3)	35.9 (19.1-54.7)	34.9 (23.0-47.8)	35.8 (19.7-54.2)
BMI category							
Normal weight	21.7 (20.0-23.5)*	18.4 (12.0-25.8)*	28.0 (23.2-32.9)*	46.7 (6.6-89.5)*	23.3 (15.8-31.8)*	22.6 (19.1-26.3)*	26.8 (16.1-38.3)*
Overweight/Obese	45.8 (37.3-54.4)	51.8 (32.9-70.5)	48.8 (44.1-53.4)	58.3 (20.5-91.2)	40.4 (31.1-50.1)	41.1 (35.5-46.9)	47.7 (33.6-61.1)
Education							
No education	65.4 (43.8-84.2)*	57.2 (22.7-88.2)*	50.4 (37.5-63.2)*	48.3 (26.7-70.2)*	31.1 (16.7-47.8)	48.5 (35.2-61.9)*	50.2 (30.4-69.3)*
Primary	47.8 (21.1-75.2)	26.1 (7.0-51.8)	45.2 (37.7-52.8)	25.7 (16.6-36.1)	39.4 (33.1-45.8)	33.4 (26.6-40.5)	36.3 (23.7-50.4)
≥Secondary	29.5 (17.4-43.3)	21.4 (17.1-26.0)	25.7 (23.2-28.3)	18.6 (13.8-23.9)	27.9 (21.2-35.1)	27.0 (20.1-34.5)	25.0 (18.8-31.9)
Employment							
Unemployed	44.0 (39.0-49.0)*	29.0 (5.0-63.0)*	47.0 (37.0-57.0)*	23.0 (14.0-34.0)*	32.0 (20.0-45.0)*	43.0 (40.0-46.0)*	36.3 (25.8-49.0)*
Employed	16.0 (11.0-22.0)	31.0 (25.0-38.0)	57.0 (33.0-79.0)	29.0 (27.0-31.0)	24.0 (18.0-32.0)	30.0 (25.0-35.0)	31.2 (23.2-49.5)

Hypertension prevalence was reported with 95% confidence intervals. * = (P < 0.05). BMI=body mass index, y=year

4.2 SECTION B – SECONDARY DATA ANALYSIS

4.2.1 DESCRIPTION OF THE SAMPLE POPULATIONS IN THE DATASETS

A total of 93, 247 participants from 10 countries were included in the analysis. As shown in Table 4.3, there were more female participants than male participants in all the countries except Morocco where only data for women were provided. This is not surprising because the DHS was designed predominantly to target women in order to measure their understanding of family planning and fertility issues.

In each country, the majority of the participants were less than 45 years of age. Respondents from the sub-Saharan African countries (Lesotho and Senegal) were younger than those from other countries.

The highest proportions of respondents with formal education were found in the Eastern European countries (Albania, Armenia, Azerbaijan, Ukraine, Uzbekistan), whereas countries in Africa (Senegal and Morocco) had the highest proportions of respondents without formal education.

Respondents from Eastern European countries were more likely to be living in urban settings than in rural settings; whereas, African countries generally had higher proportions of rural settlers than urban settlers.

Apart from Uzbekistan, there was a higher percentage of non-smokers compared to smokers in each country. Ukraine, Uzbekistan and Lesotho had higher proportions of current drinkers than non-drinkers, whereas Albania had a higher proportion of non-drinkers compared to drinkers. The other countries not mentioned had no data on alcohol consumption.

Across the 10 countries, respondents from each wealth quintile were fairly represented. However, unlike the other countries, respondents from Ukraine and Maldives were more likely to be employed than unemployed.

Table 4.3: Baseline characteristics of study populations in included countries

	Eastern Europe					North Africa		Sub-Saharan Africa		Indian Sub-Continent
	Albania [*n* (%)]	**Armenia [*n* (%)]**	**Azerbaijan [*n* (%)]**	**Ukraine [*n* (%)]**	**Uzbekistan [*n* (%)]**	**Egypt [*n* (%)]**	**Morocco [*n* (%)]**	**Lesotho [*n* (%)]**	**Senegal [*n* (%)]**	**Maldives [*n* (%)]**
Gender										
Female	7,584 (71.6)	5,922 (78.9)	8,444 (76.8)	6,841 (68.3)	5,463 (70.1)	6,578 (54.8)	16,798	7,624 (69.7)	15,688 (76.1)	7,131 (80.5)
Male	3,013 (28.4)	1,584 (21.1)	2,558 (23.3)	3,178 (31.7)	2,333 (29.9)	5,430 (45.2)	-	3,317 (30.3)	4,929 (23.9)	1,727 (19.5)
Age group										
15-24	3,526 (33.3)	2,434 (32.4)	3,589 (32.6)	2,717 (27.1)	2,930 (37.6)	4,141 (34.5)	6,368 (37.9)	4,865 (44.5)	8,921 (43.3)	1,647 (18.6)
25-34	2,237 (21.1)	2,233 (29.8)	2,679 (24.4)	2,858 (28.5)	2,220 (28.5)	2,969 (24.7)	4,847 (28.9)	2,995 (27.4)	5,967 (28.9)	3,231 (36.5)
35-44	3,223 (30.4)	1,735 (23.1)	3,102 (28.2)	2,851 (28.5)	1,814 (23.3)	2,379 (19.8)	3,892 (23.2)	1,905 (17.4)	3,931 (19.1)	2,660 (30.0)
45-54	1,611 (15.2)	1,104 (14.7)	1,530 (13.9)	1,593 (15.9)	774 (9.9)	1,826 (15.2)	1,691 (10.1)	1,010 (9.2)	1,561 (7.6)	1,134 (12.8)
≥55	-	-	102 (0.93)	-	58 (0.7)	693 (5.8)	-	166 (1.5)	237 (1.2)	186 (2.1)
Education										
No Education	52 (0.49)	4 (0.05)	127 (1.2)	4 (0.0)	-	2,736 (22.8)	8,917 (53.1)	615 (5.6)	11,898 (57.7)	2,587 (29.7)
Primary	4,850 (45.8)	542 (7.2)	148 (1.4)	13 (0.1)	4,322 (55.6)	1,653 (13.8)	3,253 (19.4)	5,526 (50.5)	4,392 (21.3)	3,037 (34.8)
Secondary	4,364 (41.2)	2,867 (38.2)	9,323 (84.7)	4,625 (46.2)	755 (9.7)	5,782 (48.2)	3,821 (22.8)	4,271 (39.0)	4,055 (19.7)	2,812 (32.3)
Higher	1,331 (12.6)	4,093 (54.5)	1,404 (12.8)	5,377 (53.7)	2,714 (33.76)	1,837 (15.3)	807 (4.8)	529 (4.8)	272 (1.3)	284 (3.3)
Place of residence										
Rural	5,096 (48.1)	2,477 (33.0)	5,167 (47.0)	3,735 (37.3)	4,366 (56.0)	6,942 (57.8)	7,801 (46.4)	8,228 (75.2)	12,367 (60.0)	7,543 (85.2)
Urban	5,501 (51.9)	5,029 (67.0)	5,835 (53.0)	6,284 (62.7)	3,430 (44.0)	5,066 (42.2)	8,997 (53.6)	2,713 (24.8)	8,250 (40.0)	1,315 (14.9)
Currently smoking										
No	9,455 (89.2)	6,467 (86.2)	1,335 (52.2)	7,391 (74.0)	341 (33.2)	9,942 (82.9)	-	9,769 (89.6)	19,831 (96.2)	7,884 (89.1)
Yes	1,142 (10.8)	1,033 (13.8)	1,221 (47.8)	2,594 (26.0)	687 (66.8)	2,054 (17.1)	-	1,141 (10.4)	784 (3.8)	962 (10.9)
Currently drink alcohol										
No	6,311 (59.6)	-	-	1,408 (14.1)	3,684 (47.3)	-	-	1,542 (46.5)	-	-
Yes	4,286 (40.5)	-	-	8,576 (85.9)	4,111 (52.7)	-	-	1,773 (53.5)	-	-
Wealth quintile										
Lowest	2,135 (20.2)	1,378 (18.4)	2,276 (20.7)	1,512 (15.1)	-	2,326 (19.4)	3,527 (21.0)	2,167 (19.8)	4,911 (23.8)	1,929 (21.8)
Second	1,812 (17.1)	1,619 (21.6)	2,351 (21.4)	2,494 (24.9)	-	2,580 (21.5)	3,512 (20.9)	2,148 (19.6)	4,655 (22.6)	2,263 (25.6)
Middle	1,899 (17.9)	1,678 (22.4)	2,448 (22.2)	2,052 (20.5)	-	2,449 (20.4)	3,299 (19.6)	2,088 (19.1)	4,730 (22.9)	2,420 (27.3)
Fourth	2,473 (23.3)	1,646 (21.9)	2,150 (19.5)	1,815 (18.1)	-	2,190 (18.2)	3,132 (18.7)	2,229 (20.4)	3,571 (17.3)	1,396 (15.8)
Highest	2,278 (21.5)	1,185 (15.8)	1,777 (16.2)	2,146 (21.4)	-	2,463 (20.5)	3,328 (19.8)	2,309 (21.1)	2,750 (13.3)	850 (9.6)
Marital status										
Never married or living alone	3,950 (37.3)	2,942 (39.2)	6,933 (63.0)	4,492 (44.8)	-	4,336 (36.1)	7,947 (47.3)	5,409 (49.4)	7,761 (37.6)	655 (7.4)
Married or living together	6,647 (62.7)	4,564 (60.8)	4,069 (37.0)	5,527 (55.2)	-	7,672 (63.9)	8,851 (52.7)	5,532 (50.6)	12,856 (62.4)	8,203 (92.6)
Currently working										
No	6,368 (60.1)	4,593 (61.2)	7,713 (70.4)	2,832 (28.3)	4,093 (52.5)	6,675 (97.1)	13,426 (80.0)	5,996 (54.8)	10,951 (53.1)	4,236 (47.9)
Yes	4,229 (39.9)	2,905 (38.7)	3,248 (29.6)	7,164 (71.7)	3,700 (47.5)	201 (2.9)	3,361 (20.0)	4,943 (45.2)	9,666 (46.9)	4,604 (52.1)
Diabetes										
Non diabetic	-	1,761 (97.2)	10,320 (99.0)	-	-	11,627 (96.8)	-	9,443 (98.1)	20,540 (99.6)	8,399 (96.7)
Diabetic	-	51 (2.81)	106 (1.0)	-	-	381 (3.2)	-	182 (1.9)	77 (0.4)	289 (3.3)
Heart disease										
No	5,065 (47.8)	-	2,653 (91.3)	-	-	11,903 (99.2)	-	-	20,478 (99.3)	8,627 (97.5)
Yes	5,532 (52.2)	-	254 (8.7)	-	-	99 (0.8)	-	-	139 (0.7)	219 (2.5)
Stroke										
No	9,455 (89.2)	-	2,857 (98.4)	-	-	11,936 (99.5)	-	-	-	8,658 (98.0)
Yes	1,142 (10.8)	-	46 (1.6)	-	-	65 (0.5)	-	-	-	175 (2.0)

4.2.1.1 PREVALENCE OF HYPERTENSION ACCORDING TO SOCIO-DEMOGRAPHIC CHARACTERISTICS IN SELECTED COUNTRIES

As shown in Table 4.4, the prevalence of hypertension was highest in Albania (22.7%) but lowest in Morocco (5.4%).

Prevalence estimates of hypertension were higher among men in Albania, Ukraine, Uzbekistan, Lesotho, and the Maldives; whereas women in Armenia, Azerbaijan, Egypt, and Senegal had higher proportions of hypertension compared to their male counterparts.

The proportion of hypertension increased significantly with age in all countries except Senegal, where hypertension prevalence was relatively low among respondents aged 55 years and above. It is worth emphasizing that there were only 237 respondents (1.2%) aged 55 years and above in Senegal, so that the findings in this small sample size may not be generalizable to all adults within this age group in the country.

In Ukraine, Egypt, Senegal and Maldives, the prevalence of hypertension was highest in respondents without formal education; whereas in Lesotho, hypertension prevalence was highest among respondents with the highest level of educational attainment.

Respondents living in rural areas in the Eastern European countries were more likely to have a higher prevalence of hypertension, compared to respondents who lived in urban areas. Conversely, prevalence estimates of hypertension in countries in other regions were higher in urban areas than in rural areas.

Hypertension prevalence was significantly higher among current smokers than non-smokers in Albania, Azerbaijan and Ukraine. Conversely, non-smokers in Senegal reported significantly higher rates of hypertension, compared to smokers. In countries with alcohol use data (Albania, Uzbekistan and Lesotho), hypertension rates were higher among drinkers than non-drinkers.

Respondents within the lowest wealth quintiles in Albania, Armenia, and Ukraine presented the highest prevalence of hypertension. Whereas respondents within the highest wealth Quintiles in Egypt, Morocco, Lesotho, and the Maldives recorded the highest proportions of hypertension.

The proportion of hypertension was higher among respondents who were employed compared to their unemployed counterparts in all the Eastern European countries, and in Senegal and Egypt, whereas no significant association between employment status and hypertension prevalence was observed in the other countries.

Table 4.4: Prevalence of hypertension by socio-demographic characteristics in included countries

	Eastern Europe					North Africa		Sub-Saharan Africa		Indian Sub-Continent
	Albania (%)	**Armenia (%)**	**Azerbaijan (%)**	**Ukraine (%)**	**Uzbekistan (%)**	**Egypt (%)**	**Morocco (%)**	**Lesotho (%)**	**Senegal (%)**	**Maldives (%)**
Overall prevalence	22.7	17.2	12.3	17.3	9.8	15.7	5.4	12.5	7.2	7.6
Overall Mean Age (SD)	31.7 (10.9)	31.2 (10.2)	31.7 (10.8)	32.4 (10.0)	29.9 (10.4)	32.4 (12.5)	29.6 (10.0)	28.5 (10.6)	28.3 (10.1)	33.9 (9.3)
Gender										
Male	26.3*	12.8*	11.0*	17.8	11.2*	13.5*	-	13.2	1.7*	8.6
Female	19.8	18.0	12.7	17.1	9.2	17.5	5.4	12.2	9.0	7.4
Age group										
15-24	10.7*	3.0*	3.7*	3.4*	3.5*	6.4*	3.6*	5.9*	3.2*	2.4*
25-34	18.0	11.1	9.1	10.6	7.2	11.0	5.7	11.8	7.9	3.8
35-44	30.5	24.4	17.5	25.2	15.6	18.7	5.9	20.7	12.4	9.3
45-54	38.4	44.6	25.4	39.1	26.2	30.5	10.9	27.6	14.0	18.6
≥55	-	-	40.2	-	29.3	41.7	-	35.5	8.9	30.1
Education										
No Education	14.3*	-	11.0*	50.0*	-	21.9*	5.2	11.4*	8.2*	14.0*
Primary	27.1	12.2*	8.8	16.7	9.1*	20.2	5.7	12.5	7.5	6.5
Secondary	21.5	20.0	12.7	17.8	7.8	12.0	5.6	11.8	4.2	3.5
Higher	11.8	16.0	10.0	16.8	11.6	13.8	7.0	20.6	4.0	3.5
Place of residence										
Rural	26.9*	18.9	11.7*	19.4*	9.9	14.7*	4.8*	11.8*	6.3*	7.5
Urban	19.1	16.3	12.9	16.0	9.7	17.0	6.2	14.7	8.7	8.7
Currently smoking										
No	20.4*	17.2	9.7*	16.7*	15.8	15.6	-	12.4	7.5*	7.6
Yes	30.8	16.9	12.4	19.3	15.3	15.9	-	13.7	1.7	8.4
Currently drink alcohol										
No	18.9*	-	-	-	7.8*	-	-	11.2*	-	-
Yes	27.0	-	-	-	11.6	-	-	14.9	-	-
Wealth quintile										
Lowest	28.9*	23.1*	12.7*	19.6*	-	14.4	4.8	10.0*	4.9*	7.8
Second	24.0	17.3	13.1	18.4	-	15.4	5.1	10.5	6.6	7.7
Middle	24.9	14.9	13.4	17.9	-	15.6	5.9	12.7	7.8	7.6
Fourth	22.7	16.4	12.2	16.1	-	15.4	4.5	13.7	9.8	6.8
Highest	14.9	15.7	9.2	14.9	-	17.5	7.1	15.5	8.2	8.5
Marital status										
Never married or living alone	13.5*	8.6*	7.0*	13.1*	-	10.0*	10.6*	9.6*	3.2*	9.9*
Married or living together	28.5	20.5	15.4	20.7	-	18.9	5.3	15.4	9.6	7.5
Currently working										
No	19.1*	15.5*	11.8*	11.8*	8.6*	15.4*	5.2	9.8*	6.7*	7.2
Yes	27.0	20.3	13.4	19.5	11.2	23.4	6.6	15.8	7.9	8.0
Diabetes										
Non diabetic	-	16.4*	12.0*	-	-	14.4*	-	12.7*	7.2*	6.7*
Diabetic	-	45.1	41.5	-	-	56.2	-	36.3	20.8	34.6
Heart disease										
No	22.0	-	23.5*	-	-	15.3*	-	-	7.2*	7.3*
Yes	23.2	-	33.9	-	-	58.6	-	-	10.1	20.0
Stroke										
No	23.0	-	24.5	-	-	15.5*	-	-	-	7.5*
Yes	20.7	-	23.9	-	-	41.5	-	-	-	15.2

Key: *= $p<0.05$

4.2.1.2 SOCIO-DEMOGRAPHIC PATTERNS OF HYPERTENSION PREVALENCE IN PERSONS AGED 15 – 24 YEARS

Table 4.5 illustrates that the prevalence of hypertension was highest among 15-24 year olds living in Albania (10.7%) and lowest in the Maldives (2.4%).

Overall, prevalence estimates of hypertension in each country was lower for each group, compared to the overall estimates.

The proportion of hypertension was higher among men in Albania, Azerbaijan, Ukraine, Uzbekistan, and Lesotho.

Respondents with progressively higher levels of education attainment had lower hypertension prevalence in Albania, Armenia, Azerbaijan, Ukraine, and Egypt. In contrast, respondents with progressively higher levels of education attainment had higher prevalence estimates of hypertension in Uzbekistan, Morocco, Maldives, and Lesotho.

Respondents living in rural areas in the Eastern European countries had higher prevalence of hypertension, compared to those living in urban areas. However, in Morocco, Lesotho, Senegal, and Maldives, respondents living in urban settings had slightly higher prevalence estimates of hypertension.

Hypertension prevalence was higher among current smokers than non-smokers in all countries except Uzbekistan, where the reverse was the case. Regarding alcohol consumption, the proportion of hypertension was significantly higher among current drinkers compared to non-drinkers in all countries with alcohol use data.

With the exception Morocco, Senegal, and Maldives, respondents within the lowest wealth quintiles had the highest prevalence of hypertension.

There was no pattern of note regarding the prevalence of hypertension according to employment status.

Table 4.5: Socio-demographic patterns of hypertension prevalence in persons aged 15-24 years in selected countries

	Eastern Europe					North Africa		Sub-Saharan Africa		Indian Sub-Continent
	Albania (%)	**Armenia (%)**	**Azerbaijan (%)**	**Ukraine (%)**	**Uzbekistan (%)**	**Egypt (%)**	**Morocco (%)**	**Lesotho (%)**	**Senegal (%)**	**Maldives (%)**
Overall prevalence	10.7	3.0	3.7	3.4	3.5	6.4	3.6	5.9	3.2	2.4
Gender										
Female	7.7*	3.5	3.6	3.3	3.0*	6.9	3.6	5.9	4.2*	2.4
Male	14.1	1.6	4.1	3.8	4.8	5.9	-	6.0	0.2	3.1
Education										
No Education	-	-	-	-	-	7.9	3.3	3.0	3.9*	0.0
Primary	14.6*	2.0	7.4	-	3.1	6.4	3.0	6.0	3.4	2.3
Secondary	9.2	4.4	3.7	3.6	3.1	6.4	5.0	5.9	2.2	2.5
Higher	4.3	2.3	3.8	3.3	9.3	5.6	7.1	6.3	6.0	3.1
Place of residence										
Rural	13.8*	4.0	4.8*	4.2	10.0	6.5	3.1	5.8	3.0	2.2
Urban	7.7	2.4	2.7	3.0	8.1	6.3	4.2	6.2	3.6	3.9
Currently smoking										
No	9.6*	2.9	3.3*	3.0*	10.6	6.2	-	5.8	-	2.3
Yes	18.4	4.3	7.0	5.1	8.3	7.9	-	7.4	-	4.0
Currently drink alcohol										
No	19.7*	-	-	1.6*	2.8*	-	-	-	-	-
Yes	20.0	-	-	4.1	4.6	-	-	-	-	-
Wealth quintile										
Lowest	16.8*	5.1	5.0*	5.2	-	7.9	1.8	6.7	2.6	3.4
Second	13.0	1.6	3.7	2.6	-	5.6	4.0	5.4	3.0	1.7
Middle	9.0	2.7	3.8	4.1	-	7.5	3.6	6.0	3.2	2.2
Fourth	9.2	4.0	4.0	2.4	-	5.1	4.5	6.6	4.0	1.9
Highest	6.0	2.0	1.8	3.5	-	5.6	5.4	4.6	3.6	4.5
Marital status										
Never married or living alone	11.0	1.3*	3.0*	2.5*	-	5.8*	-	5.1*	1.7*	1.1
Married or living together	7.9	5.2	5.9	7.2	-	8.3	3.7	7.9	6.1	2.5
Currently working										
No	9.2*	3.3	3.6	2.7*	3.1*	6.3	3.4	5.9	3.2	3.2*
Yes	16.2	1.2	5.0	4.6	4.7	3.6	5.1	5.9	3.3	1.4
Diabetes										
Non diabetic	-	2.9*	-	-	-	6.3*	-	6.0*	-	2.3*
Diabetic	-	16.7	-	-	-	33.3	-	20.0	-	16.7
Heart disease										
No	11.4	-	-	-	-	6.4*	-	-	3.2	2.2*
Yes	10.2	-	-	-	-	23.1	-	-	7.9	13.3
Stroke										
No	10.4	-	-	-	-	6.4	-	-	-	2.3*
Yes	12.8	-	-	-	-	11.8	-	-	-	13.3

Key: *= $p<0.05$

4.2.1.3 SOCIO-DEMOGRAPHIC PATTERNS OF HYPERTENSION PREVALENCE IN PERSONS AGED 25 – 34 YEARS

As shown in Table 4.6, the prevalence of hypertension was highest among 25-34 year olds living in Albania (18.0%) and lowest among respondents from the Maldives (3.8%).

Overall, prevalence estimates of hypertension for each country was lower in this age group, compared to the overall estimates.

The proportion of hypertension was higher among males in Albania, Armenia, Ukraine, Uzbekistan, and Lesotho.

Respondents with no formal education in Azerbaijan and Maldives had the highest estimates of hypertension, while respondents with the highest level of education in Uzbekistan, Morocco and Lesotho had the highest rates of hypertension.

Respondents living in rural areas in Albania, Armenia, Azerbaijan, Ukraine, and Egypt had higher prevalence estimates of hypertension, compared to those in urban areas. Respondents in urban areas in other countries had higher prevalence estimates of hypertension than their counterparts in rural areas.

Non-smokers in Armenia, Azerbaijan, Uzbekistan, Senegal and Maldives had higher proportions of hypertension compared to current smokers. With regards to alcohol consumption, the proportion of hypertension was significantly higher among current drinkers compared to non-drinkers in countries with alcohol use data.

Respondents within the lowest wealth quintiles in Albania, Armenia, and Ukraine had the highest prevalence estimates of hypertension, whereas respondents within the highest wealth quintiles in Morocco, Lesotho, and Maldives had the highest proportions of hypertension.

There was no pattern of note regarding hypertension prevalence and employment status.

Table 4.6: Socio-demographic patterns of hypertension prevalence in persons aged 25-34 years in selected countries

	Eastern Europe					North Africa		Sub-Saharan Africa		Indian Sub-Continent
	Albania (%)	**Armenia (%)**	**Azerbaijan (%)**	**Ukraine (%)**	**Uzbekistan (%)**	**Egypt (%)**	**Morocco (%)**	**Lesotho (%)**	**Senegal (%)**	**Maldives (%)**
Overall prevalence	18.0	11.1	9.1	10.6	7.2	11.0	5.7	11.8	7.9	3.8
Gender										
Female	13.7*	11.0	9.9*	9.0*	3.0*	11.6	5.7	11.6	9.6*	4.4*
Male	25.1	12.3	6.2	15.2	4.8	10.3	-	12.3	1.1	1.0
Education										
No Education	11.1*	-	14.3	-	-	10.7	5.2	11.7	7.7*	8.3*
Primary	22.2	9.1	5.6	-	6.9	11.5	6.6	10.5	9.9	4.4
Secondary	16.1	11.9	9.4	12.0	7.6	11.3	5.2	13.0	5.9	2.8
Higher	9.9	10.9	7.3	9.6	15.2	10.1	10.6	14.1	1.8	1.9
Place of residence										
Rural	23.7*	12.2	9.5	12.6*	3.1	11.3	4.7*	11.4	6.8*	3.6
Urban	14.1	10.6	8.8	9.5	4.1	10.7	6.7	12.6	9.7	5.1
Currently smoking										
No	16.4*	11.2	7.3	9.4*	10.7	10.8	-	11.7	8.3*	3.9
Yes	22.8	10.9	5.4	14.0	9.8	11.8	-	11.9	1.4	3.2
Currently drink alcohol										
No	14.8*	-	-	7.5	2.8*	-	-	-	-	-
Yes	21.5	-	-	11.1	4.6	-	-	-	-	-
Wealth quintile										
Lowest	28.0*	16.3	7.9	13.5	-	10.0	4.1	9.4	4.9*	4.5
Second	17.8	11.6	9.9	11.0	-	13.5	5.7	11.0	7.0	3.8
Middle	24.7	7.9	8.6	11.2	-	11.7	6.3	12.6	9.2	3.5
Fourth	17.3	10.0	10.1	10.2	-	9.3	4.7	12.8	11.1	2.8
Highest	8.6	12.5	9.2	8.1	-	10.4	8.0	12.9	8.5	5.2
Marital status										
Never married or living alone	18.1	9.7	7.5	12.1	-	8.3*	14.3*	12.2	5.0*	4.7
Married or living together	18.0	11.4	9.6	9.8	-	11.7	5.5	11.5	8.8	3.8
Currently working										
No	17.1	11.4	9.5	10.5	3.1*	11.5	5.5	10.0*	9.3*	4.5*
Yes	18.9	10.7	8.2	10.6	4.7	11.1	6.7	13.2	6.7	3.1
Diabetes										
Non diabetic	-	11.1	8.9	-	-	10.9*	-	11.5*	7.9	3.5*
Diabetic	-	14.3	23.1	-	-	31.3	-	21.2	9.1	23.1
Heart disease										
No	16.9	-	-	-	-	11.0	-	-	8.0	3.7
Yes	18.9	-	-	-	-	27.3	-	-	5.5	8.5
Stroke										
No	18.6	-	-	-	-	11.0	-	-	-	3.8
Yes	14.4	-	-	-	-	27.3	-	-	-	6.3

Key: *= p<0.05

4.2.1.4 SOCIO-DEMOGRAPHIC PATTERNS OF HYPERTENSION PREVALENCE IN PERSONS AGED 35 – 44 YEARS

As shown in Table 4.7, the prevalence of hypertension was highest among 35-44 year olds living in Albania (30.5%) and lowest among respondents from Morocco (5.9%).

Overall, prevalence estimates of hypertension in each country (except Morocco and Senegal) was lower for this age group, compared to the overall estimates. Prevalence estimates in Morocco and Senegal in this age group were somewhat comparable with the overall estimates.

The prevalence of hypertension was highest among males in Albania, Ukraine, and Lesotho. However, in Uzbekistan the prevalence was the same for both sexes (15.6%).

Respondents with no formal education in Albania, Egypt, and Maldives had higher hypertension prevalence, compared to those with higher levels of educational attainment. Conversely, respondents with the highest levels of educational attainment in Uzbekistan and Lesotho had the highest proportions of hypertension.

Although respondents living in rural areas had higher prevalence estimates of hypertension, compared to their counterparts in urban areas, respondents living in urban settings in the sub-Saharan African countries had higher hypertension rates, compared to those living in rural areas.

There was no pattern of note with regard to the associations of hypertension with lifestyle factors (smoking and drinking) and other socio-economic indicators (wealth and employment status).

Table 4.7: Socio-demographic patterns of hypertension prevalence in persons aged 35-44 years in selected LMICs

	Eastern Europe					North Africa		Sub-Saharan Africa		Indian Sub-Continent
	Albania (%)	**Armenia (%)**	**Azerbaijan (%)**	**Ukraine (%)**	**Uzbekistan (%)**	**Egypt (%)**	**Morocco (%)**	**Lesotho (%)**	**Senegal (%)**	**Maldives (%)**
Overall prevalence	30.5	24.4	17.4	25.2	15.6	18.7	5.9	20.7	12.4	9.3
Gender										
Female	29.1	24.5	18.8	25.1	15.6	21.5	5.9	20.1	15.1*	10.2*
Male	32.5	23.4	12.0*	25.5	15.6	15.2*	-	22.4	2.1	5.4
Education										
No Education	37.5*	-	10.0*	-	-	20.2	6.1	13.1	12.3	10.5
Primary	35.1	31.3	10.7	-	17.1	18.6	4.9	18.7	12.3	8.5
Secondary	29.8	27.0	18.5	25.8	13.2	17.4	6.6	24.2	15.9	7.1
Higher	15.9	22.6	10.9	24.7	28.9	19.0	2.8	30.5	4.6	6.1
Place of residence										
Rural	35.3*	27.1	18.8	28.2*	17.5	18.7	5.9	19.3	10.1*	9.4
Urban	26.2	23.4	16.2	23.3	13.3	18.7	5.8	24.6	16.4	9.0
Currently smoking										
No	28.5*	24.2	10.8	24.9	16.3	19.4	-	20.5	12.9*	9.4
Yes	36.4	26.3	14.0	26.4	18.8	15.6	-	22.6	2.7	8.5
Currently drink alcohol										
No	28.2*	-	-	26.4	14.7	-	-	-	-	-
Yes	32.7	-	-	25.2	16.2	-	-	-	-	-
Wealth quintile										
Lowest	38.4*	26.5	18.0*	27.5*	-	19.0	7.2	13.3*	7.5*	9.3
Second	34.1	24.4	20.7	28.5	-	19.7	5.5	16.7	11.7	10.2
Middle	30.2	26.4	18.7	26.1	-	19.0	6.9	23.5	13.8	9.4
Fourth	28.9	23.9	16.1	22.6	-	16.0	3.6	20.7	18.3	8.2
Highest	23.2	19.7	12.0	20.9	-	19.5	5.6	28.1	14.5	8.4
Marital status										
Never married or living alone	28.2	19.1	7.5	27.5	-	16.8	9.7	19.2	13.0	11.0
Married or living together	30.7	17.1	9.6	24.3	-	18.9	5.8	21.3	12.4	9.2
Currently working										
No	30.8	25.3	19.8*	26.9	17.8*	21.3	5.7	17.9*	12.4	9.0
Yes	30.4	23.4	13.7	24.9	14.2	21.4	6.5	22.7	12.5	9.6
Diabetes										
Non diabetic	-	24.2	17.2	-	-	17.9*	-	21.1*	12.4	8.4*
Diabetic	-	31.3	38.2	-	-	43.1	-	37.1	22.9	27.0
Heart disease										
No	29.4	-	21.3	-	-	18.5*	-	-	12.4	9.0*
Yes	31.4	-	26.3	-	-	42.9	-	-	16.1	18.7
Stroke										
No	31.2	-	22.0	-	-	18.6	-	-	-	9.3
Yes	25.3	-	10.5	-	-	27.3	-	-	-	12.3

Key: ***** = $P < 0.05$

4.2.1.5 SOCIO-DEMOGRAPHIC PATTERNS OF HYPERTENSION PREVALENCE IN PERSONS AGED 45 – 54 YEARS

As shown in Table 4.8, the prevalence of hypertension was highest among 45-54 year olds living in Armenia (30.5%) and lowest among respondents from Morocco (10.9%).

Overall, prevalence estimates of hypertension in each country was higher for this age group, compared to the overall estimates.

The proportion of hypertension was higher among males in Albania, Ukraine, and Lesotho. However, in Uzbekistan the prevalence was the same for both sexes (15.6%).

Respondents with no formal education had higher hypertension prevalence than their educated counterparts in Azerbaijan and Senegal; whereas, the prevalence was highest among respondents with the highest levels of educational attainment in Uzbekistan, Egypt and Lesotho.

Respondents living in rural areas in the Eastern European countries had higher prevalence of hypertension; whereas, respondents living in urban settings in the African countries (Egypt, Morocco, Senegal, and Lesotho) and the Maldives had higher hypertension prevalence than their rural counterparts.

Non-smokers in Armenia, Uzbekistan, Egypt, Lesotho, Senegal, and Maldives had higher proportions of hypertension compared to current smokers in these countries. Regarding alcohol consumption, the proportion of hypertension was significantly higher among drinkers in Ukraine compared to non-drinkers. There was no difference in hypertension prevalence by drinking status in the other countries that had alcohol use data.

Respondents within the lowest wealth quintiles in Armenia had the highest prevalence of hypertension, whereas respondents within the highest wealth quintiles in the African countries and the Maldives had the highest proportions of hypertension.

The prevalence of hypertension was higher among unemployed respondents in Senegal, Maldives, and all the Eastern European countries, compared to their employed counterparts.

Table 4.8: Socio-demographic patterns of hypertension prevalence in persons aged 45-54 years in selected LMICs

	Eastern Europe					North Africa		Sub-Saharan Africa		Indian Sub-Continent
	Albania (%)	**Armenia (%)**	**Azerbaijan (%)**	**Ukraine (%)**	**Uzbekistan (%)**	**Egypt (%)**	**Morocco (%)**	**Lesotho (%)**	**Senegal (%)**	**Maldives (%)**
Overall prevalence	38.4	44.6	25.3	39.1	26.2	30.5	10.9	27.6	14.0	18.6
Gender										
Female	35.8	45.2	28.3*	40.1	28.2	34.6*	10.9	30.8*	19.9*	20.7*
Male	40.9	40.0	19.3	36.3	23.5	25.9	-	22.0	4.5	14.6
Education										
No Education	-	-	33.3*	-	-	30.4	8.2*	11.4*	14.3	18.3
Primary	43.4*	44.4	14.3	66.7*	25.1	32.2	33.3	25.5	13.8	17.8
Secondary	36.5	48.7	26.5	43.1	13.9	28.8	25.0	40.8	12.7	26.3
Higher	26.8	41.6	19.3	35.9	58.2	31.0	0.0	46.2	9.1	18.2
Place of residence										
Rural	44.0*	52.0	25.7	39.9	29.6*	28.1*	9.0	24.8*	11.8*	18.5
Urban	34.0	40.6	25.0	38.6	23.2	33.3	14.0	36.9	17.9	19.0
Currently smoking										
No	37.0	45.2	17.8	39.3	24.6	31.6	-	29.2*	14.7*	20.3*
Yes	42.0	38.5	20.6	39.1	22.6	26.6	-	17.7	3.3	11.4
Currently drink alcohol										
No	34.0*	-	-	40.9	24.0	-	-	-	-	-
Yes	41.9	-	-	39.1	27.4	-	-	-	-	-
Wealth quintile										
Lowest	41.0*	68.1*	28.0*	39.3	-	23.8*	16.7*	16.5*	9.0*	15.0
Second	38.6	42.7	25.7	39.7	-	29.1	0.0	18.9	10.2	18.5
Middle	45.2	38.3	30.0	38.0	-	29.0	9.1	25.8	17.9	21.9
Fourth	43.3	35.9	24.9	39.7	-	35.6	13.3	38.9	20.2	20.4
Highest	25.3	42.6	17.5	38.9	-	33.9	26.7	40.3	19.3	15.1
Marital status										
Never married or living alone	27.4	40.5	26.8	41.0	-	36.0	22.2	29.9	17.9	22.0
Married or living together	39.1	45.3	25.0	38.4	-	29.7	10.1	26.5	13.5	18.1
Currently working										
No	42.0	48.0	29.0*	45.9*	28.2	34.5*	10.3	24.9	17.1	19.0
Yes	36.5	41.1	21.4	37.7	25.0	50.0	14.3	29.5	12.9	18.2
Diabetes										
Non diabetic	-	42.3*	24.3*	-	-	27.3*	-	26.7*	13.9	16.3*
Diabetic	-	72.7	53.3	-	-	62.0	-	65.9	26.1	52.1
Heart disease										
No	38.0	-	24.2*	-	-	29.9*	-	-	14.0	18.1*
Yes	38.6	-	38.2	-	-	67.9	-	-	21.4	31.0
Stroke										
No	39.2	-	25.4	-	-	30.2*	-	-	-	18.1*
Yes	33.6	-	33.3	-	-	58.8	-	-	-	32.3

Key: *= $p<0.05$

4.2.1.6 SOCIO-DEMOGRAPHIC PATTERNS OF HYPERTENSION PREVALENCE IN PERSONS AGED 55 YEARS AND ABOVE

As shown in Table 4.9, the prevalence of hypertension was highest among respondents aged 55 years and above in Egypt (41.7%) and lowest among respondents from Senegal (8.9%). It is worth noting that only Egypt had information for men and women in this age group. The prevalence of hypertension was significantly higher among women than men in Egypt.

Overall, prevalence estimates of hypertension in each country was higher for this age group, compared to the overall estimates.

Respondents with the highest levels of educational attainment had higher hypertension prevalence in Uzbekistan, Egypt, and Lesotho.

Respondents living in urban areas had higher prevalence of hypertension, compared to those in rural areas.

With exception for Azerbaijan, non-smokers had higher proportions of hypertension, compared to current smokers. Regarding alcohol consumption, only Uzbekistan had information on drinking status and the proportion of hypertension was higher among non-drinkers compared to current drinkers.

Respondents within the highest wealth quintiles in Egypt, Lesotho, Senegal, and Maldives had the highest prevalence estimates of hypertension.

With exception for Lesotho, the prevalence of hypertension was higher among unemployed respondents, compared to their employed counterparts.

The proportions of hypertension were higher among respondents who suffered a comorbidity.

Table 4.9: Socio-demographic patterns of hypertension prevalence in persons aged ≥55 years in selected LMICs

			Eastern Europe			North Africa		Sub-Saharan Africa		Indian Sub-Continent
	Albania (%)	**Armenia (%)**	**Azerbaijan (%)**	**Ukraine (%)**	**Uzbekistan (%)**	**Egypt (%)**	**Morocco (%)**	**Lesotho (%)**	**Senegal (%)**	**Maldives (%)**
Overall prevalence	-	-	40.2	-	29.3	41.7	-	35.5	8.9	30.1
Gender										
Female	-	-	-	-	-	52.1*	-	-	-	-
Male	-	-	40.2	-	29.3	30.9	-	35.5	8.9	30.1
Education										
No Education	-	-	-	-	-	42.1	-	21.4*	6.9	28.5
Primary	-	-	-	-	23.5	39.4	-	41.9	11.8	35.7
Secondary	-	-	26.5	-	33.3	42.2	-	33.3	15.8	44.4
Higher	-	-	19.3	-	45.8	44.3	-	83.3	-	-
Place of residence										
Rural	-	-	38.3	-	20.0	36.3*	-	32.2*	6.6	26.9*
Urban	-	-	41.8	-	34.2	48.1	-	56.5	12.9	50.0
Currently smoking										
No	-	-	38.8	-	44.4	44.8*	-	38.9	9.6	30.3
Yes	-	-	42.3	-	33.3	29.5	-	27.1	3.6	29.6
Currently drink alcohol										
No	-	-	-	-	40.0	-	-	-	-	-
Yes	-	-	-	-	28.3	-	-	-	-	-
Wealth quintile										
Lowest	-	-	35.3*	-	-	40.4	-	34.6	4.2	25.5
Second	-	-	26.3	-	-	37.0	-	28.6	13.3	26.1
Middle	-	-	67.9	-	-	38.5	-	38.5	6.0	23.8
Fourth	-	-	31.6	-	-	41.5	-	40.0	10.7	38.1
Highest	-	-	26.3	-	-	49.7	-	40.9	14.3	58.8
Marital status										
Never married or living alone	-	-	-	-	-	54.0*	-	29.9	-	18.2
Married or living together	-	-	41.4	-	-	37.9	-	26.5	9.1	30.9
Currently working										
No	-	-	50.0	-	33.3	51.7	-	31.9	14.3	45.0
Yes	-	-	35.7	-	26.5	41.9	-	37.0	8.1	28.3
Diabetes										
Non diabetic	-	-	35.2	-	-	37.9*	-	35.2	8.7	25.8*
Diabetic	-	-	50.0	-	-	61.8	-	66.7	16.7	63.2
Heart disease										
No	-	-	40.0	-	-	39.7*	-	-	8.9	27.4*
Yes	-	-	45.5	-	-	52.3	-	-	-	77.8
Stroke										
No	-	-	-	-	-	40.9*	-	-	-	29.6
Yes	-	-	-	-	-	68.3	-	-	-	50.0

Key: *= $p<0.05$

4.2.1.7 SOCIO-DEMOGRAPHIC PATTERNS OF HYPERTENSION PREVALENCE IN MEN

Stratification by gender was decided a priori, because of the well-known differences in hypertension etiology and natural history between men and women (Stranges & Guallar, 2012). As shown in Table 4.10, the prevalence of hypertension was highest among Albanian men (26.3%) and lowest among Senegalese men (1.7%). In addition, Men aged 45 years and above had the highest prevalence of hypertension in all countries.

Men with no education had the highest proportions of hypertension in Albania, Azerbaijan, Ukraine, Senegal and Maldives; whereas men with the highest levels of educational attainment had the highest proportions of hypertension in Armenia, Uzbekistan, and Lesotho.

Men living in rural areas of Albania, Azerbaijan, and Ukraine recorded the highest prevalence of hypertension compared to men living in urban areas in these countries. However, in Armenia, Uzbekistan, Lesotho, Senegal and Maldives, men living in urban settings had the highest prevalence of hypertension.

Hypertension prevalence was higher among current smokers than non-smokers in Albania, Armenia, Azerbaijan, Ukraine, and Lesotho. Conversely, non-current smokers in Senegal and Maldives reported higher proportions of hypertension compared to smokers. The proportion of hypertension was significantly higher among current drinkers compared to non-drinkers in all countries with alcohol use data.

Men within the lowest wealth quintiles in Albania, Azerbaijan, and Ukraine had the highest prevalence of hypertension; whereas men within the highest wealth quintiles in Armenia, Lesotho, Senegal, and Maldives the highest proportions of hypertension.

In all nine countries except the Maldives, men who were employed had higher prevalence estimates of hypertension compared to men who were unemployed.

Table 4.10: Socio-demographic patterns of hypertension prevalence among the Men in selected countries

	Eastern Europe					North Africa		Sub-Saharan Africa		Indian Sub-Continent
	Albania (%)	**Armenia (%)**	**Azerbaijan (%)**	**Ukraine (%)**	**Uzbekistan (%)**	**Egypt (%)**	**Morocco[#] (%)**	**Lesotho (%)**	**Senegal (%)**	**Maldives (%)**
Overall prevalence	26.3	12.8	11.0	17.8	11.2	13.5	-	13.2	1.7	8.6
Overall Mean Age (SD)	31.8 (11.4)	30.5 (10.1)	33.8 (12.2)	32.1 (10.2)	31.4 (11.5)	32.7 (12.7)	-	29.7 (12.2)	29.9 (12.4)	39.5 (11.1)
Age group										
15-24	14.1*	1.6*	4.1*	3.8*	4.8*	5.9*	-	6.0[a]	0.2[a]	3.1[a]
25-34	25.1	12.3	6.2	15.2	8.0	10.3	-	12.3	1.1	1.0
35-44	32.5	23.4	12.0	25.5	15.6	15.2	-	22.4	2.1	5.4
45-54	40.9	40.0	19.3	36.3	23.5	25.9	-	22.0	4.5	14.6
≥55	-	-	40.2	-	29.3	30.9	-	35.5	8.9	30.1
Education										
No Education	22.2*	-	7.7	50.0	-	18.8*	-	12.6[a]	2.0[d]	14.8[a]
Primary	30.5	12.1	11.1	0.0	9.3*	16.2	-	12.3	1.7	4.9
Secondary	25.2	11.0	11.1	18.3	10.0	10.8	-	12.7	1.2	4.3
Higher	17.2	14.3	10.8	17.3	10.4	15.7	-	28.0	1.6	5.9
Place of residence										
Rural	30.3*	8.6	11.5	18.9	9.5*	13.4	-	12.0[a]	1.4[d]	8.0[c]
Urban	23.1	14.8	10.5	17.2	12.7	13.6	-	17.5	2.1	11.8
Currently smoking										
No	21.2*	8.7	9.7*	14.2*	15.3	12.3*	-	13.2[d]	1.7[d]	9.8[d]
Yes	32.8	16.1	12.4	21.0	15.3	15.6	-	13.3	1.4	7.2
Currently drink alcohol										
No	16.9*	-	-	-	7.6*	-	-	11.2[a]	-	-
Yes	31.3	-	-	-	12.1	-	-	14.9	-	-
Wealth quintile										
Lowest	31.4*	14.0	11.2*	21.7*	-	12.3	-	13.6[a]	1.5[d]	9.3[d]
Second	28.7	8.9	10.8	15.6	-	14.7	-	10.9	1.1	6.5
Middle	28.6	8.2	14.6	17.2	-	13.0	-	10.3	1.7	8.1
Fourth	27.2	17.2	9.9	20.6	-	12.3	-	13.5	1.8	9.6
Highest	18.5	17.8	7.3	15.8	-	15.0	-	18.7	2.8	11.5
Marital status										
Never married or living alone	16.0*	5.1*	4.5*	14.0*	-	6.8*	-	9.6[a]	0.5[a]	8.1[d]
Married or living together	34.4	22.2	14.4	21.6	-	18.1	-	18.3	3.3	8.6
Currently working										
No	19.0	7.8*	10.2	9.7*	10.2	7.1*	-	10.0[a]	0.9[c]	14.5[c]
Yes	30.4	17.7	11.5	20.2	11.9	24.3	-	15.0	1.9	8.1
Diabetes										
Non diabetic	-	11.8*	10.5*	-	-	12.7*	-	13.7[a]	1.7[d]	7.4[a]
Diabetic	-	40.0	41.7	-	-	45.1	-	31.7	6.3	37.5
Heart disease										
No	23.6*	-	20.7	-	-	13.1*	-	-	1.7[d]	8.1[a]
Yes	27.6	-	26.9	-	-	56.0	-	-	0.0	36.7
Stroke										
No	26.7	-	21.5	-	-	13.3*	-	-	-	8.5[d]
Yes	24.2	-	10.5	-	-	44.1	-	-	-	18.2

Key: *= $p<0.05$, [#]= female data only

4.2.1.8 SOCIO-DEMOGRAPHIC PATTERNS OF HYPERTENSION PREVALENCE IN WOMEN

As shown in Table 4.11, the prevalence of hypertension was highest among Albanian women (19.8%) and lowest among Moroccan women (5.4%). Women aged 45 years and above had the highest prevalence of hypertension in all countries.

There were no notable patterns of hypertension prevalence across the different levels of educational attainment.

Women living in rural areas of the Eastern European countries (Albania, Armenia, Azerbaijan, Ukraine, and Uzbekistan) had higher prevalence estimates of hypertension compared to women living in urban areas in these countries. However, in African countries (Egypt, Morocco, Lesotho, Senegal) and the Indian sub-continent (Maldives), women living in urban settings had higher prevalence estimates of hypertension.

Hypertension prevalence was higher among current smokers in Armenia, Egypt, Lesotho, Senegal, and the Maldives. Conversely, non-smokers in Albania, Ukraine, and Uzbekistan had higher proportions of hypertension than smokers. The proportion of hypertension was significantly higher among women who were current drinkers compared to non-drinkers in all countries with alcohol use data.

Women within the lowest wealth quintiles in Eastern European had the highest prevalence estimates of hypertension; whereas women within the highest wealth quintiles in African countries had the highest proportions of hypertension.

In all 10 countries, the proportion of hypertension was higher among women who were employed compared to their unemployed counterparts.

Table 4.11: Socio-demographic patterns of hypertension prevalence among women in selected LMICs

	Eastern Europe					North Africa		Sub-Saharan Africa		Indian Sub-Continent
	Albania (%)	**Armenia (%)**	**Azerbaijan (%)**	**Ukraine (%)**	**Uzbekistan (%)**	**Egypt (%)**	**Morocco (%)**	**Lesotho (%)**	**Senegal (%)**	**Maldives (%)**
Overall prevalence	19.8	18.0	12.7	17.1	9.2	17.5	5.4	12.2	9.0	7.4
Overall Mean Age (SD)	31.6 (10.7)	31.4 (10.2)	31.1 (10.3)	32.5 (10.0)	29.3 (9.8)	32.2 (12.2)	29.6 (10.0)	28.1 (9.8)	27.8 (9.2)	32.5 (8.3)
Age group										
15-24	7.7*	3.5*	3.6*	3.3*	3.0*	6.9*	3.6*	5.9*	4.2*	2.4*
25-34	13.7	11.0	9.9	9.0	6.8	11.6	5.7	11.6	9.6	4.4
35-44	29.1	24.5	18.9	25.1	15.6	21.5	5.9	20.1	15.1	10.2
45-54	35.8	45.2	28.4	40.1	28.2	34.6	10.9	30.8	19.9	20.7
≥55	-	-	-	-	-	52.1	-	-	-	-
Education										
No Education	-	-	11.4*	50.0	-	23.0*	5.2	6.1*	9.6*	13.8*
Primary	24.9*	12.2*	8.5	20.0	9.0*	24.4	5.7	12.6	9.9	6.9
Secondary	17.8	21.8	13.2	17.6	6.3	13.3	5.6	11.5	5.8	3.3
Higher	7.7	16.3	9.6	16.7	10.4	11.6	7.0	17.4	6.3	2.8
Place of residence										
Rural	24.4*	20.7*	13.4	19.6*	10.0*	15.8*	4.8*	11.7*	7.7*	7.3
Urban	15.6	16.6	12.1	15.6	8.1	19.8	6.2	13.7	10.9	7.9
Currently smoking										
No	20.1	18.0	-	17.2*	23.8	17.4	-	12.2*	9.0	7.3*
Yes	14.3	27.3	-	16.7	15.2	28.2	-	40.0	9.5	14.7
Currently drink alcohol										
No	19.7*	-	-	-	7.8*	-	-	-	-	-
Yes	20.0	-	-	-	12.6	-	-	-	-	-
Wealth quintile										
Lowest	27.3*	25.0*	13.2*	18.7*	-	16.0	4.8	8.5*	6.0*	7.5
Second	20.6	18.6	13.7	19.4	-	15.9	5.1	10.3	8.2	8.0
Middle	21.9	16.3	13.1	18.1	-	17.9	5.9	14.0	9.8	7.5
Fourth	19.0	16.2	13.0	14.5	-	18.1	4.5	13.8	12.3	6.1
Highest	11.7	15.4	9.8	14.5	-	19.6	7.1	14.3	9.8	7.7
Marital status										
Never married or living alone	11.0*	10.1*	7.7*	12.7*	-	13.3	10.6*	9.8*	4.8*	10.1*
Married or living together	24.5	20.3	15.7	20.5	-	19.4	5.3	14.3	10.9	7.2
Currently working										
No	19.1	16.6*	12.0*	12.4*	8.1*	17.2	5.2	9.8*	7.3*	7.0
Yes	21.4	21.0	15.4	19.3	10.8	20.4	6.6	16.4	11.9	8.0
Diabetes										
Non diabetic	-	17.3*	12.5*	-	-	15.8*	-	12.3*	8.9*	6.6*
Diabetic	-	46.3	41.4	-	-	62.8	-	38.5	24.6	33.8
Heart disease										
No	21.2*	-	24.7*	-	-	17.1*	-	-	9.0	7.2*
Yes	18.3	-	36.9	-	-	61.2	-	-	11.7	17.3
Stroke										
No	20.2*	-	25.7	-	-	17.4*	-	-	-	7.3*
Yes	15.7	-	33.3	-	-	38.7	-	-	-	14.8

Key: *= $p<0.05$

4.2.2 RESULTS OF THE UNIVARIABLE LOGISTIC REGRESSION ANALYSIS – FACTORS ASSOCIATED WITH HYPERTENSION

As shown in Table 4.12, the odds of having hypertension were significantly higher among men compared to women in Albania and Uzbekistan, whereas the odds of having hypertension were significantly higher among women compared to men in Armenia, Egypt and Senegal.

In all ten countries, the odds of having hypertension were highest among respondents 45 years of age and above, compared to respondents who were progressively younger.

The odds of hypertension were highest among respondents with the highest levels of educational attainment in Uzbekistan and Lesotho, whereas respondents with the highest levels of educational attainment had the lowest odds of hypertension in Egypt, Maldives and Senegal. Of note, the odds of hypertension in respondents with no education were highest in the Maldives.

Respondents living in urban areas across the Eastern European countries (Albania, Azerbaijan and Ukraine) had significantly lower odds of hypertension compared to respondents living in the rural areas. However, the odds of developing hypertension were significantly higher among respondents living in the urban areas compared to rural areas in the African countries (Egypt, Morocco, Lesotho and Senegal).

The odds of hypertension were significantly higher among current smokers compared to non-smokers in Albania, Azerbaijan and Ukraine, whereas respondents with hypertension in Senegal were significantly more likely to be non-smokers than smokers. Regarding alcohol consumption, the odds of hypertension were also higher among current drinkers compared to non-drinkers in countries with alcohol use data.

In the Eastern European countries (Albania, Armenia, Azerbaijan and Ukraine), the odds of developing hypertension were lowest among respondents in the highest wealth quintiles; whereas, in African countries (Egypt, Morocco, Lesotho, Senegal), the odds of hypertension were highest among respondents in the highest wealth quintiles. The odds of hypertension were significantly higher among employed respondents compared to unemployed respondents in all countries except Morocco, Lesotho and Maldives, where the associations between hypertension and employment status were not statistically significant.

Table 4.12: Unadjusted odds ratio & 95% Confidence Intervals of the risk of hypertension in all countries

	Eastern Europe					**North Africa**		**Sub-Saharan Africa**		**Indian Sub-Continent**
	Albania OR (95% CI)	**Armenia OR (95% CI)**	**Azerbaijan OR (95% CI)**	**Ukraine OR (95% CI)**	**Uzbekistan OR (95% CI)**	**Egypt OR (95% CI)**	**Morocco OR (95% CI)**	**Lesotho OR (95% CI)**	**Senegal OR (95% CI)**	**Maldives OR (95% CI)**
Prevalence (%)	22.7	17.2	12.3	17.3	9.8	15.7	5.4	12.5	7.2	7.6
Gender										
Female	1.00	1.00	1.00	1.00	1.00	1.00	-	1.00	1.00	1.00
Male	1.44 (1.28, 1.62)[*]	0.67 (0.46, 0.97)[*]	0.85 (0.74, 0.98)[*]	1.05 (0.93, 1.19)	1.24 (1.06, 1.45)[*]	0.74 (0.67, 0.82)[*]	-	1.09 (0.97, 1.23)	0.17 (0.14, 0.22)[*]	1.16 (0.96, 1.41)
Age group										
15-24	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
25-34	1.83 (1.51, 2.22)[*]	4.02 (2.29, 7.06)[*]	2.58 (2.08, 3.21)[*]	3.36 (2.63, 4.30)[*]	2.12 (1.64, 2.73)[*]	1.81 (1.53, 2.14)[*]	1.62 (1.11, 2.37)[*]	2.12 (1.80, 2.50)[*]	2.60 (2.23, 3.02)[*]	1.61 (1.11, 2.32)[*]
35-44	3.66 (3.09, 4.33)[*]	10.4 (6.02, 17.88)[*]	5.48 (4.51, 6.67)[*]	9.52 (7.56, 12.00)[*]	5.07 (4.02, 6.41)[*]	3.36 (2.86, 3.94)[*]	1.68 (1.12, 2.52)[*]	4.16 (3.53, 4.89)[*]	4.27 (3.67, 4.97)[*]	4.15 (2.93, 5.88)[*]
45-54	5.19 (4.30, 6.25)[*]	25.86 (14.93, 44.79)[*]	8.76 (7.12, 10.78)[*]	18.17 (14.31, 23.05)[*]	9.76 (7.57, 12.57)[*]	6.41 (5.47, 7.53)[*]	3.32 (1.74, 6.35)[*]	6.09 (5.07, 7.31)[*]	4.91 (4.08, 5.91)[*]	9.19 (6.44, 13.12)[*]
≥55	-	-	17.32 (11.25, 26.69)[*]	-	11.38 (6.25, 20.71)[*]	10.46 (8.60, 12.72)[*]	-	8.80 (6.26, 12.35)[*]	2.92 (1.84, 4.65)[*]	17.35 (10.98, 27.41)[*]
Education										
No Education	1.00	-	1.00	1.00	-	1.00	1.00	1.00	1.00	1.00
Primary	2.23 (0.77, 6.46)	1.00	0.78 (0.35, 1.72)	0.20 (0.17, 2.39)	1.00	0.90 (0.78, 1.04)	1.11 (0.79, 1.54)	1.11 (0.85, 1.44)	0.91 (0.80, 1.03)	0.43 (0.36, 0.52)[*]
Secondary	1.64 (0.57, 4.75)	1.81 (0.98, 3.33)	1.17 (0.67, 2.05)	0.22 (0.30, 1.54)	1.18 (0.97, 1.42)	0.49 (0.43, 0.55)[*]	1.09 (0.76, 1.55)	1.03 (0.80, 1.36)	0.49 (0.42, 0.58)[*]	0.22 (0.17, 0.28)[*]
Higher	0.80 (0.27, 2.36)	1.38 (0.76, 2.52)	0.89 (0.50, 1.60)	0.20 (0.28, 1.44)	1.52 (1.24, 1.87)[*]	0.57 (0.48, 0.67)[*]	1.37 (0.75, 2.52)	2.02 (1.46, 2.80)[*]	0.47 (0.26, 0.86)[*]	0.22 (0.19, 0.43)[*]
Place of residence										
Rural	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Urban	0.64 (0.57, 0.71)[*]	0.84 (0.65, 1.08)	0.89 (0.80, 1.00)[*]	0.79 (0.71, 0.89)[*]	0.98 (0.84, 1.14)	1.18 (1.07, 1.30)[*]	1.31 (1.02, 1.69)[*]	1.29 (1.14, 1.46)[*]	1.42 (1.28, 1.58)[*]	1.19 (0.96, 1.47)
Currently smoking										
No	1.00	1.00	1.00	1.00	1.00	1.00	-	1.00	1.00	1.00
Yes	1.74 (1.52, 1.98)[*]	0.97 (0.64, 1.49)	1.31 (1.02, 1.68)[*]	1.19 (1.05, 1.34)[*]	1.04 (0.73, 1.49)	1.01 (0.89, 1.16)	-	1.12 (0.93, 1.34)	0.21 (0.12, 0.36)[*]	1.13 (0.88, 1.45)
Wealth quintile										
Lowest	1.00	1.00	1.00	1.00	-	1.00	1.00	1.00	1.00	1.00
Second	0.77 (0.64, 0.93)[*]	0.69 (0.48, 1.01)	1.03 (0.87, 1.23)	0.92 (0.78, 1.09)	-	1.08 (0.93, 1.27)	1.05 (0.72, 1.53)	1.06 (0.87, 1.29)	1.36 (1.15, 1.62)[*]	0.98 (0.78, 1.23)
Middle	0.81 (0.68, 0.98)[*]	0.58 (0.39, 0.85)[*]	1.07 (0.90, 1.26)	0.89 (0.75, 1.07)	-	1.11 (0.94, 1.30)	1.24 (0.85, 1.81)	1.31 (1.08, 1.59)[*]	1.64 (1.39, 1.94)[*]	0.97 (0.77, 1.22)
Fourth	0.72 (0.61, 0.86)[*]	0.65 (0.45, 0.95)[*]	0.96 (0.80, 1.14)	0.79 (0.65, 0.95)[*]	-	1.09 (0.92, 1.28)	0.94 (0.60, 1.45)	1.42 (1.18, 1.71)[*]	2.10 (1.77, 2.49)[*]	0.85 (0.65, 1.12)
Highest	0.43 (0.36, 0.52)[*]	0.62 (0.41, 0.93)[*]	0.69 (0.57, 0.85)[*]	0.72 (0.60, 0.86)[*]	-	1.26 (1.08, 1.47)[*]	1.52 (1.03, 2.24)[*]	1.64 (1.37, 1.97)[*]	1.72 (1.42, 2.07)[*]	1.09 (0.81, 1.47)
Marital status										
Never married or living alone	1.00	1.00	1.00	1.00	-	1.00	1.00	1.00	1.00	1.00
Married or living together	2.55 (2.23, 2.92)[*]	2.74 (1.96, 3.86)[*]	2.41 (2.10, 2.77)[*]	1.74 (1.55, 1.94)[*]	-	2.08 (1.85, 2.34)[*]	0.47 (0.25, 0.87)[*]	1.70 (1.52, 1.92)[*]	3.19 (2.78, 3.67)[*]	0.73 (0.56, 0.97)[*]
Currently working										
No	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Yes	1.57 (1.39, 1.76)[*]	1.39 (1.08, 1.78)[*]	1.16 (1.02, 1.31)[*]	1.81 (1.59, 2.07)[*]	1.35 (1.16, 1.57)[*]	1.67 (1.20, 2.33)[*]	1.29 (0.92, 1.80)	1.72 (1.53, 1.93)[*]	1.20 (1.08, 1.33)[*]	1.13 (0.96, 1.32)
Diabetes										
Non diabetic	-	1.00	1.00	-	-	1.00	-	1.00	1.00	1.00
Diabetic	-	4.18 (2.37, 7.36)[*]	5.18 (3.51, 7.67)[*]	-	-	7.65 (6.21, 9.42)[*]	-	3.92 (2.88, 5.33)[*]	3.39 (1.95, 5.90)[*]	7.36 (5.67, 9.56)[*]
Heart disease										
No	1.00	-	1.00	-	-	1.00	-	-	1.00	1.00
Yes	1.07 (0.95, 1.21)	-	1.66 (1.26, 2.19)[*]	-	-	7.82 (5.22, 11.70)[*]	-	-	1.44 (0.83, 2.51)	3.16 (2.24, 4.46)[*]
Stroke										
No	1.00	-	1.00	-	-	1.00	-	-	-	1.00
Yes	0.87 (0.72, 1.04)	-	0.97 (0.49, 1.92)	-	-	3.86 (2.35, 6.34)[*]	-	-	-	2.22 (1.45, 3.39)[a]

Key: *=*p*<0.05

4.2.2.1 INTERACTION BETWEEN AGE AND GENDER IN PREDICTING HYPERTENSION RISK

Age and gender remain among the more robust factors in explaining differences in cardiovascular disease and mortality (Sacco et al., 1997; Möller-Leimkühler, 2007). The potential interaction between age and gender was considered in predicting hypertension risk for each selected country, with the exception of Morocco which had data for women only.

As expected, the risk of hypertension increased with increasing age in a non-linear pattern in all the countries (Figures 4.7 – 4.15).

In Albania, the risk of developing hypertension was higher in men compared to women across all age groups (Figure 4.7). However, in Azerbaijan (Figure 4.9), Egypt (Figure 4.10), Maldives (Figure 4.12) and Senegal (Figure 4.13), the probability of developing hypertension was higher among women and across all age groups.

In Armenia (Figure 4.8), Lesotho (Figure 4.11), Ukraine (Figure 4.14), and Uzbekistan (Figure 4.16) the trends were similar in both men and women.

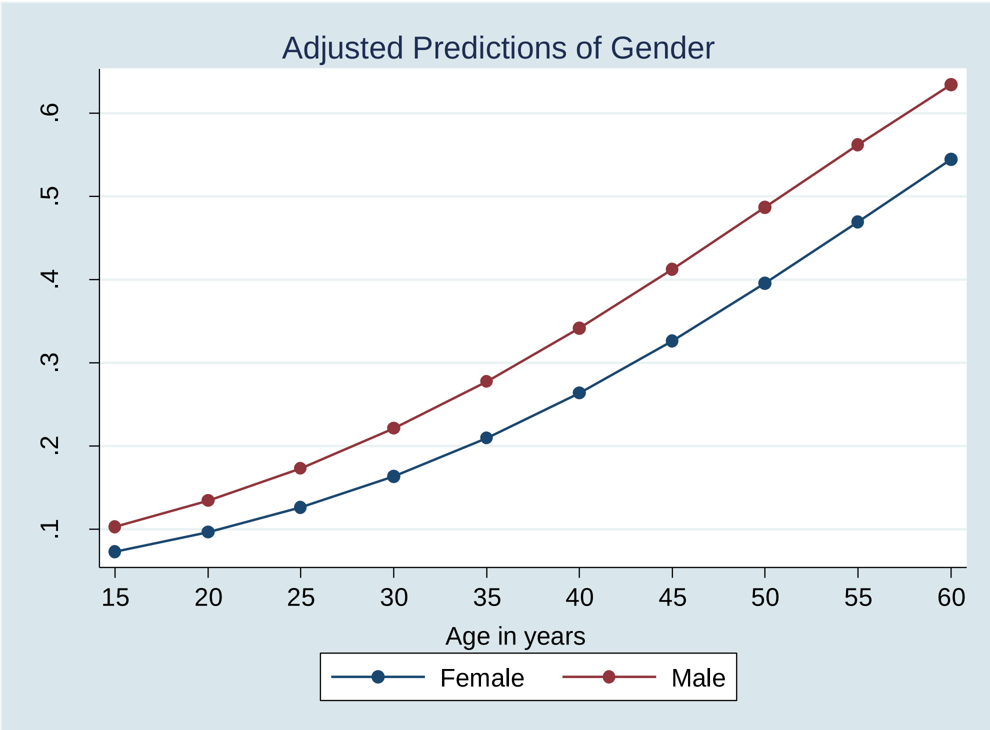


Figure 4.7: Interaction between age and gender predicting the risk of hypertension in Albania

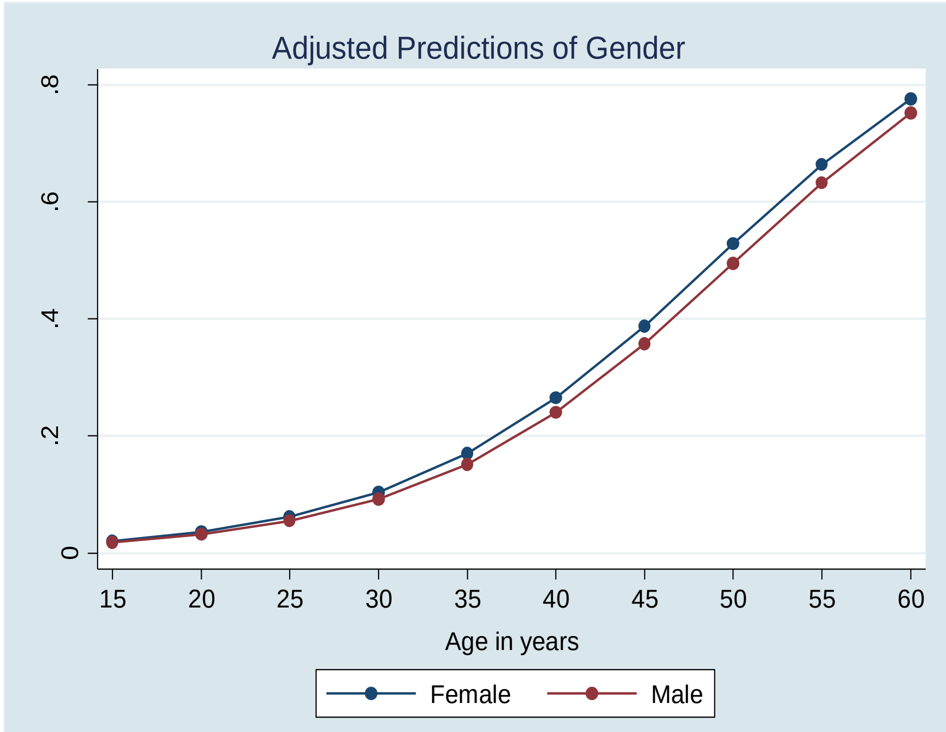
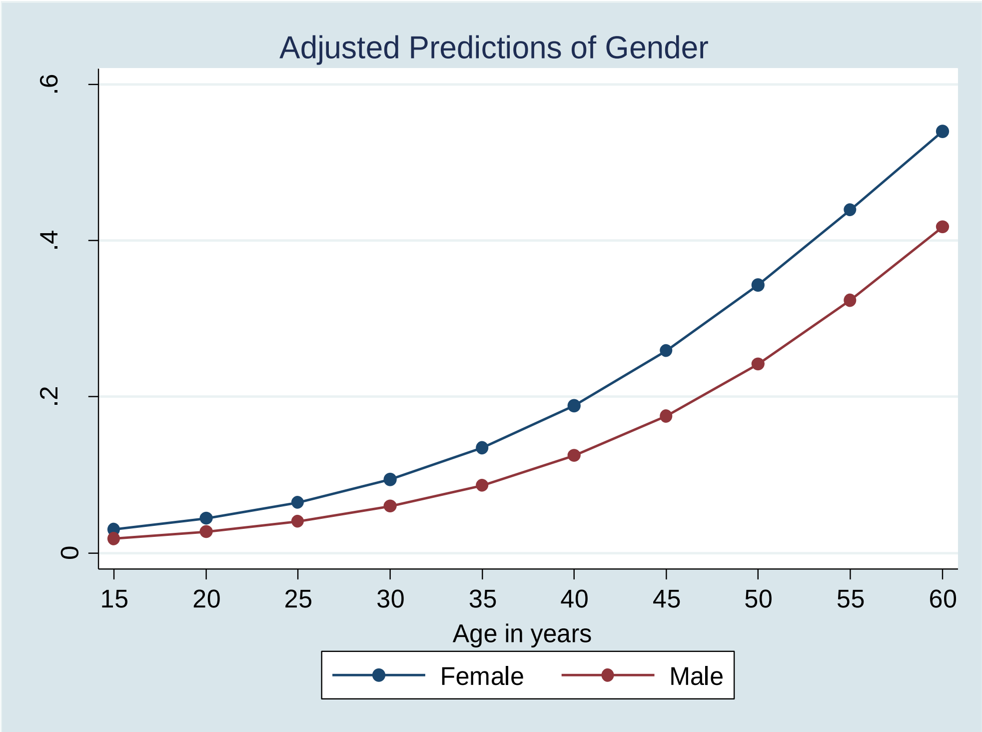


Figure 4.8: Interaction between age and gender predicting the risk of hypertension in Armenia



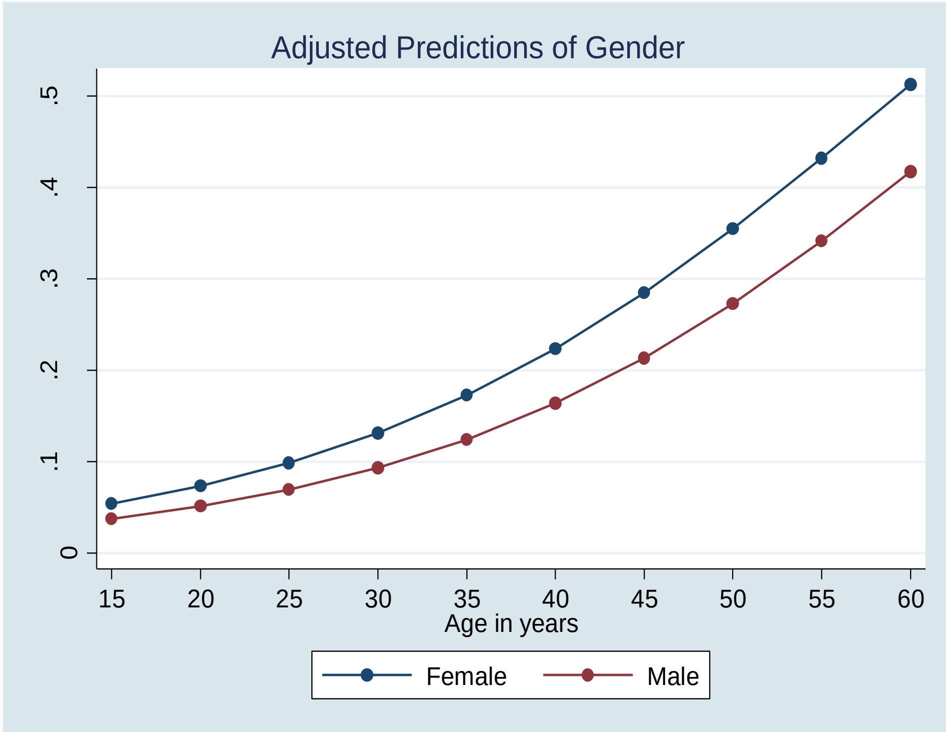


Figure 4.9: Interaction between age and gender predicting the risk of hypertension in Azerbaijan

Figure 4.10: Interaction between age and gender predicting the risk of hypertension in Egypt

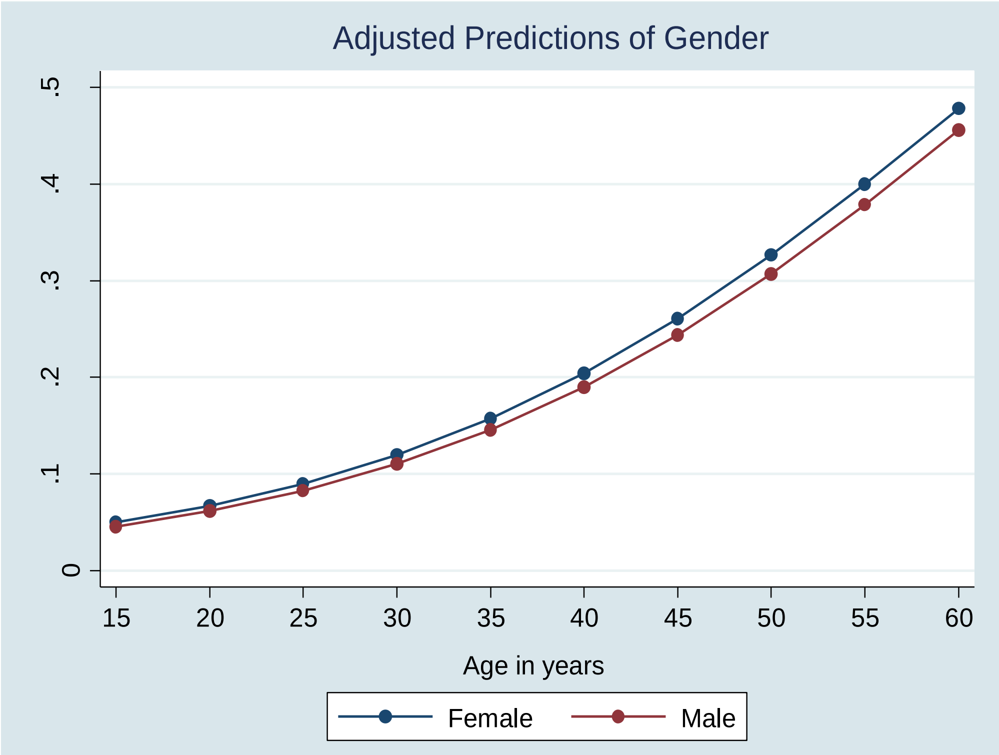


Figure 4.11: Interaction between age and gender predicting the risk of hypertension in Lesotho

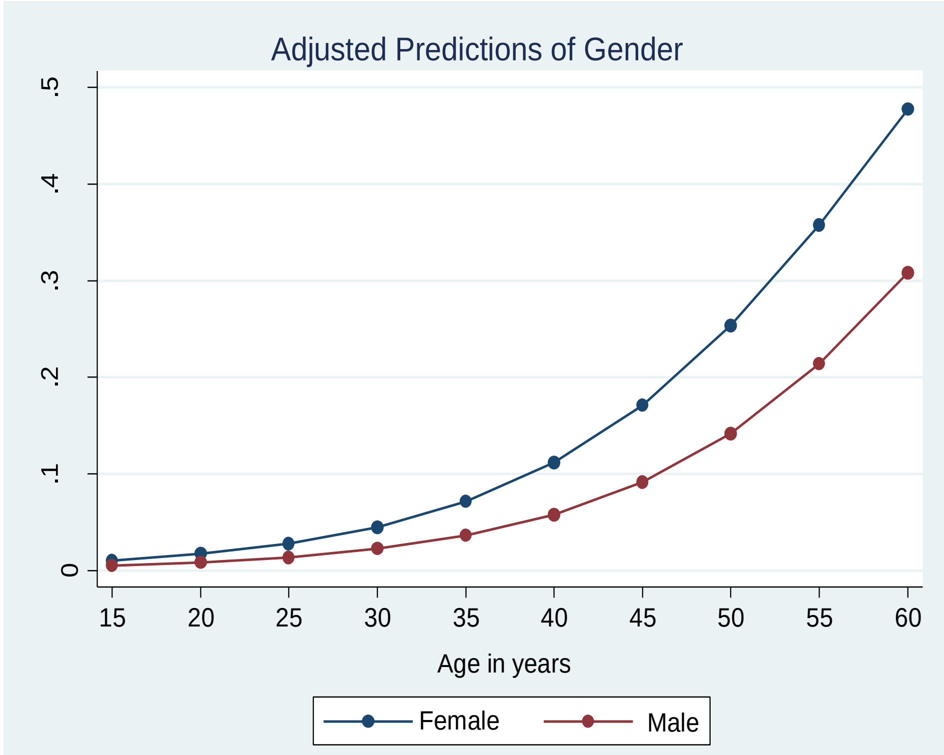
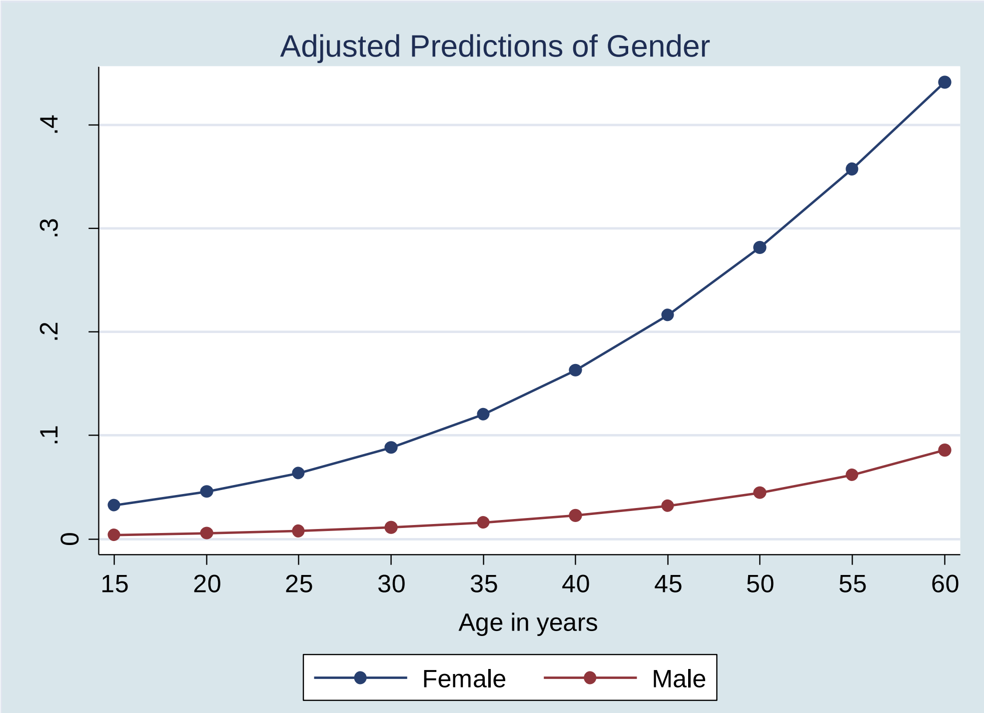


Figure 4.12: Interaction between age and gender predicting the risk of hypertension in Maldives



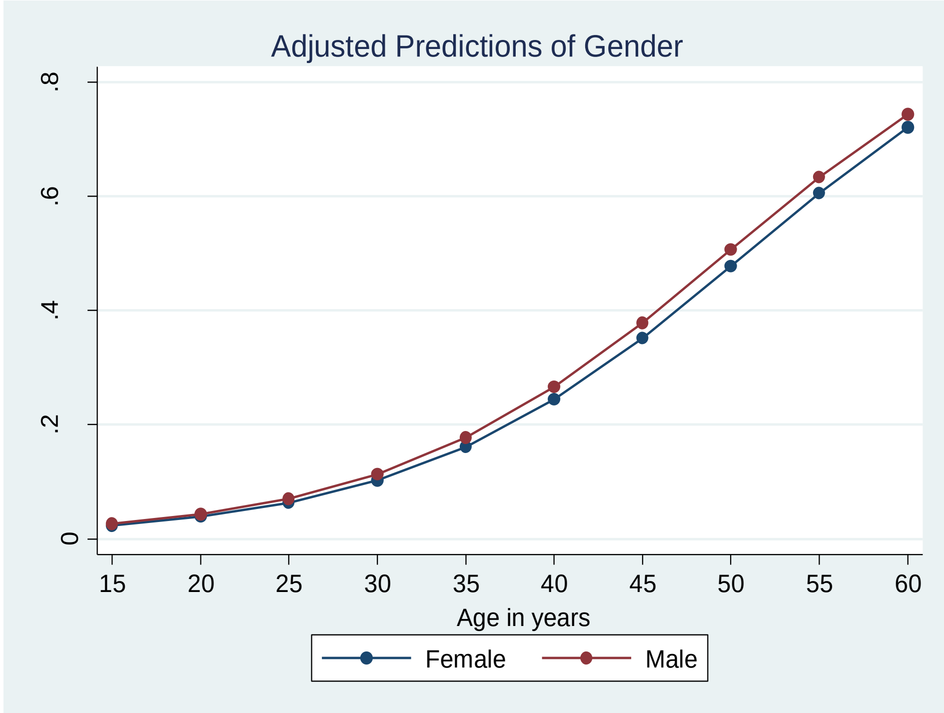


Figure 4.13: Interaction between age and gender predicting the risk of hypertension in Senegal

Figure 4.14: Interaction between age and gender predicting the risk of hypertension in Ukraine

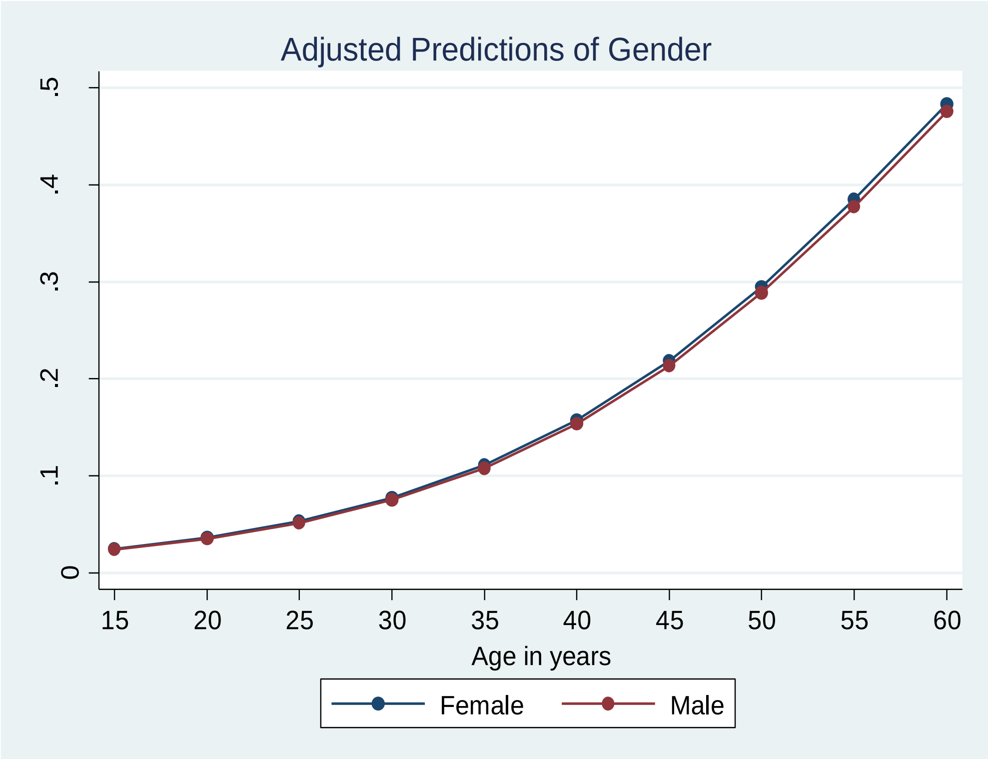


Figure 4.15: Interaction between age and gender predicting the risk of hypertension in Uzbekistan

4.2.3 RESULTS OF THE MULTIVARIABLE LOGISTIC REGRESSION ANALYSIS

As shown in Table 4.13 After adjusting for multiple confounders, the odds of developing hypertension were higher among men in Albania and Uzbekistan compared to women. The odds of hypertension were lower among men compared to women in Armenia, Egypt, and Senegal.

In all 10 countries, the odds of hypertension remained the highest in respondents aged 45 years and above.

The odds of hypertension also remained the highest among respondents with the highest levels of educational attainment in Uzbekistan and Lesotho, and lowest among respondents with the highest levels of educational attainment in Egypt, Senegal and Maldives.

Respondents living in urban areas of Albania and Ukraine still had lower odds of developing hypertension compared to respondents living in rural areas, and the odds of developing hypertension remained higher among respondents living in urban areas of Azerbaijan, Egypt, Morocco, Lesotho, and Senegal.

Current smokers living in Albania and Ukraine had higher odds of developing compared to non-smokers. However, the odds were higher in non-smokers compared to smokers in Azerbaijan and Senegal.

Respondents within the highest wealth Quintiles in Armenia had the lowest odds of developing hypertension, whereas respondents within the highest wealth quintiles in Lesotho had the highest odds of developing hypertension.

In the sub-Saharan African countries, the odds of developing hypertension remained higher among employed respondents compared to unemployed respondents.

Table 4.13: Covariate adjusted odds ratio & 95% Confidence Interval of the risk of hypertension in all countries

	Eastern Europe					North Africa		Sub-Saharan Africa		Indian Sub-Continent
	Albania OR (95% CI)	**Armenia OR (95% CI)**	**Azerbaijan OR (95% CI)**	**Ukraine OR (95% CI)**	**Uzbekistan OR (95% CI)**	**Egypt OR (95% CI)**	**Morocco OR (95% CI)**	**Lesotho OR (95% CI)**	**Senegal OR (95% CI)**	**Maldives OR (95% CI)**
Overall prevalence (%)	22.7	17.2	12.3	17.3	9.8	15.7	5.4	12.5	7.2	7.6
Overall Mean Age (SD)	31.7 (10.9)	31.2 (10.2)	31.7 (10.8)	32.4 (10.0)	29.9 (10.4)	32.4 (12.5)	29.6 (10.0)	28.5 (10.6)	28.3 (10.1)	33.9 (9.3)
Gender										
Female	1.00	1.00	-	-	1.00	1.00	-	-	1.00	-
Male	1.33 (1.13, 1.57)*	0.91 (0.60, 1.39)	-	-	1.10 (0.91, 1.33)	0.70 (0.54, 0.91)*	-	-	0.13 (0.10, 0.17)*	-
Age group										
15-24	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
25-34	2.01 (1.58, 2.57)*	3.68 (2.05, 6.62)*	-	3.49 (2.68, 4.54)*	2.14 (1.65, 2.78)*	1.68 (1.31, 2.14)*	1.60 (1.10, 2.33)*	1.84 (1.53, 2.22)[a]	1.93 (1.64, 2.28)*	1.34 (0.90, 1.98)
35-44	3.92 (3.05, 5.06)*	9.35 (5.26, 16.61)*	-	9.97 (7.75, 12.83)*	5.19 (4.07, 6.63)*	3.14 (2.44, 4.05)*	1.63 (1.08, 2.45)*	3.87 (3.20, 4.67)[a]	3.12 (2.63, 3.71)*	2.55 (1.69, 3.85)*
45-54	5.70 (4.35, 7.47)*	22.72 (12.72, 40.61)*	1.28 (0.84, 2.00)	19.08 (14.75, 24.67)*	9.90 (7.60, 12.90)*	5.67 (4.35, 7.40)*	3.20 (1.67, 6.14)*	5.85 (4.73, 7.22)[a]	4.62 (3.75, 5.71)*	5.13 (3.30, 7.97)*
≥55	-	-	2.91 (1.63, 5.21)*	-	11.37 (6.09, 21.21)*	11.27 (8.31, 15.29)*	-	9.48 (6.45, 13.94)[a]	12.85 (7.47, 22.12)*	9.22 (5.37, 15.82)*
Education										
No Education	-	-	-	-	-	1.00	-	1.00	1.00	1.00
Primary	-	-	-	-	1.00	1.11 (0.89, 1.39)	-	1.79 (1.31, 2.45)[a]	1.14 (0.99, 1.33)	0.80 (0.64, 1.00)*
Secondary	-	-	-	-	0.81 (0.60, 1.10)	0.99 (0.79, 1.22)	-	2.04 (1.46, 2.85)[a]	1.00 (0.82, 1.22)	0.60 (0.43, 0.83)*
Higher	-	-	-	-	1.18 (0.94, 1.48)	0.72 (0.50, 1.01)	-	2.45 (1.64, 3.66)[a]	0.58 (0.31, 1.10)	0.48 (0.24, 0.96)*
Place of residence										
Rural	1.00	-	1.00	1.00	-	1.00	1.00	1.00	1.00	-
Urban	0.80 (0.65, 0.98)*	-	2.03 (1.27, 3.26)*	0.86 (0.74, 1.00)*	-	1.29 (1.06, 1.58)*	1.30 (0.87, 1.93)	1.11 (0.88, 1.40)	1.41 (1.22, 1.62)*	-
Currently smoking										
No	1.00	-	1.00	1.00	-	-	-	-	1.00	-
Yes	1.22 (1.04, 1.38)*	-	0.90 (0.62, 1.31)	1.20 (1.05, 1.37)*	-	-	-	-	0.81 (0.45, 1.47)	-
Wealth quintile										
Lowest	1.00	1.00	1.00	1.00	-	1.00	1.00	1.00	1.00	-
Second	0.76 (0.62, 0.93)*	0.60 (0.40, 0.92)*	1.63 (0.86, 2.99)	0.95 (0.80, 1.14)	-	1.04 (0.82, 1.31)	1.00 (0.68, 1.47)	1.02 (0.82, 1.29)	1.21 (1.01, 1.45)*	-
Middle	0.84 (0.67, 1.04)	0.54 (0.36, 0.83)*	1.44 (0.77, 2.71)	0.96 (0.79, 1.17)	-	1.10 (0.86, 1.42)	1.06 (0.67, 1.68)	1.31 (1.04, 1.65)*	1.32 (1.09, 1.59)*	-
Fourth	0.91 (0.70, 1.18)	0.56 (0.37, 0.85)*	1.20 (0.60, 2.44)	0.88 (0.70, 1.11)	-	1.15 (0.86, 1.53)	0.72 (0.41, 1.28)	1.40 (1.11, 1.78)*	1.39 (1.12, 1.71)*	-
Highest	0.61 (0.46, 0.83)	0.58 (0.37, 0.91)*	0.97 (0.41, 2.32)	0.85 (0.67, 1.06)	-	1.07 (0.78, 1.48)	1.14 (0.66, 1.97)	1.34 (1.02, 1.76)*	1.05 (0.82, 1.34)	-
Marital status										
Never married or living alone	1.00	1.00	1.00	1.00	-	1.00	1.00	1.00	1.00	1.00
Married or living together	0.98 (0.80, 1.21)	1.46 (1.00, 2.15)*	0.88 (0.27, 2.88)	0.92 (0.81, 1.05)	-	1.57 (1.20, 2.05)	0.51 (0.28, 0.96)*	1.15 (1.01, 1.32)*	1.86 (1.58, 2.19)*	0.92 (0.68, 1.24)
Currently working										
No	1.00	1.00	1.00	1.00	1.00	1.00	-	1.00	1.00	-
Yes	1.01 (0.87, 1.16)	0.90 (0.68, 1.19)	0.70 (0.46, 1.08)	0.97 (0.83, 1.13)	0.92 (0.78, 1.09)	1.23 (0.79, 1.90)	-	1.22 (1.07, 1.39)*	1.25 (1.10, 1.40)[8]	-
Diabetes										
Non diabetic	-	1.00	1.00	-	-	1.00	-	1.00	1.00	1.00
Diabetic	-	2.38 (1.27, 4.45)*	2.89 (1.26, 6.62)	-	-	4.06 (2.96, 5.57)*	-	2.90 (2.08, 4.04)*	1.54 (0.86, 2.76)	5.03 (3.81, 6.64)*
Heart disease										
No	-	-	1.00	-	-	1.00	-	-	-	1.00
Yes	-	-	1.33 (0.72, 2.46)	-	-	3.47 (1.80, 6.68)*	-	-	-	2.45 (1.63, 3.69)*
Stroke										
No	-	-	-	-	-	1.00	-	-	-	1.00
Yes	-	-	-	-	-	2.08 (0.94, 4.62)*	-	-	-	1.16 (0.70, 1.93)

Key: *= $p<0.05$

4.2.4 RESULTS OF THE BAYESIAN ANALYSIS AND DISEASE MAPPING

The Bayesian analyses conducted in this study were limited to the countries with the highest prevalence of hypertension from each region (Albania, Egypt, and Lesotho). All the maps have been produced taking into account age and other covariates as potential confounders. Of note, unlike the other covariates included in the Bayesian model, the Bayesian analyses do not return the adjusted posterior OR for age, but instead return a graph of hypertension prevalence plotted against age (Figures 4.17, 4.20, and 4.23).

4.2.4.1 BAYESIAN ANALYSIS OF THE ALBANIA DATASET

Table 4.14 presents the posterior odds ratios of hypertension across selected study characteristics. As shown, after controlling for age (Figure 4.17) and other covariates in the Bayesian model, the odds of hypertension were higher among men compared to women. There was no significant association between higher educational level and hypertension, however, the odds of hypertension among respondents with primary education were higher compared to respondents with no education. Respondents in each of the upper four quintiles were less likely to have hypertension, compared to respondents in the lowest quintile. While there was no significant association between smoking status and hypertension, current drinkers were more likely to be hypertensive compared to non-drinkers.

In exploring the relationship between age and hypertension in the Albania dataset, Figure 4.20 shows a linear relationship between age and hypertension prevalence in the Albania study population. This finding is similar with the results of the multivariable logistic regression which also shows increasing odds of hypertension with progressively higher age groups.

Table 4.14: Posterior odds ratio & 95% Credible Interval of the likelihood of hypertension

	Posterior Odds Ratio (POR) (95% Credible Interval)
Gender	
Male	1.39 (1.20, 1.60)
Female	1.00
Education	
No Education	1.00
Primary	2.48 (1.95, 8.08)
Secondary	1.99 (0.77, 7.46)
Higher	1.20 (0.42, 4.44)
Wealth quintile	
Lowest	1.00
Second	0.77 (0.67, 0.93)
Middle	0.82 (0.68, 1.02)
Fourth	0.84 (0.70, 1.02)
Highest	0.62 (0.47, 0.82)
Smoking status	
Noncurrent smoker	1.00
Current smoker	1.14 (0.95, 1.34)
Drinking status	
Noncurrent drinker	1.00
Current drinker	1.21 (1.06, 1.38)
Stroke	
No	1.00
Yes	1.07 (0.85, 1.35)

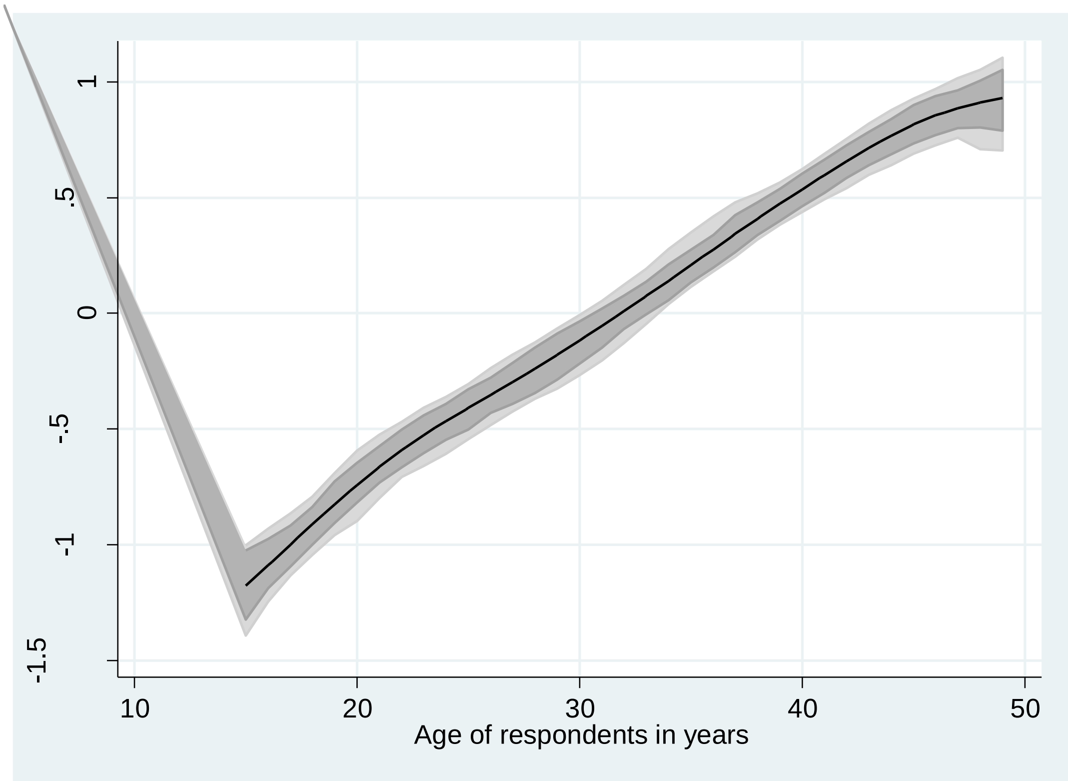


Figure 4.17: Logit effect of age. Shown are the posterior logit within the 95% and 80% pointwise credible intervals

Figure 4.18 is a map showing the map of Albania with its districts.

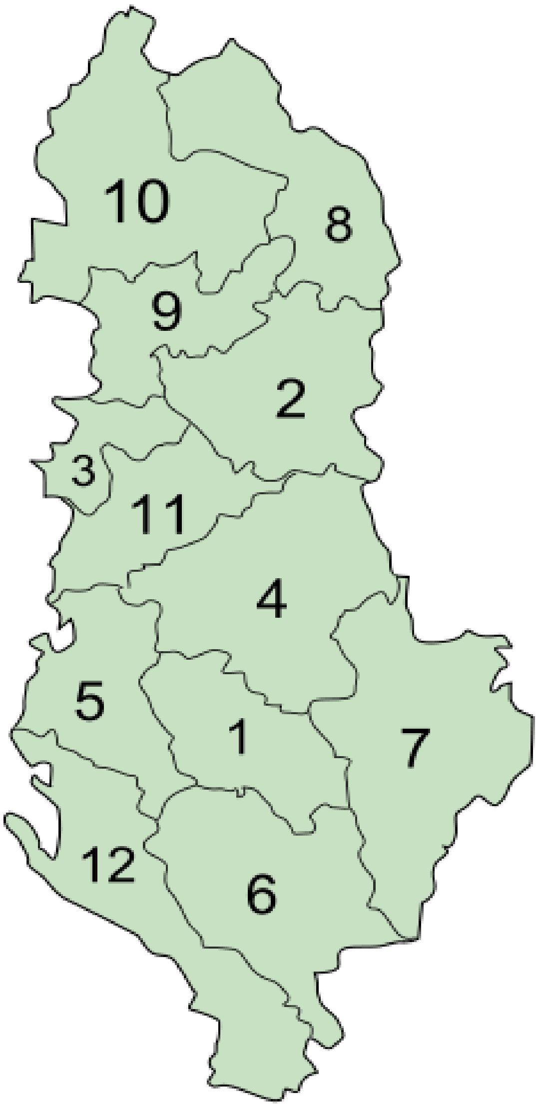
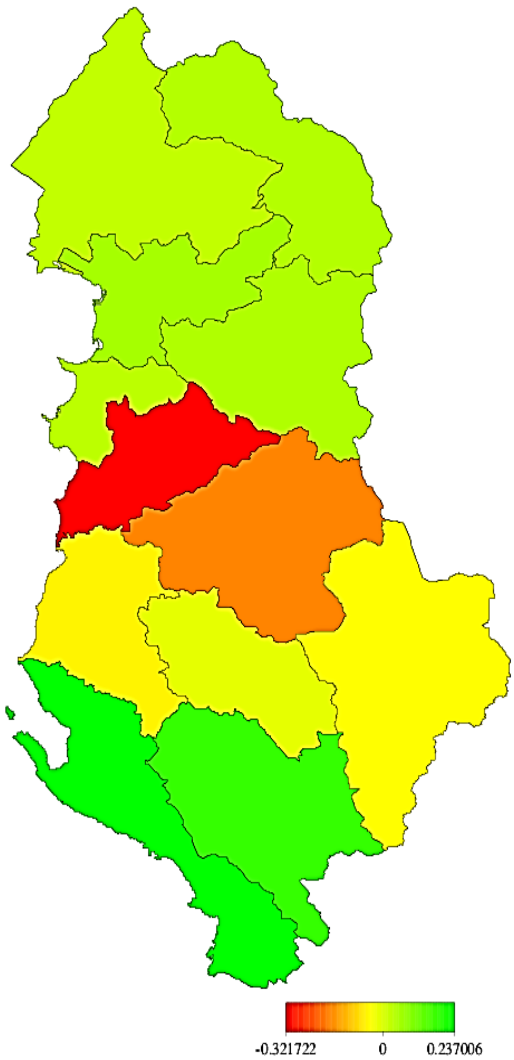


Figure 4.18: Map of Albania by districts. 1, Berat. 2, Diber. 3, Durres. 4, Elbasan. 5, Fier. 6, Gjirokaster. 7, Korce. 8, Kukes. 9, Lezhe. 10, Shkoder. 11, Tirana. 12, Vlore.

Figure 4.18 maps the prevalence of Albania across its 12 districts, where the districts with the highest and lowest prevalence of hypertension are denoted by colours red and green respectively. Hence, drawing on Figures 4.17 and 4.18, the district with the highest prevalence of hypertension in Albania is Tirana, whereas the districts with the lowest prevalence estimates of hypertension are Gjirokaster and Vlore. It is important to emphasize that age has been into account in producing this map.



Red = high risk; green = low risk.

Figure 4.19: Covariate-adjusted residual spatial effects of hypertension at county level in Albania

4.2.4.2 BAYESIAN ANALYSIS OF THE EGYPT DATASET

Table 4.15 presents the posterior odds ratios of hypertension across selected study characteristics. After controlling for age (Figure 4.20) and other covariates in the Bayesian model, the odds of developing hypertension were lower in men, compared to women. There was no significant association between educational status and hypertension. Only respondents in the fifth wealth quintile had higher odds of developing hypertension compared to respondents in the first quintile. Smoking was not significantly associated with hypertension.

Table 4.15: Posterior odds ratio & 95% Credible Interval of the likelihood of hypertension

	Posterior Odds Ratio (POR) (95% Credible Interval)
Gender	
Male	0.63 (0.55, 0.73)
Female	1.00
Education	
No Education	1.00
Primary	1.04 (0.88, 1.20)
Secondary	1.03 (0.79, 1.19)
Higher	0.98 (0.42, 4.44)
Wealth quintile	
Lowest	1.00
Second	1.16 (0.98, 1.38)
Middle	1.20 (0.99, 1.42)
Fourth	1.18 (0.99, 1.40)
Highest	1.28 (1.03, 1.57)
Smoking status	
Noncurrent smoker	1.00
Current smoker	1.17 (0.99, 1.36)
Stroke	
No	1.00
Yes	3.35 (1.77, 5.81)

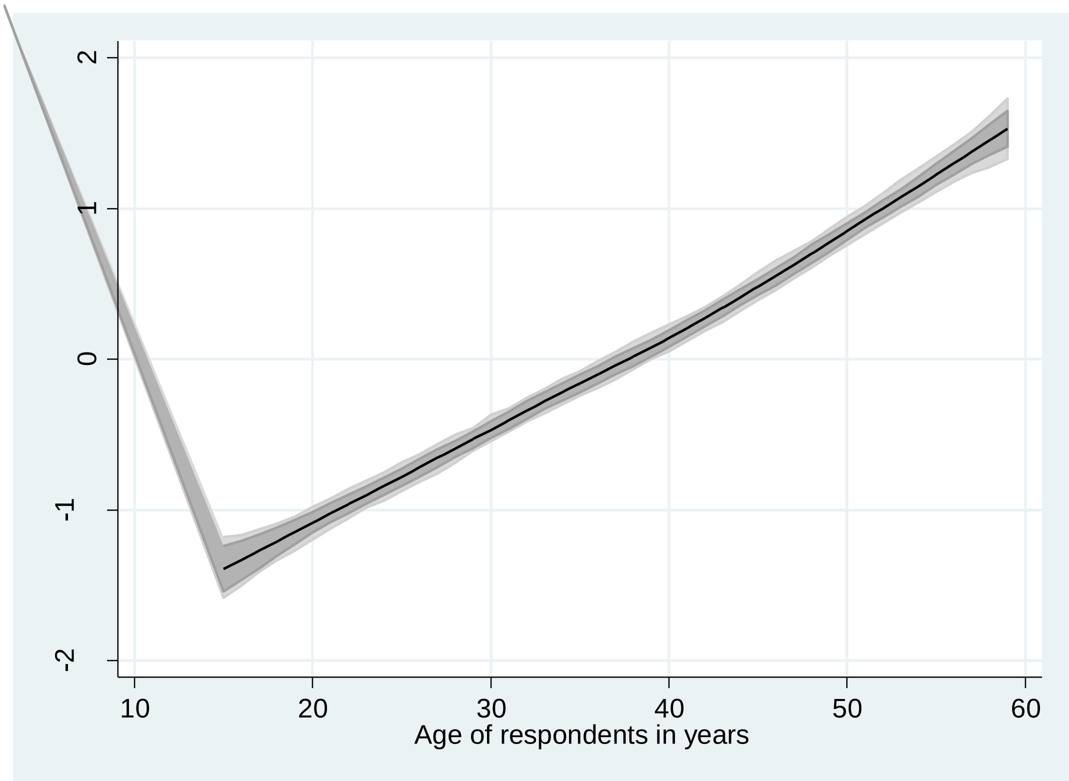


Figure 4.20: Logit effect of age. Shown are the posterior logit within the 95% and 80% pointwise credible intervals

Figure 4.21 is a map of Egypt with its districts.

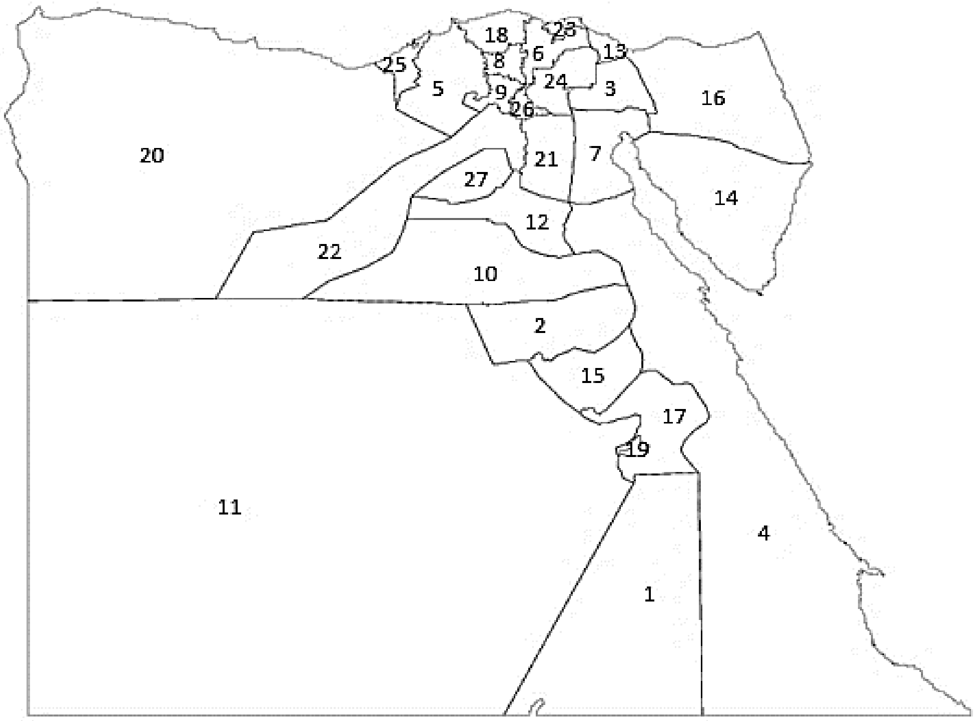
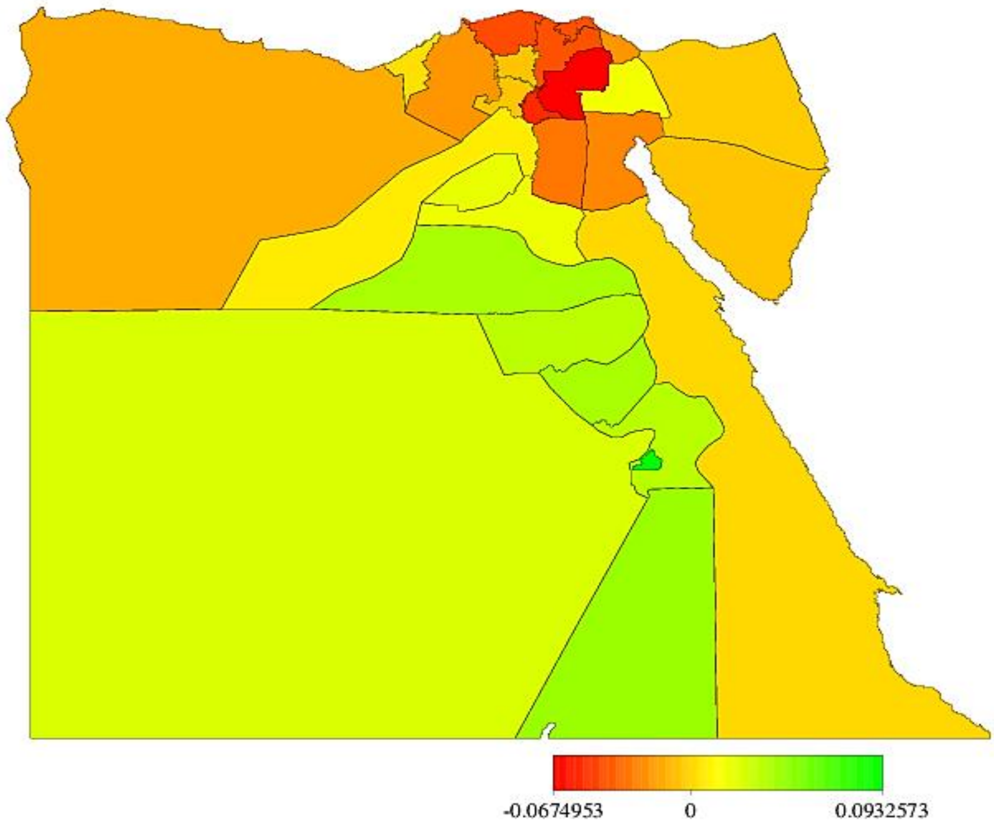


Figure 4.21: Map of Egypt by Districts. 1, Aswan. 2, Assiut. 3, Ismailia. 4, Red Sea. 5, Behera. 6, Dakahlia. 7, Suez. 8, Gharbia. 9, Menoufia. 10, Menya. 11, New Valley. 12, Beni Suef. 13, Port Said. 14, South Sainai. 15, Suhag. 16, North Sainai. 17, Qena. 18, Kafr-El-Sheikh. 19, Luxor. 20, Matrouh. 21, Cairo. 22, Giza. 23, Damietta. 24, Sharkia. 25, Alexandria. 26, Kalyoubia. 27, Fayoum.

Figure 4.22 is map of Egypt displaying variations in hypertension prevalence across its districts. As shown, the prevalence of hypertension is highest in Sharkia and Kalyoubia districts, and lowest in Aswan, Menya and Suhag districts. It is also important to reiterate that age was taken into account in producing this map.



Red = high risk; green = low risk

Figure 4.22: Covariate-adjusted residual spatial effects of hypertension at governorate level in Egypt

4.2.4.3 BAYESIAN ANALYSIS OF THE LESOTHO DATASET

Table 4.16 presents the posterior odds ratios of hypertension across selected study characteristics.

Table 4.16: Posterior odds ratio & 95% Credible Interval of the likelihood of hypertension

	Posterior Odds Ratio (POR) (95% Credible Interval)
Gender	
Male	1.10 (0.97, 1.25)
Female	1.00
Education	
No Education	1.00
Primary	1.75 (1.31, 2.25)
Secondary	2.03 (1.46, 2.69)
Higher	2.43 (1.79, 3.35)
Wealth quintile	
Lowest	1.00
Second	1.03 (0.84, 1.27)
Middle	1.28 (1.06, 1.53)
Fourth	1.38 (1.10, 1.73)
Highest	1.35 (1.12, 1.63)
Smoking status	
Noncurrent smoker	1.00
Current smoker	0.94 (0.75, 1.19)

After controlling for age (Figure 4.23) and other confounders, there was no significant association between gender (POR 1.10, 95% CI 0.97, 1.25) or smoking status (POR 0.94, 95% CI 0.75 to 1.19) with hypertension. However, the odds of developing hypertension were significantly higher for all levels of formal education, compared to no education. Respondents in the third, fourth and fifth quintiles had higher odds of hypertension, compared to respondents in the lowest quintile.

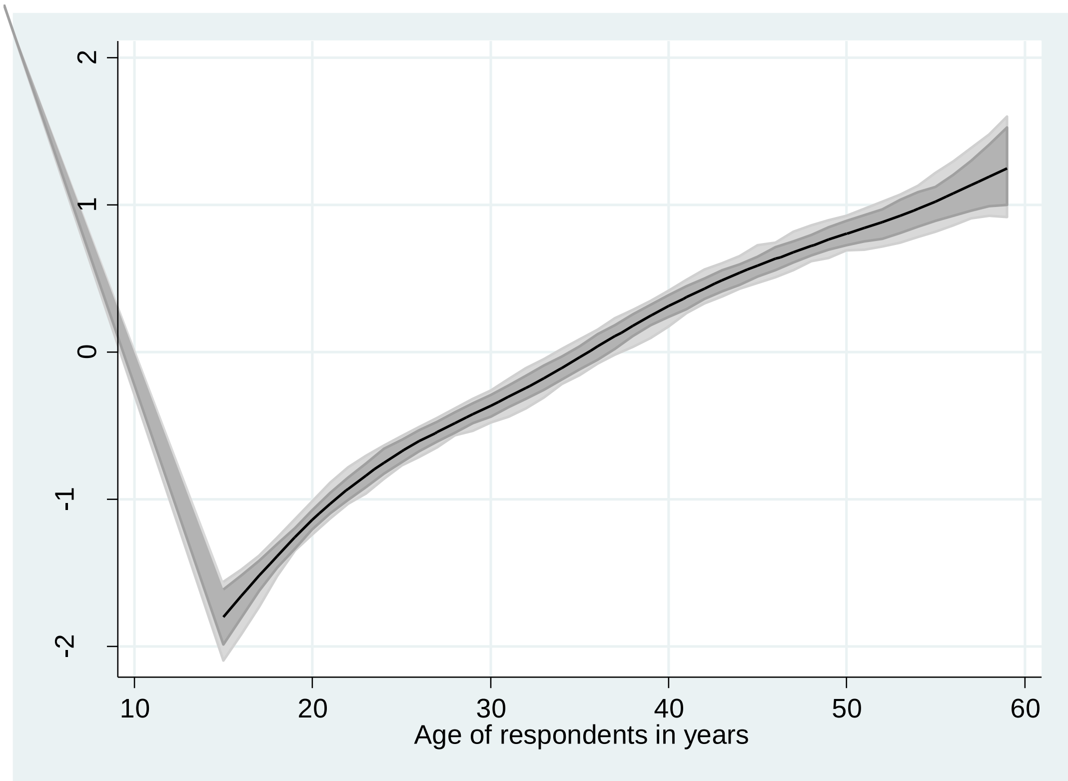
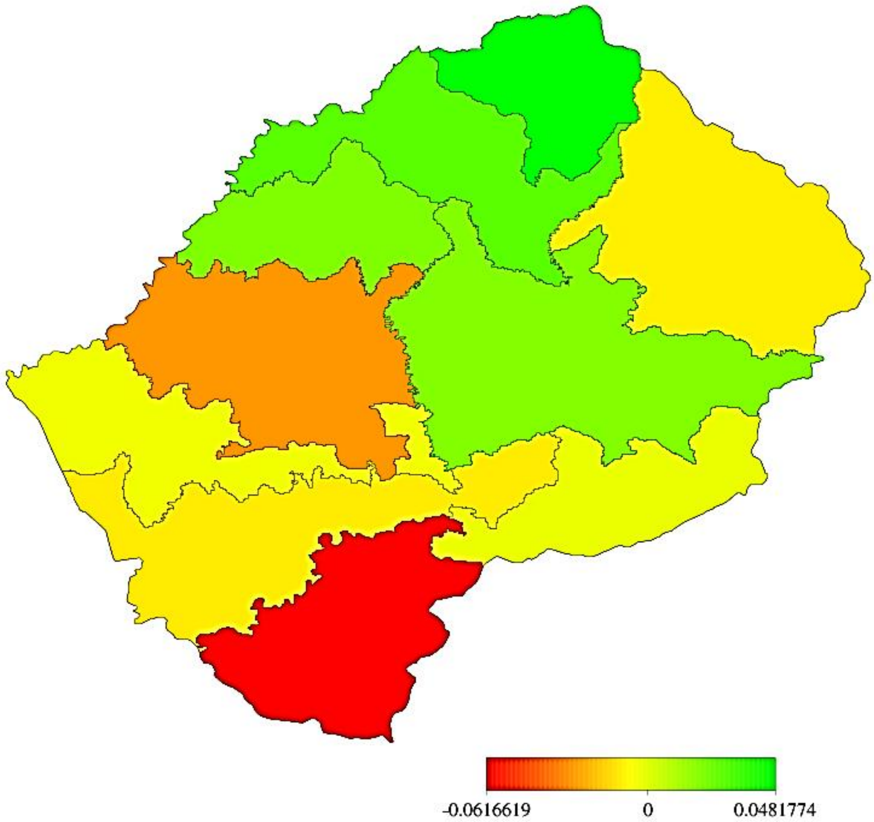


Figure 4.23: Logit effect of age. Shown are the posterior logit within the 95% and 80% pointwise credible intervals

Figure 4.24 is a map of Lesotho with its districts.

Figure 4.24: Map of Lesotho by districts. 1, Berea. 2, Butha-Buthe. 3, Leribe. 4, Mafeteng. 5, Maseru. 6, Mohale's Hoek. 7, Mokhotlong. 8, Qacha's Nek. 9, Quthing. 10, Thaba-Tseka.

Figure 4.26 is map of Lesotho displaying variations in hypertension prevalence across its districts. As shown, the prevalence of hypertension is highest in Quthing and Maseru districts, and lowest in Butha-Buthe. It is also important to reiterate that age was taken into account in producing this map.



Red = high risk; green = low risk.

Figure 4.25: Total residual spatial effects of hypertension at district level in Lesotho

The Bayesian framework is a robust technique compared to logistic regression modelling and this is why the posterior odds ratios of the Bayesian analysis differ from the odds ratios of the logistic regression analysis. The Bayesian analysis takes into account the complex nature of the datasets as well as any unobserved spatial factors.

4.3 KEY FINDINGS FROM THE RESULTS

The overall prevalence estimate of hypertension, as observed from the systematic review and meta-analysis, was 32.3%, with wide variations between countries ranging from 2.5% in rural India (Samuel *et al*., 2012) to 79.5% in Venezuela (Prince *et al*., 2012). In contrast, the overall prevalence of hypertension across the selected ten countries in the secondary data analysis was 12.5%, with prevalence estimates ranging from 5% in Morocco to 23% in Albania. However, findings from the secondary data analysis comprising ten countries may be less representative of low- and middle-income countries, compared to findings from the systematic review and meta-analysis comprising 45 countries. Nonetheless, Prince *et al*. (2012) from the systematic review included only participants who were aged 65 years and above, which could have explained the extremely high prevalence of hypertension in their study.

The results of the systematic review and meta-analysis suggest that hypertension prevalence is highest in the Latin America and Caribbean region. In contrast, findings from the secondary data analysis show that the prevalence of hypertension is highest in the Eastern European countries. However, it is worth emphasizing that countries in the Latin America and Caribbean region were not represented in the secondary data analysis because there were no datasets from countries in the region with data on hypertension prevalence.

Overall, men had a slightly higher prevalence of hypertension compared to women in the systematic review and meta-analysis (33.0% *vs* 31.2%); however, the difference was not statistically significant. In contrast, men had a significantly higher prevalence of hypertension in Albania and Uzbekistan, whereas hypertension prevalence was significantly higher in women compared to men in Armenia, Azerbaijan, Egypt and Senegal. Across the represented age groups in the secondary data analysis, hypertension prevalence was significantly higher in women compared to men in Azerbaijan and Senegal. The Morocco dataset included data from women only.

In the systematic review and secondary data analysis, hypertension prevalence was directly associated with increased age.

In the systematic review, prevalence of hypertension was significantly higher in participants with no education, compared to those with some form of formal education in most regions and overall. Similarly, the results of the secondary data analysis revealed an inverse association between educational attainment and hypertension prevalence in at least one country in each region.

The findings were also consistent between the systematic review and secondary data analysis regarding the association between hypertension prevalence and the place of residence. For instance, the systematic review revealed a higher prevalence of hypertension among people who lived in urban areas compared to those who lived in rural areas in all regions except in Eastern Europe, where the reverse was the case. Similarly, the results of the secondary data analysis showed higher prevalence of hypertension in the rural areas in Eastern European countries, whereas hypertension prevalence was higher in urban areas in the other selected countries representing other regions. These findings were not unexpected given that Eastern Europe is likely to be further along than other regions in the Epidemiological transition, and this is accompanied by changes in health patterns, where residents of urban areas now adopt healthier lifestyles than previously known.

The results of the systematic review were somewhat contradictory to the secondary data analysis regarding the association between smoking status and hypertension. The systematic review revealed that hypertension prevalence was significantly higher among non-smokers compared to smokers in all regions except Asia. In the secondary data analysis, hypertension prevalence was only higher among non-smokers, compared to smokers, in Senegal. In most of the European countries in the secondary data analysis, hypertension prevalence was higher among smokers compared to non-smokers. The reasons for the difference in the associations between smoking and hypertension between the systematic review and secondary data analysis are speculative at this point, and may only reside in characteristic differences between the study populations.

The findings from mapping the distribution of hypertension in Albania show that Tirana and Elbasan have a higher burden of hypertension compared to other districts. In Egypt, Sharkia and Kalyoubia have a higher burden of hypertension compared to other districts. In Lesotho, the burden of hypertension was highest in Quthing and Maseru and lowest in Butha-Buthe.

CHAPTER FIVE: DISCUSSION

In this chapter, the results of the systematic review and secondary data analysis are interpreted in the light of known confounders and compared against previous evidence. The policy/practice and research implications of the findings are also discussed in this chapter.

5.1 INTERPRETING THE FINDINGS

5.1.1 INTERPRETATION OF THE FINDINGS OF THE SYSTEMATIC REVIEW AND META-ANALYSIS

The findings suggest that hypertension represents an important public health problem in LMICs, with one in three persons affected by the disease. Expectedly, the findings also suggest that older age and increased body weight are consistent predictors of hypertension across LMICs, irrespective of the different geographical regions. These results are consistent with the role of ageing and body fat changes in the progressive impairment of endothelial function (Seals *et al.*, 2011). In addition, the significant direct association between mean age and hypertension prevalence found in the meta-regression analysis, may also explain the unusually high prevalence estimates of hypertension (> 70%) observed in a few of the included studies (Thuy *et al,* 2010; Ha *et al.,* 2013; Kiau *et al.,* 2013), given that the sampled population in these studies comprised mostly of the elderly.

Hypertension rates were more likely to be higher in upper-middle income countries than in lower-middle income countries, and the latter more likely to be higher compared to low-income countries. This finding supports the hypothesis that a temporal relationship may exist between increasing levels of affluence and urbanization and raised blood pressure. The graded rise in hypertension rates across country income groups may be characteristic of the epidemiological transition within urban societies in resource-limited settings (Meshram *et al.,* 2012; Samuel *et al.,* 2012). The higher prevalence of hypertension in urban settings compared to rural settings, as shown in the present review, are also in accordance with this hypothesis.

Hypertension prevalence was higher among uneducated and unemployed people, compared to their educated and employed counterparts, which suggest that hypertension may be associated with socio-economic inequalities in LMICs. Evidence of health inequalities associated with hypertension in LMICs are not uncommon (Gupta *et al.*, 2012; Jeemon *et al.,* 2012).

Although there was no significant gender difference in hypertension prevalence overall, the slightly higher prevalence observed among men is coherent with the male predilection for cardiovascular problems in the middle age, which attenuates in older adults as exemplified by an increased risk of cardiovascular diseases among post-menopausal women (Gupta *et al.*, 2012; Jeemon *et al.,* 2012).

The higher proportions of hypertension among non-smokers compared to smokers in most regions and overall may be attributed to smokers erroneously self-reporting their smoking status as non-smokers in some of the included studies. While this argument may account for the higher prevalence of hypertension among non-drinkers, compared to drinkers, in the sub-Saharan Africa region, it is also important to emphasize that non-smokers and non-drinkers alike may engage in other harmful behaviours known to increase the risk of hypertension. Obviously, the potential of reverse causation in cross-sectional studies cannot be ruled out, as it is possible that both non-smokers and non-drinkers may have quit these harmful behaviours due to other underlying medical conditions (Gupta *et al.*, 2013). However, it is important to state that never smokers and never drinkers could not be separated from former smokers and former drinkers in the majority of the included studies.

5.1.2 INTERPRETATION OF THE SECONDARY DATA ANALYSIS FINDINGS

There were differences in the prevalence of hypertension between the countries included in the secondary analysis. Generally, countries in Eastern Europe had higher estimates of hypertension prevalence compared to other countries. This variation may be explained by the fact that Eastern European countries are in the third stage of epidemiological transition, which is the age of degenerative and man-made diseases, where cardiovascular diseases are more prevalent, compared to the other countries in the secondary analysis which are in the first and second stages (Yusuf *et al.* 2001; Kreatsoulas & Anand, 2010).

There were also between-country differences in the determinants of hypertension, which may explain the variations in hypertension prevalence. For instance, smoking rates were as high as 67% across the Eastern European countries, and only 17% across the other countries represented in the secondary analysis. However, variations in other factors, such as social trust, trust in government and violence, may be just as likely to explain the differences in hypertension prevalence between the selected countries. For instance, Albania had the highest prevalence of the hypertension (22.7%) in the analysis and ranks much lower than Morocco (5.4% prevalence) in the World Happiness Report score, which is a development indicator and measures the perceived trust of a people in government, among other indicators of happiness and well-being (Sachs *et al.*, 2016).

Another possible explanation of the lowest proportion of hypertension in Morocco is religion. Moroccans consider themselves to be religious (El Majhad, 2015), and being a predominantly Muslim country, societal factors intertwined with religion might play a significant role in explaining the low prevalence of hypertension in this country. For instance, Moroccans are likely to abide by the doctrines of Islam, which encourage abstinence from alcohol, smoking, and other lifestyle habits that are predisposing factors of hypertension. In addition, only women were represented in the Morocco dataset, and women are less likely to engage in lifestyle practices that are risk factors for hypertension.

Hypertension prevalence was higher in men compared to women in Albania, Ukraine, Uzbekistan, Lesotho and Maldives; whereas hypertension prevalence was higher in women compared to men in Armenia, Azerbaijan, Egypt, and Senegal. While the higher prevalence of hypertension in men compared to women might be expected, given the penchant for high-risk behaviour among the former, the reverse may be somewhat unexpected. The high prevalence of cardiovascular disorders in post-menopausal women may not account for the higher prevalence of hypertension in women than in men, given that respondents aged 55 years and above were grossly underrepresented in the secondary data analysis. Nonetheless, it is interesting to note that the resident populations of these four countries (Armenia, Azerbaijan, Egypt, and Senegal) largely religious, so that issues relating to social and religious patriarchy are common and may be at play. For instance, prioritizing the rights of men over women in the family restricts the freedom of women to get an education and participate in the decision-making process in the family and the society, which may potentially bring about social exclusion, emotional distress from being subject to domestic and other forms of violence, and eventually, high blood pressure (Joseph, 1996; Brosschot *et al.* 2005). This interpretation of the findings is consistent with the association between the lack of education and hypertension observed in the results.

The stratification of hypertension prevalence by age and according to the different socio-economic characteristics revealed that hypertension prevalence was lower (or at least somewhat comparable) in each country for patients between 15 and 34 years of age compared to the overall estimates, whereas prevalence estimates were higher in each country for patients over 34 years of age compared to the overall estimates. These findings are coherent with age as a consistent correlate of hypertension in low- and middle-income countries. It is also important to reiterate that hypertension prevalence was higher among progressively older age groups, and this finding was consistent across all countries except Senegal, where prevalence of hypertension in respondents aged 55 years and above was lower than prevalence estimates obtained for respondents aged between 35 and 54 years. However, the number of respondents aged 55 years and above were markedly smaller (n=237) than the numbers of respondents in younger age groups. This small sample size may explain the low prevalence of hypertension in this age group, which may not be generalizable to all adults aged 55 years and above in Senegal.

The observed higher prevalence of hypertension in respondents with no formal education compared to respondents with formal education in Ukraine, Egypt, Senegal, and Maldives were expected and are consistent with materialist explanations underpinning health inequalities associated with hypertension (Kreatsoulas & Anand, 2010). In contrast, the contradictory findings observed among respondents in Lesotho may be the reduced access to health care among the resident population of Lesotho, the majority of whom are literate (UNESCO Institute for Statistics Data Centre, 2007). For instance, with Lesotho spending more than 12% of its GDP on education, it is not surprising that about 85% of people aged 14 years and above are literate in the country (UNESCO Institute for Statistics Data Centre, 2007). However, access to medical care is limited by a number of factors, notably the low doctor to patient ratio: in 2013, there was one physician for every 20,000 patients in Lesotho (Doctors without Borders, 2007).

Similarly, regarding wealth, the higher prevalence of hypertension among people in the lowest wealth quintiles, compared to people in upper quintiles, was expected in countries in Eastern European, and is in line with the materialist explanations underlying health inequalities associated with hypertension. In countries in Africa, the higher prevalence of hypertension among people in the upper wealth quintiles compared to those in lower wealth quintiles is consistent with the nutritional and other lifestyle transition that come with affluence in these countries.

To reiterate, the higher prevalence of hypertension in the rural areas, compared to urban areas in Eastern European countries, and vice versa in the other selected countries representing other regions were not unexpected given that Eastern Europe is likely to be further along than other regions in the Epidemiological transition, and this is accompanied by changes in health patterns, where residents of urban areas now adopt healthier lifestyles than previously known (Levenson *et al.* 2002; Reddy, 2004; Marmot & Wilkinson, 2006; Joshi *et al.* 2008).

In contrast to other countries in the secondary data analysis, non-smokers had a higher prevalence of hypertension compared to smokers in Armenia, Uzbekistan, and Senegal. As with the systematic review, this may be attributed to smokers erroneously self-reporting their smoking status as non-smokers in these countries.

The higher prevalence of hypertension among employed respondents, compared to their unemployed counterparts in all countries in the Eastern European region, and in African countries, such as Senegal and Egypt, explain the nutritional and other lifestyle transition that comes with improved socio-economic position. It is also consistent with the psychosocial explanations underlying the aetiology of hypertension, such as job strain, which is a public health issue in these countries (Habibi et al., 2015). It is worthy to note that unemployment was not protective in the other selected countries.

Recall that Bayesian analysis was conducted to assess the spatial distribution of hypertension prevalence in Albania, Egypt and Lesotho — countries with the highest prevalence of hypertension in each of the represented regions. In Albania, the analyses revealed marked variations in hypertension prevalence across the 12 districts after controlling for age and other confounders. The observed variations showed a clear pattern where hypertension prevalence was much higher in districts located in the Central region of the country (Tirana and Elbasan), but lower in the districts farther away from the Central region. Interestingly, Tirana is the capital of Albania, and has the highest urban population in the country; the urban population accounts for 88% of the total district. Hence, it stands to reason why Tirana is the district with the highest prevalence of hypertension in Albania. Although the neighbouring district, Elbasan, is slightly more rural with an urban population accounting for 45% of the district population (INSTAT, 2014), the relatively higher prevalence of hypertension in this district, compared to other districts in the Northern and Southern regions of Albania, may be explained by the close proximity which allows for the ease of travel for between these two districts (Tirana and Elbasan) for commercial and other reasons.

However, the results showed a significantly higher prevalence of hypertension among respondents who lived in rural areas in Albania, compared to respondents who lived in urban areas. In fact, residence in urban Albania was associated with a statistically significant decrease in the risk of hypertension, compared to residence in rural Albania. Hence, it may be unlikely that the large urban population in Tirana accounts, even though in part, for the geographical variation of hypertension prevalence in Albania. Notwithstanding that, it is important to emphasize at this point that the city of Tirana suffers from problems related to overpopulation, including high levels of air and noise pollution, which have been brought about by a substantial increase in the number of cars over the last decades (United Nations Environment Programme, 2000). In addition, the increased construction of new buildings generates large amounts of inhaled particulate matter (INSTAT, 2014), which has been implicated in the aetiology of hypertension (Du *et al*., 2016). Such environmental factors may contribute significantly to the relatively higher prevalence of hypertension in Albania compared to other districts, and as such, the observed variation in hypertension prevalence in Albania.

In Egypt, the results also revealed a striking variation in hypertension prevalence across its 27 districts. After adjusting for age and other important factors, there was a clear pattern where hypertension prevalence where districts with relatively higher prevalence of hypertension (Sharkia, Kalyoubia, Kafr-El-Sheikh, Dakahlia, Damietta, Cairo, Suez, Matrouh and Behera) are those with higher levels of socio-economic inequalities, compared to districts where hypertension prevalence was lower (Radwan, 1977; Korayem, 1994; Ibrahim, 1999; Hlasny & Verme, 2013; Ibrahim, 2013; Verme *et al.*, 2014).

In Lesotho, the results also showed substantial variation in hypertension prevalence across the 10 districts in the country. After adjusting for age and other important factors, there was a clear pattern where hypertension prevalence was highest in Quthing and Maseru districts. In 2008, unemployment levels in these districts were each greater than 50% (Lesotho Bureau of Statistics, 2008). It is also likely that unemployment levels in these districts currently drive the unemployment rates in Lesotho. Given that results revealed a significant direct association between unemployment level and hypertension prevalence in the sub-Saharan African countries, it is possible that unemployment rates may contribute substantially to the geographical variation of hypertension prevalence in Lesotho.

5.2 COMPARISON WITH PREVIOUS EVIDENCE

5.2.1 COMPARING THE SYSTEMATIC REVIEW AND META-ANALYSIS WITH PREVIOUS EVIDENCE

The results of the review corroborate those of Kearney *et al*. (2005) where hypertension prevalence was the highest among Latin America and Caribbean populations, compared to other regions, based on data collected prior to 2001. This broadly suggests that hypertension prevalence estimates in the Latin America and Caribbean region may have driven prevalence of the disease in the developing world for more than a decade. However, participants from countries in this region were not the oldest and did not have the highest prevalence estimates of any of the traditional risk factors examined in the review. Hence, the reasons for the higher prevalence of hypertension in the Latin America and Caribbean region, compared to the other regions are largely speculative at this point.

The higher prevalence of hypertension in urban settings compared to rural settings, as shown in our study, is consistent with previous reviews: Addo *et al*. (2007) in a systematic review examining the evidence pertaining to hypertension in sub-Saharan Africa found higher prevalence estimates (of hypertension) among people in urban areas, compared to those in rural areas, in all ten studies that provided information on this comparison. Similarly, Anchala *et al*. (2014), in a systematic review and meta-analysis of hypertension prevalence in India, found higher prevalence estimates in urban residents, compared to rural residents (33% versus 25%).

The higher prevalence of hypertension in older people, compared to younger people, was also consistent across all included studies reviewed by Addo *et al*. (2007).

Although male and female hypertension prevalence estimates were comparable overall, the slightly higher prevalence in males, compared to females, observed in the results, are also consistent with Addo *et al*. (2007).

The association between combined overweight/obesity and hypertension shown in our results exemplify the role of excess body weight in hypertension prevalence, which has been long recognised and consistent across numerous observational and trial data (Khan *et al*., 2013; Zaman *et al*., 2013; Adhikari *et al*., 2014; Gupta *et al*., 2015; Menon *et al*., 2015).

The dearth of evidence from systematic reviews and meta-analyses investigating the link between socio-economic factors and hypertension in low- and middle-income countries precluded comparison of our findings with such previous evidence. However, the present findings regarding the association between employment status and hypertension differ from the results of a previous retrospective cohort study comprising 9,985 participants aged 50 or over across 13 European countries (Rumball-Smith *et al*., 2014).

Overall, the present findings revealed a higher prevalence of hypertension in participants who were unemployed, compared to those who were employed. In contrast, Rumball-Smith *et al*. (2014) consistently found no association between unemployment and hypertension, irrespective of the metrics used for defining the experience of not working. However, this contradictory finding may be explained by the different populations between the two studies, where unemployed participants in the retrospective cohort study may have been more likely to be out of the workforce willingly, given the age demographic (age > 50 years), and may therefore be spared the psychosocial effects of being unemployed. In contrast, the unemployed participants in the present review were predominantly younger and may therefore be less likely to be out of the workforce by choice and less likely to be spared the psychosocial effects of unemployment. Psychosocial factors associated with hypertension are not uncommon and have been described previously (section 1.2.3.3).

Again, most of the represented countries in the retrospective cohort study are high-income, so that the social deprivation and health inequality that comes with unemployment tends to be cushioned by free health and social care systems in these countries. More importantly, Rumball-Smith *et al*. (2014) have cited that the possibility of bias may have contributed to the null findings. For instance, hypertension was assessed retrospectively based on self-reported physician diagnosis, which carried the risk of misclassifying hypertensive participants as normotensive, potentially underestimating any association between unemployment and hypertension if this bias was equally likely to affect unemployed and employed participants (Rumball-Smith *et al*., 2014).

The absence of other social risk factors in the studies included in the present review (e.g. social stress, job strain) also precluded any comparison with previous evidence in this regard. However, the considerable burden of social factors in low- and middle-income countries and the impact of these factors on hypertension prevalence in these countries have previously been acknowledged (section 1.2.3.3).

5.2.2 COMPARING THE SECONDARY DATA ANALYSIS WITH PREVIOUS EVIDENCE

The analyses of the 2008/09 Albania DHS estimated a 23% prevalence of hypertension, which was consistent with estimates obtained from previous analyses of the Albania DHS dataset (Harhay *et al.*, 2013; Petrela *et al.*, 2013).

Zelveian & Podosyan (2011), in a cross-sectional study of 748 participants, found the prevalence of hypertension in Armenia to be 27.4% overall, and significantly higher in men than in women. While these findings contradict the present analysis, it is worth noting that their study was conducted in Yerevan, which is the capital city of Armenia, and therefore not likely to provide a nationally representative sample.

Roberts *et al*. (2012), in their analysis of a nationally representative household survey of 1781 respondents conducted in 2010 found hypertension prevalence in Azerbaijan to be 22.7%. While this contradicts the 12.3% prevalence found in the present analysis, it is important to recall that the present analysis was of a DHS survey conducted in 2006. Hence, it is possible that hypertension prevalence in Azerbaijan increased considerably during this four-year period.

Similarly, analysis of a nationally representative household survey of 1992 respondents conducted in 2010 found hypertension prevalence in Ukraine to be 33.4% (Roberts *et al*., 2012), which contradicts the 17.3% prevalence observed in the present analysis of the 2007 Ukraine DHS dataset. Again, it is possible that hypertension prevalence in Ukraine increased considerably during this three-year period.

Harhay *et al*. (2013), in their analyses of the 2010 DHS datasets for Albania, Armenia, Azerbaijan and Ukraine, associated poverty, rural residence and lower educational status with increased risk of hypertension, which are consistent with the present analyses.

Mishra *et al*. (2006), in their analysis of the 2002 Uzbekistan Health Examination Survey, found a significant risk of hypertension associated with being employed among men in Uzbekistan, but no significant association between employment status and hypertension risk was observed among women. Their findings contradict the present analysis, which shows a reversal of these associations in men and women, where a significant high risk of hypertension was found among working women in Uzbekistan, but not among working men. However, the reasons for these contrasting findings are not clear, especially considering that there was no indication that data on hypertension was collected differently from men and women.

A 2012 STEPwise survey conducted by the Ministry of Health and Population in Egypt, in collaboration with WHO, revealed a 40% prevalence of hypertension among adults in the country (WHO, 2016m). This prevalence is a much higher estimate than the 15.7% prevalence obtained from the present analysis of the 2008 Egypt DHS dataset. It is possible that hypertension prevalence in Egypt increased considerably within this four-year gap, especially given that non-communicable diseases account for more than 80% of all deaths and more than 60% of premature deaths in Egypt. However, it is also important to emphasize that the respondents aged 15–18 years, in whom hypertension prevalence is very low, were included the present analyses, whereas the STEPwise survey only included adults who were older than this age group. In addition, there may have been fundamental differences in the methods for assessing hypertension between the 2008 Egypt DHS survey and the 2012 STEPwise survey.

Analysis of the 2000 National Health Survey in Morocco revealed a 37% prevalence of hypertension among Moroccan women (Tazi *et al*., 2003), which contradicts the 5.4% female prevalence observed in the present analysis of the 2003/2004 DHS dataset. However, a decrease in hypertension prevalence of this magnitude (37% to 5%) may be unrealistic and inconsistent with current trends in Morocco, where cardiovascular disease and other non-communicable diseases account for 75% of all deaths (WHO, 2014a). Hence, reasons for this disparity between both surveys may rely on other factors such as those highlighted in the preceding paragraph. For instance, only respondents aged 20 years and above were surveyed in the 2000 National Health Survey in Morocco, which might explain the higher prevalence of hypertension obtained from this survey; the present DHS survey was more inclusive by providing data for respondents aged 15 years and above. Again, there may have been fundamental differences in the methods for assessing hypertension between the 2000 National Survey and the 2003/2004 DHS survey.

Nair *et al*. (1994) attributed the variation in hypertension prevalence in Lesotho to nutritional transition between rural and urban populations, which is somewhat consistent with the significantly higher prevalence of hypertension in urban populations, compared to rural populations in Lesotho.

Aboobakar *et al*. (2010), in a cross-sectional survey of 2028 participants in the Maldives, found a significantly higher risk of hypertension among participants with no formal education, compared to participants who were educated. Their finding was consistent with the present analyses of the 2009 Maldives DHS survey, which showed significantly higher prevalence of hypertension among uneducated people compared to those who are educated.

In a recent cross-sectional survey, Macia *et al*. (2016) found a prevalence of hypertension of 24.7%. While this estimate contradicts the 7.6% prevalence found in the present analysis of the 2010/2011 Senegal DHS dataset, it may also suggest that hypertension prevalence may have increased about three-folds in the past six years.

In addition, the association between a lack of education and hypertension is also consistent with the present analysis.

5.3 LIMITATIONS AND STRENGTHS

5.3.1 LIMITATIONS AND STRENGTHS OF THE SYSTEMATIC REVIEW AND META-ANALYSIS

It is acknowledged that the overall quality of the included studies was moderate at best, especially given that more than a third of the studies (39%) were assessed as having high risk of sampling bias. However, as shown using meta-regression analysis, the high rates of sampling bias had no undue impact on the overall hypertension prevalence. A salient limitation in light of the risk of bias is that non-response bias was not assessed in the included studies, and this stems from the fact the adopted tool (Newcastle-Ottawa Scale) does not offer a provision of non-response bias to be assessed.

High amounts of heterogeneity across the included studies was another limitation of our study. Prevalence estimates from different regions were pooled in this meta-analysis, and as expected, high heterogeneity between studies was found in the meta-analyses. A substantial amount of the heterogeneity across studies was explained by such factors as differences in population characteristics and study methodologies. Nonetheless, as affirmed by previous evidence, meta-analyses are the preferred options to narrative syntheses for interpreting the results in a review, even in spite of the presence of a considerable amount of heterogeneity (Ranasinghe *et al.,* 2015). Heterogeneity appeared to be the norm rather than exception in published meta-analyses of observational studies, in which case, it should be expected and quantified appropriately (Rahman *et al.,* 2015).

Only studies from 45 countries were included in the meta-analysis, whereas the World Bank (2015) and International Monetary Fund (2009) recognize 156 developing countries. Hence, majority of the low- and middle-income countries were not represented in the systematic review, potentially increasing the risk of selection bias and threatening the external validity of the findings. Nonetheless, coverage of evidence for all geographic regions might be reasonable, potentially allowing for generalisability of the results across geographic regions.

In addition, there is a possibility that non-smokers and non-drinkers may potentially be at risk of hypertension due to other health-damaging behaviours; this study therefore highlights the importance of expatiating on other lifestyle variables as potential correlates of hypertension and other cardiovascular conditions. For example, the potential impact of differential dietary patterns and dietary salt intake on the observed variations in hypertension prevalence across countries were not examined and it is likely that differences in average dietary salt intake at the population level may contribute to some of the observed variations in hypertension prevalence across countries and world regions (Edwards *et al.,* 2000; Amoah, 2003; Bhansali *et al.,* 2015).

In spite of the aforementioned limitations, the review's strengths are important. In addition to providing the most comprehensive evidence of the status of hypertension in low- and middle-income countries, comprehensive searches of databases were conducted to ensure that all relevant publications were identified. Potential bias was also reduced during the conduct of this review by having the authors independently scan through the search output and extract the data.

5.3.2 LIMITATIONS AND STRENGTHS OF THE SECONDARY DATA ANALYSIS

The cross-sectional nature of the secondary data analysis does not allow for temporal or causal interpretations of the observed associations between socio-demographic risk factors and hypertension.

With only 10 countries included in the analysis, including the all-women data for Morocco, the surveys were not representative of low- and middle-income countries, potentially introducing a high risk of selection bias in the secondary analyses and threatening the external validity of the findings. In addition, absence of datasets from East Asia/Pacific and Latin America/Caribbean regions also limit the generalizability of the findings to low- and middle-income countries in these regions.

Data on most variables were collected on a self-report basis, increasing the likelihood of information (recall) bias, which may affect the observed associations between socio-demographic factors and hypertension risk.

There were missing data for some variables in the analyses. For example, the Armenia and Uzbekistan datasets provided no information on people with no education, so that it was not possible to examine the associations of hypertension across all levels of educational attainment in these countries. It is unclear from the datasets if the reason for missing data is because Armenia and Uzbekistan have attained a certain minimum of educational attainment where it is unlikely to have persons aged 15 years and above to be without formal education.

Due to ongoing epidemiological transition in the 10 countries explored (Yusuf *et al*., 2001), it is speculated that the observed prevalence of hypertension in each country may have been underestimated, given that the datasets are not recent.

The potential variations in the access to anti-hypertensive medications could not be examined because the data were not available, potentially precluding any assessment of its impact on hypertension prevalence in low- and middle-income countries.

Across all the 10 datasets, there was hardly any information on other important social factors that may be associated with hypertension prevalence in low- and middle-income countries such as social stress, job strain, overcrowding, physical activity, dietary habits, sleep patterns etc. Data on these variables would have provided more robust information about the social determinants and other risk factors of hypertension in the selected countries.

Besides the above limitations, it is important to acknowledge that the secondary analyses have also provided novel information on the spatial distribution of socio-demographic factors associated with hypertension in low- and middle-income settings.

5.4 IMPLICATIONS OF THE RESULTS

5.4.1 IMPLICATIONS FOR PRACTICE AND POLICY

The elderly, overweight/obese, non-educated and urban settlers present opportunities for targeted health promotion and preventive interventions in LMICs. Given the high burden of infectious diseases in these countries, it might be economically justified to implement intervention programs for hypertension in higher-risk populations alone. However, the occurrence of hypertension in the general population remains unacceptably high, which poses an ethical dilemma to relying on high-risk strategies only in these settings; countries in the Middle East and North Africa region may even not have sufficient evidence to implement public health interventions in certain high-risk populations such as the elderly.

Health inequalities associated with hypertension have been recognized as an important public health issue in low- and middle-income countries (Cappuccio *et al.,* 2004; Gupta *et al.*, 2012; Jeemon *et al.,* 2012). Addressing the wider social determinants of the disease is therefore crucial to its control in these countries. Failure to address these issues portends additional threats to the sustainability of public health infrastructure, especially alongside the prevailing effects of infectious disease epidemics. For instance, in countries such as Egypt, Senegal and Maldives, where education is protective against hypertension, resources, though limited, can be deployed more effectively to achieve a significant reduction in the proportions of adolescents and adults without formal education.

In countries where being employed was associated with hypertension (such as Albania, Armenia, Azerbaijan Ukraine, Uzbekistan, Egypt and Senegal), country-wide policies that ensure that employers of labour conform to international ethical standards in dealing with their employees must be enforced as a matter of public health in order to prevent job strain or other stressors that may be associated with hypertension and its complications.

The geographical variations of hypertension observed in Albania, Egypt and Lesotho will provide policy makers with information on how to allocate resources so that the amount of attention given to the districts within these countries is directly proportional to the district prevalence of hypertension and the magnitudes of its associations with spatial and non-spatial factors. Policy makers and public health planners in LMICs may adopt the WHO global action plan targets (see Box 2) as a guide to tackling health disparities associated with hypertension at the district level. This is especially important within the contexts of other low- and middle-income countries where hypertension constitutes considerable economic burden (WHO, 2014b). Although, by definition, LMICs have a low GDP, which consequently reduces spending on health expenditure, however, considering that hypertension is associated with a much larger disability adjusted life years in LMICs, compared to high income countries, the cost-effective solution would be to prioritize government spending on health care over sectors of the economy that do not require urgent reforms. Interventions that could be useful for preventing hypertension in districts considered hotspots for hypertension are summarized in Table 5.1.

Population-wide strategies such as reduction in dietary salt intake from processed foods are warranted in these low-resource settings, because they have been proven to be cost-effective means to shift blood pressure distribution at the population level, thus reducing the burden of cardiovascular disease associated with the epidemic of hypertension (Agyemang *et al.,* 2006; Duda *et al.,* 2007; Erhun *et al.,* 2005; Kamadjeu *et al.,* 2006; Kenge *et al.,* 2007; Niakara *et al.,* 2007). Specifically, population-wide salt reduction through legislation, voluntary agreements with food industries and mass media campaigns are evidence-based cost-effective strategies for reducing hypertension prevalence in low- and middle-income countries, potentially preventing millions of years lost to the disease as a result of ill-health, disability or premature death (Omuemu *et al.* 2007).

Overall, the findings could be useful for the design of screening and treatment programs for hypertension in low- and middle-income countries. Early screening and initial management in primary care centers is key to tackling the burden of hypertension in low- and middle-income countries. Given that doctor to patient ratios tend to be low in these countries, building the capacity of non-physician health workers (such as community health extension workers) on basic screening procedures, initial management and timely referral to secondary or tertiary health facilities where necessary could be useful.

The use of home blood pressure monitors should be encouraged and taught to patients at first contact in primary care centers. Home-based blood pressure monitoring is considered to be as accurate a blood pressure measurement as ambulatory blood pressure monitoring (National Institute for Health and Care Excellence, 2011). Given the relatively high costs in low- and middle-income countries, home blood pressure monitors could be subsidized by the governments of these countries, or by international donor agencies.

Box 2: Voluntary targets of the WHO Global Action Plan.

a. 25% reduction in the prevalence of hypertension
b. A 25% relative reduction in risk of premature mortality from cardiovascular diseases, cancer, diabetes, or chronic respiratory diseases.
c. At least 10%relative reduction in the harmful use of alcohol, as appropriate, within the national context.
d. A 10% relative reduction in prevalence of insufficient physical activity.
e. A 30% relative reduction in mean population intake of salt/sodium.
f. A 30% relative reduction in prevalence of current tobacco use in persons aged 15+ years.
g. A 25% relative reduction in the prevalence of raised blood pressure or contain the prevalence of raised blood pressure, according to national circumstances. Halt the rise in diabetes and obesity.
h. At least 50% of eligible people receive drug therapy and counselling (including glycaemic control) to prevent heart attacks and strokes.
i. An 80% availability of the affordable basic technologies and essential medicines, including generics, required to treat major non-communicable diseases in both public and private facilities.

Source: WHO, 2013e.

Table 5.1: Interventions for prevention of hypertension in LMICs

Risk factor for hypertension	**Preventive measure**
Unhealthy diet and physical activity	• Creating enabling environments for population-based salt reduction strategies • Implementing salt reduction and iodine fortification strategies • Formulating strategies for monitoring and evaluating population sodium consumption and sources of sodium in diets • Replacing trans-fat with polyunsaturated fat in diets • Creating awareness among the population about the benefits of healthy diet and increased physical activity
Tobacco use	• Increasing taxes on tobacco • Banning tobacco advertisements, promotion, and sponsorships • Smoke free legislation for public and work places should be enforced • Disseminating information about the harmful effects of tobacco through health warnings on tobacco products
Harmful alcohol use	• Increasing taxes on alcohol • Restricting retail access to alcohol and alcoholic beverages • Banning alcohol advertisements, promotion, and sponsorships

5.4.2 IMPLICATIONS FOR FUTURE RESEARCH

This research has provided a valuable platform to plan further investigations around the epidemiology and management of hypertension in low-and middle-income countries by laying a foundation for intensifying prevention efforts in those districts where hypertension is most burdensome, and investigating local drivers of hypertension within high-risk populations in these hotspots.

As highlighted in the limitations above, there was a paucity of information on other important variables such as social stress, job stain, physical activities, dietary patterns, sleep problems and medication adherence. Therefore, there is a need for more comprehensive country-specific data on hypertension and its determinants in low-and middle-income countries to account for the impact of these non-spatial factors on hypertension prevalence in low- and middle-income settings. Of note, the dearth of evidence on the social epidemiology of hypertension in low- and middle-income countries cannot be overemphasized. For instance, variations in social trust and violence and how they might drive hypertension prevalence within low- and middle-income countries remain largely unknown, even though these factors are highly pertinent in these countries.

In none of the studies or the datasets was ambulatory blood pressure measurement used to assess hypertension, even though ABPM represents the gold standard method for measuring blood pressure and diagnosing hypertension. More studies assessing hypertension using ABPM) are needed in low -and middle-income countries in order to ascertain the true prevalence of hypertension within study samples.

Finally, there is a need for studies to accurately predict future trends of hypertension prevalence estimates in low- and middle-income countries. For instance, national point prevalence surveys could provide a cost-effective approach for monitoring trends of hypertension prevalence in these countries.

CHAPTER SIX: CONCLUSIONS

This chapter summarises the important findings, while taking into account future plans for dissemination as well as reflection on the entire process involved with producing the thesis.

6.1 CONCLUSION

The systematic review and meta-analysis conducted to determine the prevalence of hypertension in low- and middle-income countries is among the first of its kind, including 242 epidemiological studies with more than one million participants from 45 countries classified as low- and middle-income by the World Bank (2015). The findings show that one out of three adults over the age of 18 years suffer from hypertension in the developing world. The findings of the systematic review also suggest that the prevalence of hypertension across the developing regions of the world may be influenced by high illiteracy and unemployment rates.

The secondary analyses of DHS datasets were conducted to identify potential correlates of hypertension in countries that provided data on hypertension prevalence from nationwide surveys. These surveys, comprising over 90,000 respondents, were conducted in 10 countries including Albania, Armenia, Azerbaijan, Ukraine, Uzbekistan, Egypt, Morocco, Lesotho, Senegal and Maldives. The findings revealed variations in hypertension prevalence between these countries, ranging from 5.4% in Morocco to 22.7% in Albania. There were also variations in potential correlates of hypertension between countries, with age being the most consistent factor directly associated with hypertension prevalence. Hypertension prevalence was also influenced by unemployment rates; however, this was only true for all Eastern European countries. Education was protective in Egypt, Senegal and Maldives, but may be a strong determinant in Lesotho given the extremely high literacy rates in the country.

Secondary analyses of the DHS datasets were also conducted to map the distribution of hypertension in countries with the highest prevalence of the disease in the represented regions (Albania, Egypt and Lesotho). These analyses revealed that the districts closest to the capital cities of these countries were hotspots for hypertension, and may warrant prioritized resource allocation over other districts in addressing this disparity.

Overall, the findings provide contemporary and up-to-date estimates that reflect the significant burden of hypertension in low- and middle-income countries and evidence that hypertension remains a major public health issue in these settings. The findings also suggest that addressing the wider social determinants of hypertension, such as illiteracy and unemployment, may reduce overall prevalence of the disease in low- and middle-income countries.

FUTURE DIRECTIONS AND REFLECTIONS

FUTURE DIRECTION

Considering the fact that the findings of this research have generated novel information about the countries explored, especially in Albania, Egypt, and Lesotho, these findings are aimed for publication in high-ranking international journals in the area of CVD research, epidemiology or public health (e.g., International Journal of Health Geographics, Hypertension, International Journal of Epidemiology, and Medicine). There is also a plan to write a review/implication article in a policy-oriented journal. It is expected that findings from this research will further emphasize the importance of collecting hypertension and blood pressure data in the on-going Demographic and Health Surveys conducted across 89 low-and middle-income countries, given the socioeconomic burden associated with the disease.

There is an on-going discussion to formulate a proposal for grant application to further expand the scope of this research, particularly towards generating country-specific data on hypertension in some selected low-and middle-income countries across Africa, through collaborations between Division of Health Sciences of Warwick Medical School and South African Medical Research Council. It is anticipated that the findings from the research will be used by local governments to start or change policy towards improving the prevention and management of hypertension and its related illnesses in the selected countries and Africa at large. There is also a plan to present the findings in workshops for various stakeholders in low- and middle-income countries, such as health professionals, government departments, non-governmental organizations, academics and journalists.

REFLECTIONS AND LESSONS LEARNT

My original background is Microbiology, but due to my passion and sheer commitment to make an impact on major public health issues in communities, particularly in low-and middle-income countries, I got into public health. Prior to embarking on my PhD journey, I established a non-governmental organisation

[Family and Youth Health Initiative (FAYOHI)] in my home state of Jigawa in Nigeria with the view of impacting on rural areas that have not been impacted upon by on-going health interventions and reforms taking place in the state and the country. I chose this topic because as shown by WHO and previous literature, hypertension is the number one risk factor for mortality and the third leading cause of disability-adjusted life years in developing regions of the world. On a personal note, I was not happy that there was no data on hypertension in Nigerian DHS surveys. However, this has posed a challenge to me and informed my decision to be part of the frontier of hypertension and cardiovascular research in Nigeria and other developing regions of the world. I would also like to state that our organisation (FAYOHI) has now entered into partnership with the Jigawa State Ministry of Health to conduct the largest ever NCDs Survey in the state and we are presently holding stakeholder engagement meetings to discuss possible cost effective approaches from the 3 Critical Pathway Analysis I developed.

Overall, conducting this research stimulated me intellectually, because of the proficiency required to conduct a systematic review and robust statistical analyses of huge datasets using novel techniques (Bayesian geospatial mapping).

Time and unavailability of data were also limiting factors, otherwise I would have liked to analyse recent primary data from the 10 countries explored (Albania, Armenia, Azerbaijan, Egypt, Lesotho, Maldives, Morocco, Senegal, Ukraine, and Uzbekistan) and do a more comparative analysis of the findings to observe the change in trends and patterns of hypertension within districts over time (e.g. From 1995-2015). Nonetheless, this study has broadened my horizons towards acquiring research skills necessary for independently conducting a research project on hypertension and other cardiovascular risk factors.

The most fascinating part of this Thesis however, is that it enabled me to apply all the knowledge I gained throughout the course of my PhD journey ranging from; Practical Project Management 1 and 2, Understanding Research & Critical Appraisal in Health Care, Practice of Public Health, SPSS (Overview for Complete Beginners & Elementary Statistical Methods) all from the University of Warwick, Introduction to Regression

Analyses from University College London Institute for Child Health, and Stata (Data management, manipulation, and analyses) from University of Oxford IT Services. There will have not been a better opportunity to bring all of these knowledge together.

If I was to do a similar research study again, I will make sure I manage my time more effectively so as to analyse as much data as I can possibly lay my hands on despite the short time frame provided (3 years).

Finally, I am confident to state that the information provided by this research will promote the understanding of hypertension across low-and middle-income countries, and also inform public health planners, decision makers, and major stakeholders on the need for adequate attention to the disease in the developing regions of the world. I am also optimistic that this research will inform and encourage policy makers to make concerted efforts towards effectively reducing the burden of hypertension and its related illnesses in low-and middle-income countries.

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APPENDICES

APPENDIX I: PROSPERO REGISTRATION

PROSPERO International prospective register of systematic reviews
Prevalence of hypertension in low-and middle-income countries: a systematic review
and meta-analysis

Ahmed Mohammed Sarki, Olalekan Uthman, Ngianga-Bakwin Kandala, Saverio Stranges, Chidozie Nduka

Citation

Ahmed Mohammed Sarki, Olalekan Uthman, Ngianga-Bakwin Kandala, Saverio Stranges, Chidozie Nduka. Prevalence of hypertension in low-and middle-income countries: a systematic review and meta-analysis. PROSPERO 2013:CRD42013006162 Available from http://www.crd.york.ac.uk/PROSPERO_REBRANDING/display_record.asp?ID=CRD42013006162

Review question(s)

To determine the prevalence of hypertension in low-and middle-income countries
To examine the pattern of hypertension across different socio-demographic characteristics (age, gender, educational attainment, wealth status, place of residence, and employment status)

Searches

A literature search of MEDLINE, EMBASE, Scopus, and Web of Knowledge will be conducted using the following subject terms "hypertension", "blood pressure", "low-and middle-income countries", "developing countries". The World Health Organization Global Cardiovascular Infobase and bibliographies of reviews and study articles will also be scrutinized for additional studies. No language or publication period restriction will be applied.

Types of study to be included

We will include all study designs in the review.

Condition or domain being studied

Hypertension.

Participants/ population

Adult population (as defined by the authors of the original studies included) living in low-and middle-income countries.

Intervention(s), exposure(s)

Not Applicable.

Comparator(s)/ control

Not Applicable.

Context

Inclusion criteria:
Studies will be included in the review if they meet the following criteria
- Population-based studies that reported the prevalence of hypertension
- Standard methods for the measurement of hypertension was described
- The definition of hypertension was equal to or above140/90 mmHg (Systolic/Diastolic blood pressure) or on anti- hypertensive medication, or self-reported health professional diagnosis of hypertension
- Sex and age-specific prevalence of hypertension was reported

Exclusion criteria:
Studies will not be included in the review if they fall into any of the following categories
- Studies where standard methods for measurement of hypertension was not clearly described
- Studies in which the definition of hypertension is not equal to or above 140/90 mmHg (Systolic/Diastolic blood pressure)
- Studies where the population or source of population could not be identified
- Hospital-based studies

Outcome(s)

Primary outcomes

Hypertension, defined as equal to or above 140/90 mmHg (Systolic/Diastolic blood pressure) or on anti-hypertensive medication, or self-reported health professional diagnosis.

Secondary outcomes

Not Applicable.

Data extraction, (selection and coding)

The titles and abstracts of studies retrieved using the search strategy from the databases and additional sources will be screened independently by two authors of the review to identify studies that meet the inclusion criteria outlined for the review.

Data from the included studies will be extracted using a standardised protocol and a data-extraction form by two authors of the review. Whenever the data of a particular article differ between the team members, the discrepancy will be resolved either by consensus, seeking additional information from the author(s) of the study or consulting another member of the review team.

The data will be extracted based on the following:

i. Methodological information; year of publication, geographic origin of publication, study setting (rural/urban), target population and their selection criteria, sample size, analysis, main findings, and reliability of outcome data.

ii. Case definition; criteria used for diagnosis and methods employed for hypertension measurement.

iii. Medication history; number of participants on antihypertensive medication.

iv. Risk factors of hypertension and other comorbidities.

v. Population-based study outcomes; incidence, prevalence disability-adjusted life years, mortality rate and prevalence of antihypertensive drugs within the study settings.

Risk of bias (quality) assessment

The reporting and methodological qualities of the included studies will be assessed using a standardised appraisal checklist and some selected items from the STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) statement respectively.

Strategy for data synthesis

Study results will be narratively described and where appropriate, we will pool the data using random effects meta- analyses.

Analysis of subgroups or subsets

Differences between studies with regards to the pattern of hypertension across different socio-demographic characteristics (age, gender, educational attainment, wealth status, place of residence, and employment status) will be explored using subgroup analyses.

Dissemination plans

The review will be disseminated via publication in a high-impact journal.

Contact details for further information

Ahmed Mohammed Sarki
Warwick Medical School,
University of Warwick,
Coventry, UK
CV4 7AL
a.m.sarki@warwick.ac.uk

Organisational affiliation of the review

Warwick Medical School, University of Warwick, Coventry, UK CV4 7ES
http://www2.warwick.ac.uk/fac/med/

Review team

Mr Ahmed Mohammed Sarki, Warwick Medical School, University of Warwick
Dr Olalekan Uthman, Warwick Medical School, University of Warwick
Dr Ngianga-Bakwin Kandala, Warwick Medical School, University of Warwick
Dr Saverio Stranges, Warwick Medical School, University of Warwick
Dr Chidozie Nduka, Warwick Medical School, University of Warwick

Anticipated or actual start date

01 November 2013

Anticipated completion date

30 November 2014

Funding sources/sponsors
No funding
Conflicts of interest
None known
Language
English
Country
England
Subject index terms status
Subject indexing assigned by CRD **Subject index terms**
Developing Countries; Humans; Hypertension; Prevalence
Stage of review
Completed but not published
Date of registration in PROSPERO
05 November 2013
Date of publication of this revision
19 February 2015
Stage of review at time of this submission Started Completed
Preliminary searches Yes Yes
Piloting of the study selection process Yes Yes
Formal screening of search results against eligibility criteria Yes Yes
Data extraction Yes Yes
Risk of bias (quality) assessment Yes Yes
Data analysis Yes Yes

APPENDIX II: REVIEW SEARCH STRATEGY

#1	'hypertension' or 'blood pressure' or 'hypertens*'
#2	'population based' or 'aetiology' or etiology' or 'prevalence' '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 III: DATA EXTRACTION FORM

Prevalence of Hypertension in Low-and Middle-Income Countries- Data Extraction Form

Primary Reviewer: …………………………… **Second Reviewer**: ………………………………

Endnote Study ID: …………………………… **Date of Extraction:** ……………………………

Study Characteristics:

Aim/objectives of the study:
……
……

Study Design: ……….

Study Inclusion and Exclusion Criteria:
……
……
……

Recruitment/Sampling Procedures used:
……
……
……

Participant Characteristics:

Age: ………………………………….

Gender: ……………………………

Ethnicity: ………………………..

Socio-economic status: ………………………………………………………………………………..

Disease characteristics: ………………………………………………………………………………..

Potential confounders: Did the authors consider the following potential confounders (tick all that apply)

Age ☐

Sex ☐

Smoking ☐

Alcohol ☐

Education status ☐

Co-morbidity ☐

BMI ☐

Recall bias ☐ ……………………………………………………………

Other (specify) ☐ ……………………………………………………………

Number of participants in each characteristic category for intervention and control group(s) or mean/median characteristic values (record whether it is the number eligible, enrolled, or randomised that is reported in the study):
……
……
……

Intervention and Setting:

Setting in which the intervention is delivered:
………………………………………………………………………………

Description of the intervention(s) and control(s) (e.g. dose, route of administration, number of cycles, duration of cycle, care provider, how the intervention was developed, theoretical basis (where relevant)):
……
……
……

Description of co-interventions: ……………………………………………………………………………………..

Outcome Measurement:

Unit of assessment/analysis: ……………………………………………………………………………………………..

Definition of hypertension used in study: ………………………………………………………………………..

Measurement tool or method used for measuring hypertension: ……………………………………..

……

Criteria used for diagnosis of hypertension:
……
……

Unit of measurement (if appropriate): ………………………………………………………………………………

Length of follow-up, number and/or times of follow-up measurements:
……..

For all intervention group(s) and control group(s):

Number of participants enrolled: ……………………………………………………………………………………

Number of participants included in analysis: ……………………………………………………………………..

Number of withdrawals, exclusions, lost to follow-up: ………………………………………………………

Type of analysis used in study (e.g. intention to treat, per protocol): ………………………………..

……….

Results of study analysis (e.g. dichotomous: odds ratio, risk ratio and confidence intervals, p-value) or (continuous: mean difference, confidence intervals): …………………………...................

……….

<u>Other Information:</u>

Description as stated in report/paper	
Key conclusions of study authors	
References to other relevant studies	
Correspondence required for further study information *(from whom, what and when)*	
Notes:	

APPENDIX IV: NEWCASTLE- OTTAWA SCALE

Risk of bias assessment tool (Newcastle-Ottawa scale)

Domain (source of bias)	Assessment	Risk of bias
Selection (representativeness of the sample)	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	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 V: PRISMA CHECKLIST

Section/topic	#	Checklist item
TITLE		
Title	1	**Identify the report as a systematic review, meta-analysis, or both.** Prevalence of Hypertension in Low- and Middle-income Countries: A Systematic Review and Meta-analysis
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.** **Background:** Low-and middle-income countries (LMICs) bear a high burden of hypertension. However, no previous systematic review has assessed the prevalence of hypertension and its determinants across all developing regions of the world. We aimed to obtain overall and regional estimates of hypertension prevalence and examine the pattern of the disease condition across different socio-demographic characteristics in LMICs. **Methods and Findings:** We searched electronic databases for articles published between 1948 and November 2014. We included population-based studies that reported hypertension prevalence using the current definition of blood pressure ≥140/90 mmHg or self-reported use of anti-hypertensive medication. We used random-effects meta-analyses to pool prevalence estimates of hypertension, overall, by World Bank region and country income group. Subgroup and meta-regression analyses were performed on socio-demographic variables. One hundred fifty two (152) studies, comprising 613,074 adults from 41 countries, met our inclusion criteria. The overall prevalence of hypertension was 32.4% (95% confidence interval [CI] 30.2–34.7) with the Latin America and Caribbean region reporting the highest prevalence (40%, 95% CI 34.0–46.0). Prevalence was also highest in upper-middle income countries (38.0%, 95% CI 35.0–42.0) and lowest in low-income countries (24.0%, 95% CI 20.0–28.0). Prevalence among adults ≥65 years was substantially higher than adults <65 years; however, we found no significant sex-difference overall (31.9% vs 30.8%, *p*=0.6). Prevalence was generally higher among the non-educated compared to educated people (49.0% vs. 24.9%, *p*<0.00001), among overweight/obese persons compared to normal weight (46.4% vs. 26.3%, *p*<0.00001), and among urban settlers compared to rural (32% vs 25%, *p*=0.0005). Meta-regression showed that combined overweight/obesity (*p*=0.001) and being uneducated (*p*=0.049) significantly accounted for between-study heterogeneity in hypertension rates. **Conclusion:** Hypertension remains a major public health issue in the developing world despite regional variations. Notwithstanding the social determinants of the disease, population-wide strategies remain pivotal to its effective prevention and control in LMICs. *PROSPERO Registration ID: CRD42013006162*
INTRODUCTION		
Rationale	3	**Describe the rationale for the review in the context of what is already known.** Hypertension drives the global burden of cardiovascular disease being widely acknowledged as the most common cardiovascular disorder and number one risk factor for mortality.[1-3] The occurrence of hypertension is increasing globally, with projections estimating a 30% increase in prevalence by the year 2025.[4] However, owing to several factors such as the ongoing nutritional transition, increasing trends in sedentary lifestyle and other modifiable risk factors, and inadequate health care systems, populations in low- and middle-income countries (LMICs) may bear a higher burden of the disease, compared to the global average. Projections estimate that three-quarters of the world's hypertensive population will reside in LMICs within the next decade.[4] However, no systematic review has been conducted to quantify the occurrence of the disease condition and its determinants across developing regions of the world: systematic reviews have hitherto been country-specific[5] or focussed on the African region.[6,7]
Objectives	4	**Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS).** Our study, therefore, aimed to provide overall and regional estimates of hypertension prevalence for the developing world, as well as to examine the pattern of this disease across different socio-demographic characteristics.
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.** This systematic review rational and methods were specified in advance and documented in a protocol which was published in the PROSPERO register (CRD42013006162)
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**. <table><tr><th></th><th>*Inclusion*</th><th>*Exclusion*</th></tr><tr><td>**Population**</td><td>Adults (18 years and above)</td><td>Adolescents and children</td></tr><tr><td>**Outcome**</td><td>Hypertension prevalence reported or deducible from subgroup estimates Hypertension assessed as: BP greater or equal to 140/90mmHg, use of antihypertensive drugs, self-reported physician-diagnosed cases</td><td>Hypertension prevalence not reported Pulmonary hypertension Hypertension assessed as: BP greater or equal to 160/95mmHg, other assessment criteria</td></tr><tr><td>**Study design**</td><td>All population-based studies, regardless of the design: cross-sectional studies, cohort studies, randomised controlled trials</td><td>Hospital-based studies Policy reports Expert reviews</td></tr><tr><td>**Study location**</td><td>Low- and middle-income countries</td><td>High-income countries</td></tr></table>
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.** We searched the following electronic databases from inception to November 2014: EMBASE, Ovid MEDLINE and the WHO Global Cardiovascular Infobase for relevant articles.
Search	**8**	**Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated.** The search was conducted using medical subject heading (MeSH) terms and keywords: "hypertension" OR "blood pressure" OR 'hypertens*' AND 'population-based' OR 'aetiology' OR 'etiology' OR 'prevalence' OR 'epidemiolog*' AND "low-and middle-income countries" OR "developing countries".
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).** Three reviewers (AMS, CN, and OU) independently evaluated the eligibility of the studies obtained from the literature searches. All articles yielded by the database search were initially screened by their titles and abstracts to obtain studies that met our inclusion criteria. In cases of discrepancies, agreement was reached by consensus and by discussion with a fourth reviewer (SS).
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.** Three reviewers (AMS, CN, and OU) independently evaluated the methodological quality of each included study and extracted data using a piloted form; discrepancies were resolved by discussion with a fourth reviewer (SS).
Data items	11	**List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made.** Data extracted included year of publication, country of origin, study design, sample size, sampling strategy, study period, setting (rural/urban), gender distribution, age group, mean age, body mass index (BMI) category, hypertension prevalence, diagnostic criteria for hypertension, blood pressure apparatus used, confounders and comorbidities. Countries were grouped by region and income according to World Bank[9] development indicators. Age group, gender, BMI category, smoker status, alcohol use, and study setting were coded as dichotomous variables. We defined overweight/obesity as BMI≥25kg/m^2. Total prevalence estimates of hypertension were calculated from studies providing only subgroup estimates. The total mean age was also obtained from studies only reporting this variable measure within subgroups.
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.** Methodological quality entailed assessing the risk of bias for each study using a domain-based tool adapted from the Newcastle-Ottawa Scale (see Appendix 2).[10] The risk of bias in a study 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.

Summary measures	**13**	**State the principal summary measures (e.g., risk ratio, difference in means).** Prevalence estimates
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.** We conducted meta-analyses the DerSimonian-Laird random effects model[12] due to anticipated variations in study population, methodologies, and stage of epidemic transition. We assessed heterogeneity among studies by inspecting forest plots and using the I^2 statistic where we interpret a value of 50% as representing moderate heterogeneity.

APPENDIX VI: SUPPLEMENTARY TABLES 1-6 SHOWING INCLUDED STUDIES BY GEOGRAPHICAL REGION

Table 1: Characteristics of included studies for the East Asia and Pacific region

First author, year	Year of data collection	Country	Setting	Age (years)	Mean age ± SD (years)	Sample size	% Males	Hypertension prevalence (male/female)	BP cut-off (mmHg)	Country income group
Shmulewitz, 2001	1994	FS Micronesia	rural	>20	42.0±14.0	2188	42.0	17.0	140/90	lower-middle
Wu, 2001	2001	China	urban	≥60	67.9±5.8	2272	41.5	59.8	140/90	upper-middle
Gu, 2002	2000-01	China	urban and rural	35-74	NR	13198	47.8	27.2(28.6/25.8)	140/90	upper-middle
Lim, 2004	1996	Malaysia	urban and rural	≥30	NR	21391	47.0	33.0(31.9/33.9)	140/90	upper-middle
Minh, 2006	2002	Vietnam	rural	25-64	NR	1996	50.1	14.1(18.1/10.1)	140/90	lower-middle
Rampal, 2008	2004	Malaysia	urban and rural	≥15	NR	16440	42.4	27.8(29.6/26.0)	140/90	upper-middle
Sun, 2008	2004-06	China	urban	≥35	51.2±11.8	45390	49.6	39.5(37.0/38.6)	140/90	upper-middle
Zhang, 2009	2006	China	urban	≥60	69.7±6.7	4141	35.3	48.5(48.4/48.6)	140/90	upper-middle
Lee, 2010	2002-06	China	urban	40-74	52.5±8.9	39252	100	25.1	140/90	upper-middle
Swaddiwudhipong, 2010	2009	Thailand	rural	≥15	52.8±11.9	5273	44.9	29.8(29.8/29.7)	140/90	upper-middle
Thuy, 2010	2005	Vietnam	urban	25-64	41.3±1.0	910	100	35.2	140/90	lower-middle
Wu, 2010	2010	China	urban	≥60	71.7±6.6	2074	41	70.4	140/90	upper-middle
Prince, 2012	2003-06	China	urban and rural	≥65	73.2±6.1	2157	43.7	60.4	140/90	upper-middle
Ha, 2013	2011	Vietnam	urban and rural	≥25	45.0	2368	43.5	23.3(30.0/19.0)	140/90	lower-middle
Kiau, 2013	2006	Malaysia	urban and rural	≥18	NR	4933	46.3	74.0(70.1/77.4)	140/90	upper-middle
Amiri, 2014	2012	Malyasia	urban	≥18	41.5±14.9	1096	43.7	39.3	140/90	upper-middle
Fan, 2014	2010	China	urban and rural	15-74	38.2±15.1	18772	40.4	24.9	140/90	upper-middle
Feng, 2014	2011-12	China	urban and rural	≥45	NR	13707	46.7	38.6	140/90	upper-middle
Lloyd-Sherlock, 2014	2007-10	China	urban and rural	≥50	NR	13348	49.8	59.5(58.8/60.1)	140/90	upper-middle

First author, year	Year of data collection	Country	Setting	Age (years)	Mean age ± SD (years)	Sample size	% Males	Hypertension prevalence (male/female)	BP cut-off (mmHg)	Country income group
Nguyen, 2014	2012	Vietnam	urban and rural	34-65	47.4±8	3779	43.3	12.3(28.3/14.6)	140/90	upper-middle
Wang, 2014	2003-10	China	urban	≥18	45.2±13.9	37141	60.7	32.1(33.7/19.3)	140/90	upper-middle
Zhao, 2015	2008-12	China	rural	18-60	53.4±10.3	6324	100	48.8	140/90	upper-middle
Hou, 2015	2008-12	China	urban and rural	≥45	NR	3797	47.7	46.2	140/90	upper-middle
Chen, 2015	2012	China	rural	≥50	NR	2208	43.1	38.5	140/90	upper-middle
Li, 2015	2015	China	urban and rural	≥18	45.1±3.6	58985	43.2	37.4	140/90	upper-middle
Wang, 2015[43]	2009	China	urban and rural	18-87	41.2±15.5	15172	45.7	42	140/90	upper-middle
Guo, 2015[44]	1991-2011	China	urban and rural	≥18	NR	24410	-	28.6	140/90	upper-middle
Li, 2015[45]	2015	China	urban	≥18	NR	2026	-	26.9	140/90	upper-middle
Gu, 2015[46]	2002	China	urban and rural	35-70	NR	7137	-	40.9	140/90	upper-middle
Lu, 2015[47]	2013	China	urban	≥18	45	4675	-	31.6	140/90	upper-middle
Ke, 2015[48]	2012	China	urban	18-93	NR	1410	45.2	34	140/90	upper-middle
Wei, 2015[49]	2015	China	urban	≥18	NR	3778	47.3	41	140/90	upper-middle
Do, 2015[50]	2005	Vietnam	urban and rural	25-64	NR	17199	-	20.7	140/90	lower-middle

BP=blood pressure, FS Micronesia=Federal States of Micronesia, SD=standard deviation, mmHg=millimetre mercury, NR=not reported in original paper. Country income group is classified according to World Bank indicators

Table 2: Characteristics of included studies for the Europe and Central Asia region

First author, Year	Year of data collection	Country	Setting	Age (years)	Mean age ± SD (years)	Sample Size	% Male	Hypertension prevalence (male/female)	BP cut-off (mmHg)	Country income group
Shapo, 2003	2001	Albania	urban	≥25	NR	1120	47.8	31.8(36.6/27.4)	140/90	upper-middle
Onal, 2004	2002	Turkey	urban	≥25	NR	423	-	35.5	140/90	upper-middle
Mishra, 2006	2002	Uzbekistan	urban and rural	15-59	NR	7796	29.9	13.6(17.0/12.0)	140/90	lower-middle
Erem, 2008	2005	Turkey	urban and rural	20-70+	40.6±14.5	4809	45.9	44.0(41.6/46.1)	140/90	upper-middle
Dorobantu, 2010	2005	Romania	urban and rural	≥18	NR	2017	42.0	44.9(50.2/41.1)	140/90	upper-middle
Altun, 2012	NR	Turkey	urban and rural	>18	40.5±16.3	10748	44.3	32.7(29.4/35.9)	140/90	upper-middle
Dogan, 2012	2005-06	Turkey	urban and rural	18-70+	47.8±13.1	2035	41.3	24.2(14.1/31.3)	140/90	upper-middle
Harhay, 2013	2008-09	Albania	urban and rural	15-49	31.9±11.0	6472	44.0	23.3(27.6/20.0)	140/90	upper-middle
Harhay, 2013	2005	Armenia	urban and rural	15-49	31.3±10.6	7552	16.0	22.6(27.3/21.7)	140/90	lower-middle
Harhay, 2013	2006	Azerbaijan	urban and rural	15-59	31.7±10.8	10958	23.0	16.4(16.6/16.4)	140/90	upper-middle
Harhay, 2013	2007	Ukraine	urban and rural	15-49	32.3±10.0	10802	47.0	28.0(31.9/24.5)	140/90	lower-middle
Supiyev, 2015	2012-13	Kazakhstan	urban	50-75	29.7±5.0	497	46.9	70.0	140/90	upper-middle

BP=blood pressure, SD=standard deviation, mmHg=millimetre mercury, NR=not reported in original paper. Country income group is classified according to World Bank Indicators

Table 3: Characteristics of included studies for the Latin America and Caribbean region

First author, year	Year of data collection	Country	Setting	Age (years)	Mean age ± SD (years)	Sample size	% Male	Hypertension prevalence (Male/Female)	BP cut-off (mmHg)	Country income group
Ordunez-Garcia, 1998	1994	Cuba	urban	>15	NR	1633	45.6	43.5(45.9/41.5)	140/90	upper-middle
Barreto, 2001	1997	Brazil	urban and rural	≥18	NR	2314	40.9	24.8(22.0/26.9)	140/90	upper-middle
Freitas, 2001	1998	Brazil	urban	≥18	NR	688	41.6	31.5(33.9/29.9)	140/90	upper-middle
Lorenzo, 2002	1987-96	Mexico	urban	35-64	47.3±0.3	2282	41.2	18.8(18.7/18.9)	140/90	upper-middle
Matos, 2003	2003	Brazil	rural	≥19	46.6±19.7	126	43.7	36.5	140/90	upper-middle
Gus, 2004	1999-2000	Brazil	urban and rural	>20	44±15.6	1063	48.2	33.7(33.3/34.1)	140/90	upper-middle
Ordunez, 2005	2001-02	Cuba	urban	15-74	NR	1667	23.4	24.1(22.8/25.2)	140/90	upper-middle
Almeida-Pitito, 2006	2005	Brazil	urban	≥30	NR	1751[f]	0	33.0	140/90	upper-middle
Jean-Baptiste, 2006	2002-03	Haiti	urban	20≥65	NR	1113	29.7	47.1(48.7/46.5)	140/90	lower-middle
Lessa, 2006	1999-2000	Brazil	urban and rural	≥20	41.1±14.4	1439	42.3	29.9(27.4/31.7)	140/90	upper-middle
Jardim, 2007	2002	Brazil	urban	>18	39.7±15.6	1739	34.6	36.4(41.8/31.8)	140/90	upper-middle
Medina-Lezama, 2007	2006	Peru	urban	≥20	49.1±17.2	1878	46.2	15.7(16.1/15.6)	140/90	upper-middle
Capilheira, 2008	2002-03	Brazil	urban	≥20	43.2±16.1	3100	43.3	23.4(18.2/27.4)	**	upper-middle
Ordunez, 2008	2001-02	Cuba	urban and rural	25-74	NR	1475	44.3	21.4(29.4/26.3)	140/90	upper-middle
Sparrenberger, 2008	2005-07	Brazil	urban	18-60	48.8±19.3	1484	41.4	40.4	140/90	upper-middle
Longo, 2009	2007	Brazil	urban	20-59	31.0±11.6	2022	47.7	33.7(31.1/38.1)	140/90	upper-middle
Reichert, 2009	2003	Brazil	urban	≥40	NR	1696	42.6	34.4(27.3/39.6)	**	upper-middle
Rodrigues, 2009	1999-01	Brazil	urban	25-64	45.0±11.0	1655	45.9	42.6(47.5/38.3)	140/90	upper-middle
Rosario, 2009	2006	Brazil	urban and rural	≥18	42.6±15.4	1003	51.3	30.1	140/90	upper-middle
Diaz, 2009	2000-01	Cuba	urban and rural	≥20	NR	19519		61	140/90	upper-middle
Cipullo, 2010	2004-05	Brazil	urban	≥18	55.0±14.7	1717	48.8	44.4(23.8/26.8)	140/90	upper-middle
Nascente, 2010	2002	Brazil	rural	>18	43.2±14.9	1168	36.8	32.7(35.8/30.9)	140/90	upper-middle
Hofelmann, 2012	2009	Brazil	urban	20-59	38.1±0.5	1702	44.5	40.0(51.6/30.5)	140/90	upper-middle
Kerkhoff, 2012	2007-08	Brazil	urban	18-90	NR	1858	42.0	34.2(32.4/52.3)	140/90	upper-middle

First author, year	Year of data collection	Country	Setting	Age (years)	Mean age ± SD (years)	Sample size	% Male	Hypertension prevalence (Male/Female)	BP cut-off (mmHg)	Country income group
Lyra, 2012	2008-09	Brazil	urban	31-90	57.4	198	34.3	64.2(51.5/70.8)	140/90	upper-middle
Prince, 2012	2003-06	Cuba	urban and rural	≥65	75.1±7.0	2944	35.0	73.9	140/90	upper-middle
Prince, 2012	2003-06	Dominican Republic	urban and rural	≥65	75.3±7.5	2011	34.1	76.9	140/90	upper-middle
Prince, 2012	2003-06	Venezuela	urban and rural	≥65	72.3±6.9	1965	36.5	79.5	140/90	upper-middle
Prince, 2012	2003-06	Peru	urban and rural	≥65	74.6±7.4	1929	38.8	49.8	140/90	upper-middle
Prince, 2012	2003-06	Mexico	urban and rural	≥65	74.3±6.7	2003	36.7	62.9	140/90	upper-middle
Mendes, 2013	2003	Brazil	urban	≥60	70.2	872	48.1	45.3(38.0/52.0)	**	upper-middle
Selem, 2013	2008	Brazil	urban	>20	NR	535	36.8	43.4	140/90	upper-middle
Silva, 2013	2009-10	Brazil	urban	20-59	37.9±11.5	1790	44.2	40.4(51.6/30.5)	140/90	upper-middle
Lloyd-Sherlock, 2014	2007-10	Mexico	urban and rural	≥50	NR	2281	46.8	58.2(55.2/60.9)	140/90	upper-middle
Posso, 2014	2011	Panama	urban and rural	≥18	NR	3406	30.4	29.6(33.5/20.7)	140/90	upper-middle
Bernabe-Ortiz, 2015	2010	Peru	rural	≥35	45.3	3238	48.3	16	140/90	upper-middle
Bresan, 2015	2010	Brazil	rural	≥20	NR	355	43.9	46.2	140/90	upper-middle
de Souza, 2015	2007	Brazil	urban and rural	≥18	NR	1729	91.7	25	140/90	upper-middle
Unger, 2015	2003	Brazil	urban	≥18	NR	5649	-	21	140/90	upper-middle
Vieira, 2015	2008-09	Brazil	urban	≥18	NR	491	-	22.6	140/90	upper-middle
Almeida, 2015	2013	Brazil	urban and rural	35-80	NR	1410	-	53.2	140/90	upper-middle

** = Self-reported only, BP=blood pressure, f= Female only sample, SD=standard deviation, mmHg=millimetre mercury, NR=not reported in original paper. Country income group is classified according to World Bank indicators

Table 4: Characteristics of included studies for the Middle East and North Africa region

First author, year	Year of data collection	Country	Setting	Age (years)	Mean age ± SD (years)	Sample size	% male	Hypertension prevalence (male/female)	BP cut-off (mmHg)	Country income group
Ibrahim, 1995	1986-90	Egypt	urban and rural	≥25	NR	6733	43.5	26.3(26.9/25.7)	140/90	lower-middle
Bahrami, 2006	2002-05	Iran	urban and rural	35-81	52.8±9.4	8998	42.1	32.5(29.8/34.5)	140/90	upper-middle
Azimi-Nezhad, 2009	2005	Iran	urban and rural	15-65	NR	4519	51.3	24.2(27.7/20.5)	140/90	upper-middle
Ramezani, 2009	2006	Iran	urban and rural	15-65	NR	3760	50.0	20.7(20.5/21.0)	140/90	upper-middle
Ebrahimi, 2010	2006	Iran	urban and rural	15-64	NR	29971	50.6	17.4(18.5/16.2)	140/90	upper-middle
Berraho, 2012	2006	Morocco	urban and rural	<50-60+	NR	525	31.3	70.4(67.7/72.0	140/90	lower-middle
Modesti, 2013	2008	Yemen	urban and rural	15-69	NR	10242	49.4	7.7(6.7/8.6)	140/90	lower-middle
Veghari, 2013	2013	Iran	urban	15-65	39.5±14.3	3497	49.8	21.2(19.8/22.6)	140/90	upper-middle
Khalifeh, 2015	2014	Lebanon	urban and rural	≥18	59.5±12.1	672	40.2	33.3	140/90	upper-middle
Matar, 2015	2012-13	Lebanon	urban and rural	≥21	42.9±15.8	1697	-	36.9	140/90	upper-middle
Sepanlou, 2015	2004-08	Iran	urban and rural	40-75	51.6±8.8	46674	42.5	40.1	140/90	upper-middle
Yazdanpanah, 2015	2015	Iran	urban and rural	≥20	NR	944	45.8	17.6	140/90	upper-middle

BP=blood pressure, SD=standard deviation, mmHg=millimetre mercury, NR=not reported in original paper. Country income group is classified according to World Bank Indicators

Table 5: Characteristics of included studies for the South Asia region

First author, year	Year of data collection	Country	Setting	Age (years)	Mean age ± SD (years)	Sample size	% Male	Hypertension prevalence (male/female)	BP cut-off (mmHg)	Country income Group
Gupta, 1994	1994	India	rural	≥20	NR	3148	63.0	21.4(24.0/17.0)	140/90	lower-middle
Gupta, 1995	-	India	urban	≥20	NR	2122	66.7	32.4(30.0/33.0)	140/90	lower-middle
Goel, 1996	1996	India	rural	≥30	NR	1572	-	7.2(5.6/8.8)	140/90	lower-middle
Singh, 1998	1997	India	urban	25-64	NR	3212[f]	-	25.6	140/90	lower-middle
Malhotra, 1999	1994-95	India	rural	16-70	NR	2559	-	4.5	140/90	lower-middle
Gurav, 2001	-	India	urban	≥18	NR	767	53.6	13.9(9.5/19.0)	140/90	lower-middle
Swami, 2002	1998-99	India	urban and rural	≥65	NR	362	42.3	58.0(52.3/62.2)	140/90	lower-middle
Hazarika, 2002	-	India	urban	≥30	45.1±11.0	1015	50.4	60.8	140/90	lower-middle
Reddy, 2002	-	India	urban	≥18	43.1±9.5	3307	88.0	28.0	140/90	lower-middle
Gupta, 2002	1990	India	urban	≥20	NR	1123	49.0	37.0(36.4/37.5)	140/90	lower-middle
Bharucha, 2003	2002	India	urban	≥20	NR	2415	45.5	36.4(32.8/39.4)	140/90	lower-middle
Deepa, 2003	2001-02	India	urban and rural	≥20	47.0±14.5	1262	44.1	22.1(23.9/19.9)	140/90	lower-middle
Hazarika, 2003	2003	India	urban	≥60	NR	888	56.3	63.6(64.2/62.9)	140/90	lower-middle
Shanthirani, 2003	2001-02	India	urban and rural	≥20	NR	1262	44.1	21.1(22.8/19.7)	140/90	lower -middle
Gupta, 2004	-	India	urban and rural	≥35	NR	88653	40.0	48.0(47.5/48.4)	140/90	lower -middle
Hazarika, 2004	-	India	rural	≥30	NR	3180	45.3	33.3	140/90	lower -middle
Ahmad, 2005	1990-94	Pakistan	urban and rural	≥18	NR	8432	46.6	35.6(29.0/41.3)	140/90	lower-middle
Das, 2005	2001	India	urban	≥18	NR	1609	53.9	24.9	140/90	lower-middle
Siddiqui, 2005	2005	Pakistan	urban	≥15	34.0±15.1	327	50.5	15.0(17.5/14.0)	140/90	lower-middle
Prabhakaran, 2005	-	India	urban	20-59	42.0	2122	100	30.0	140/90	lower-middle
Thankappan, 2006	-	India	rural	≥30	50.0	4955		36.7(36.0/37.2)	140/90	lower-middle
Mohan, 2007	2001-02	India	urban and rural	≥20	43.0±12.5	2350	49.5	20.0(23.2/17.1)	140/90	lower-middle
Vaidya, 2007	2004-05	Nepal	rural	≥35	NR	1000	100	22.7	140/90	low
Wijewardene, 2007	2004	Sri Lanka	urban and rural	30-65	46.5±9.2	6047	44.5	19.1(18.8/19.3)	140/90	lower-middle

First author, year	Year of data collection	Country	Setting	Age (years)	Mean age ± SD (years)	Sample size	% Male	Hypertension prevalence (male/female)	BP cut-off (mmHg)	Country income group
Reddy, 2007	-	India	-	-	39.8±11.9	19973	59.6	33.8	140/90	lower-middle
Gupta, 2007	-	India	urban	≥20	NR	1127	49.3	52.4(54.3/57.9)	140/90	lower-middle
Chaturvedi, 2007	-	India	urban	≥20	NR	2318		44.8	140/90	lower-middle
Agrawal, 2008	2005	India	rural	≥30	NR	406	53.7	33.5(35.3/31.4)	140/90	lower-middle
Yadav, 2008	-	India	urban	≥60	NR	294	40.5	39.5(41.0/38.0)	140/90	lower-middle
Kusuma, 2009	2006	India	urban	≥20	NR	453	48.8	18.3(20.8/15.9)	140/90	lower-middle
Pednekar, 2009	1991-97	India	urban	≥35	NR	148173	59	46.2(47.3/45.7)	140/90	lower-middle
Pednekar, 2009	-	India	urban	≥35	NR	146827	59.6	90	140/90	lower-middle
Midha, 2009	2009	India	urban and rural	≥20	NR	800	44.4	23.6	140/90	lower-middle
Bhardwaj, 2010	2009	India	rural	≥18	NR	1092	46.4	35.9(39.8/33.2)	140/90	lower-middle
Jonas, 2010	2007-08	India	rural	≥30	49.5±13.4	4711	46.5	22.1(22.5/21.7)	140/90	lower-middle
Kinra, 2010	2005-07	India	rural	20-69	NR	1983	69.3	20.2(20.0/22.0)	140/90	lower-middle
Kar, 2010	2004-05	India	urban and rural	≥30	NR	400	-	35.7	140/90	lower-middle
Chataut, 2011	2011	Nepal	rural	≥18	NR	527	40.6	22.4(32.7/15.3)	140/90	low
Norboo, 2011	2007-11	India	urban and rural	≥20	53.8±15.0	2800	44.3	37.0	140/90	lower-middle
Manimunda, 2011	2007-09	India	rural	≥18	NR	975	43.5	50.5(50.7/50.3)	140/90	lower-middle
Thrift, 2011	-	India	rural	≥18	39.7	1479	46.2	11.4	140/90	lower-middle
Bansal, 2012	2010	India	rural	≥15	NR	968	70.0	32.3(30.9/27.8)	140/90	lower-middle
Bharati, 2012	2009	India	urban and rural	≥30	NR	856	37.4	27.6(26.9/28.0)	140/90	lower-middle
Dutta, 2012	2007-11	India	rural	≥18	43.0	1186[f]	0	24.7	140/90	lower-middle
Esam, 2012	2011-12	India	rural	≥15	NR	504	57.0	27.4(26.3/28.8)	140/90	lower-middle
Prasad, 2012	2011	India	urban	≥20	47.5±12.9	1178	50.0	36.6(38.5/34.7)	140/90	lower-middle
Prince, 2012	2003-06	India	urban and rural	≥65	72.0±6.0	1977	44.3	57.3	140/90	lower-middle
Vaidya, 2012	1980	Nepal	rural	≥21	NR	1218	43.3	33.8(38.3/30.8)	140/90	low
Vaidya, 2012	2009	Nepal	rural	≥35	NR	641	NR	17.5	140/90	low
Meshram, 2012	1998-99	India	rural	≥18	NR	4192	45.1	40.0(44.8/35.8)	140/90	lower-middle
Samuel, 2012	1998-2002	India	rural	26-32	28.3±1.1	2218	52.3	2.5	140/90	lower-middle

First author, year	Year of data collection	Country	Setting	Age (years)	Mean age ± SD (years)	Sample size	% Male	Hypertension prevalence (male/female)	BP cut-off (mmHg)	Country income group
Kaur, 2012	-	India	urban and rural	40-70	NR	600	-	18	140/90	lower-middle
Jeemon, 2012	2003-06	India	urban	≥18	40.9±11.0	10543	-	33.8	140/90	lower-middle
Gupta, 2012	2009-10	India	urban	20-59		739	61.0	33.6(39.5/24.6)	140/90	lower-middle
Gupta, 2012	-	India	urban and rural	35-70	NR	4608	-	39.2	140/90	lower-middle
Chinnakali, 2012	-	India	rural	-	NR	211	-	40.5(39.2/40.8)	140/90	lower-middle
Kokiwar, 2012	-	India	rural	≥30	NR	924	-	19.0(23.4/14.4)	140/90	lower-middle
Borah, 2012	2012	India	urban and rural	≥18	NR	916	50.8	44.4	140/90	lower-middle
Bhagyalaxmi, 2013	2008	India	urban and rural	15-64	37.7±1.4	3489	51.2	25.8(27.6/23.9)	140/90	lower-middle
Gupta, 2013	2006-10	India	urban	20-75	NR	6106	55.2	42.8(43.8/41.5)	140/90	lower-middle
Khan, 2013	1994-97	Nepal	rural	≥16	34.2	1679[f]	0	3.3	140/90	low
Adhikari, 2014	2013	Nepal	urban and rural	15-64	NR	1240	53.6	22.3(24.8/19.3)	140/90	low
Lloyd-Sherlock, 2014	2007-10	India	urban and rural	≥50	NR	7238	51.1	32.3(30.3/35.0)	140/90	lower-middle
Zaman, 2015	2013	Bangladesh	urban and rural	≥25	NR	4073	44.5	23.1	140/90	Lower-middle
Gupta, 2015	2005-09	India	urban	20-75	NR	6198	55.8	31.6	140/90	lower-middle
Menon, 2015	2014	India	rural	≥18	NR	84456	51.4	11.5	140/90	lower-middle
Ranasinghe, 2015	2005-06	Sri Lanka	urban and rural	≥18	46.1±15.1	4482	39.5	26.5	140/90	lower-middle
Rahman, 2015	2011	Bangladesh	urban and rural	≥35	NR	7876		24.4	140/90	low
Bhansali, 2015	-	India	urban and rural	≥20	NR	14059	-	26.3	140/90	upper-middle

Table 6: Characteristics of included studies for the sub-Saharan Africa region

First author, year	Year of data collection	Country	Setting	Age (years)	Mean age ± SD (years)	Sample size	% Males	Hypertension prevalence (male/female)	BP cut-off (mmHg)	Country income group
Edwards, 2000	1996-97	Tanzania	urban and rural	≥15	43.0±11.0	1695	43.1	30.6(30.0/30.2)	140/90	low
Amoah, 2003	2003	Ghana	urban	≥25	NR	4733	40.0	28.3	140/90	lower-middle
Cappuccio, 2004	2001-02	Ghana	urban and rural	40-75	54.7±11.3	1013	38.0	28.7(29.9/28.0)	140/90	lower-middle
Erhun, 2004	2004	Nigeria	urban	≥18	NR	1000	66.5	21.0(23.3/16.4)	140/90	lower-middle
Agyemang, 2006	2004	Ghana	urban and rural	16 ≥50	NR	1431	45.0	29.4(31.0/28.0)	140/90	lower-middle
Kamadjeu, 2006	2003	Cameroon	urban and rural	≥15	NR	10011	40.0	24.1(25.6/23.1)	140/90	lower-middle
Duda, 2007	2000	Ghana	urban	≥18	46.8±18.0	1321[f]	-	23.7	140/90	lower-middle
Kengme, 2007	2004	Cameroon	urban	15-99	NR	2559	40.3	34.9	140/90	lower-middle
Niakara, 200	2004	Burkina Faso	urban	≥35	NR	2044	46.8	40.2(38.9/40.1)	140/90	low
Omuemu, 2007	2007	Nigeria	rural	≥15	30.7±14.6	590	60.2	20.2(24.8/13.2)	140/90	lower-middle
Thorogood, 2007	2002	South Africa	rural	≥35	NR	402	24.0	43.0(44.0/42.0)	140/90	upper-middle
Damasceno, 2009	2005	Mozambique	urban/rural	25-64	NR	3323	36.5	33.1(35.7/31.2)	140/90	low
Grimsrud, 2009	2002-04	South Africa	urban and rural	≥18	37.0	4351	46.3	16.7(10.7/23.6)	140/90	upper-middle
Tesfaye, 2009	2006	Ethiopia	urban	25-64	NR	3713	41.4	30.0(31.5/28.9)	140/90	low
Wamala, 2009	2006	Uganda	rural	≥20	39.6±15.8	842	51.0	30.4(25.4/34.0)	140/90	low
Ekwunife, 2010	2009	Nigeria	urban	≥18	34.9±13.9	756	48.1	21.1(40.3/24.7)	140/90	lower-middle
Oladapo, 2010	2002-05	Nigeria	rural	18-64	42.1±21.6	2000	43.7	20.8(21.1/20.5)	140/90	lower-middle
Sani, 2010	2006	Nigeria	urban	18-75	37.6±10.6	300	43.0	25.7(27.9/24.0)	140/90	lower-middle
Ulasi, 2010	2010	Nigeria	urban	25-64	NR	1458	48.6	32.8	140/90	lower-middle
Maher, 2011	2008-09	Uganda	rural	≥18	32.8±18.0	6678	56.6	22.0(22.5/22.6)	140/90	low
Ulasi, 2011	2010	Nigeria	urban	≥18	38.0±13.3	688	51.5	42.2(46.3/37.7)	140/90	lower-middle
Wokoma, 2011	2011	Nigeria	rural	≥15	48.9±14.8	152	40.0	27.9	140/90	lower-middle
Awoke, 2012	2012	Ethiopia	urban	≥35	51.5±14.4	679	47.6	28.3(26.0/30.3)	140/90	low
Dzudie, 2012	2011	Nigeria	urban	≥18	NR	2120	52.7	47.5(50.1/44.6)	140/90	lower-middle

First author, year	Year of data collection	Country	Setting	Age (years)	Mean age ± SD (years)	Sample size	% Males	Hypertension prevalence (male/female)	BP cut-off (mmHg)	Country income group
Hendriks, 2012	2009-11	Nigeria	rural	≥18	45.3±18.3	2678	46.6	21.0	140/90	lower-middle
Hendriks, 2012	2009-11	Kenya	rural	≥18	40.9±16.2	2111	40.1	20.2	140/90	low
Hendriks, 2012	2009-11	Tanzania	urban	≥18	36.8±11.2	1046	40.4	19.0	140/90	low
Hendriks, 2012	2009-11	Namibia	urban	≥18	36.9±13.4	1733	44.5	32.0	140/90	upper-middle
Macia, 2012	2009	Senegal	urban and rural	50-59	NR	500	52.6	65.4(63.9/67.1)	140/90	lower-middle
Mayega, 2012	2011	Uganda	rural	35-60	NR	1656	48.6	20.5(20.7/20.3)	140/90	low
Msyamboza, 2012	2009	Malawi	urban and rural	25-64	NR	3727	31.8	33.2(36.9/29.9)	140/90	low
Adebayo, 2013	2013	Nigeria	rural	15-90	32.3±14.7	1000	48.6	26.4(27.3/25.4)	140/90	lower-middle
Asekun-Olarinmoye, 2013	2011	Nigeria	rural	≥18	49.7±1.6	259	38.6	13.2(15.0/11.9)	140/90	lower-middle
Ekanem, 2013	2013	Nigeria	urban	16-65	31.7±7.6	442	51.6	47.0	140/90	lower-middle
Kandala, 2013	1998	South Africa	urban and rural	≥15	41.8±16	13596	41.8	30.4(27.4/32.6)	140/90	upper-middle
Musinguzi, 2013	2012	Uganda	urban and rural	≥15	NR	4563	35.6	21.8(21.7/22.3)	140/90	low
Ogah, 2013	2012	Nigeria	urban and rural	≥15	41.7±18.5	2928	47.8	31.0(33.5/30.5)	140/90	lower-middle
Ogunmola, 2013	2013	Nigeria	rural	≥40	66.8±12.1	104	31.7	66.4	140/90	lower-middle
Okpechi, 2013	2011-12	Nigeria	urban and rural	≥18	41.7±0.3	2983	47.9	31.4(34.9/28.1)	140/90	lower-middle
Peer, 2013	2008-09	South Africa	urban	25-64	NR	1099	35.7	38.9	140/90	upper-middle
Peltzer, 2013	2008	South Africa	urban and rural	≥50	NR	3840	42.7	77.3(74.4/79.6)	140/90	upper-middle
Pessinaba, 2013	2010	Senegal	urban	≥15	53.6±15.8	1424	31.0	46.0(41.7/47.9)	140/90	lower-middle
Awosan, 2014	2012	Nigeria	urban	20-69	35.4±8.3	390	53.0	29.1(26.2/32.4)	140/90	lower-middle
Awuah, 2014	2010-11	Ghana	urban	15-59	31.0±10.6	714	46.1	28.3(31.0/25.6)	140/90	lower-middle
Doulougou, 2014	2012	Burkina Faso	urban and rural	≥18	NR	1481	51.7	9.4(7.6/8.0)	140/90	low
Doulougou, 2014	2010	Burkina Faso	urban	≥18	NR	2041	44.3	18.6	140/90	low
Duboz, 2014	2009	Senegal	urban	NR	NR	600	-	27.5	140/90	lower-middle
Helelo, 2014	2013	Ethiopia	rural	≥31	47.4±12.2	518	44.2	22.4(26.2/19.4)	140/90	low
Lloyd-Sherlock, 2014	2007-10	Ghana	urban and rural	≥50	NR	4716	49.7	57.1(54.6/59.9)	140/90	lower-middle

First author, year	Year of data collection	Country	Setting	Age (years)	Mean age ± SD (years)	Sample size	% Males	Hypertension prevalence (male/female)	BP cut-off (mmHg)	Country income group
Lloyd-Sherlock, 2014	2007-10	South Africa	urban and rural	≥50	NR	3820	44.0	77.9(74.7/80.3)	140/90	upper-middle
Moges, 2014	2005	Ethiopia	urban	≥18	38.8±10.7	68	42.6	13.3(17.2/10.3)	140/90	low
Minicuci, 2014	2007/08	Ghana	urban and rural	≥50	NR	4724	49.7	51.1	140/90	lower-middle
Oladimeji, 2014	2012	Nigeria	urban	≥18	43.0±9.0	801	62.0	29	140/90	lower-middle
Oluyombo, 2015	2015	Nigeria	urban and rural	≥18	61.7±18.5	750	29.5	47.2	140/90	lower-middle
Abebe, 2015	2012	Ethiopia	urban and rural	≥35	47.0±12.4	2200	46.3	27.9	140/90	low
First author, year	**Year of data collection**	**Country**	**Setting**	**Age (years)**	**Mean age ± SD (years)**	**Sample size**	**% Males**	**Hypertension prevalence (male/female)**	**BP cut-off (mmHg)**	**Country income group**
Akpan, 2015	-	Nigeria	urban and rural	≥18	NR	1565	-	38	140/90	lower-middle
Angaw, 2015	2014	Ethiopia	urban	≥48	39.0±10.4	655	44.4	27.3(28.3/26.2)	140/90	low
Anteneh, 2015	2014	Ethiopia	urban	≥30	NR	678	45.6	25.1	140/90	low
Asiki, 2015	2011	Uganda	rural	≥18	NR	7741	43.7	12.3	140/90	low
Isara, 2015	2013	Nigeria	rural	≥18	NR	845	31.1	37.6(43.7/35.1)	140/90	lower-middle
Musinguzi, 2015	-	Uganda	urban and rural	≥15	34.5±15.5	4432	36.3	20.2	140/90	low
Oguoma, 2015	2014	Nigeria	urban and rural	≥18	40.6±20.6	422	35.3	35.7	140/90	lower-middle
Wandera, 2015	2010	Uganda	urban and rural	≥50	NR	2382	16.4	16.0(10.8/20.3)	140/90	low
Sowemimo, 2015	2015	Nigeria	urban	18-90	38.8±15.6	806	-	33.1(36.8/31.1)	140/90	lower-middle
Kingue, 2015	-	Cameroon	urban and rural	≥16	NR	15470	-	29.7	140/90	lower-middle
Bushara, 2015	2015	Sudan	rural	18-90	39.6±15.9	1099	41.9	38.2(36.7/39.3)	140/90	lower-middle
Seck, 2015	2015	Senegal	rural	≥18	40.9±17.2	627	40.1	23.4(24.9/22.4)	140/90	lower-middle
Ezeala-Adekaibe, 2015	2015	Nigeria	urban	≥20	NR	774	-	52.5(55.4/50.8)	140/90	lower-middle
Ibekwe, 2015	2012	Nigeria	rural	≥18	NR	272	-	21	140/90	lower-middle
Ugwuja, 2015	2015	Nigeria	rural	≥18	NR	267	-	23.2	140/90	lower-middle
Botha, 2015	2010	South Africa	urban and rural	≥18	NR	429	-	44.5	140/90	upper-middle
Sander, 2015	2007-10	Uganda	rural	-	NR	426	-	8.0	140/90	low

BP=blood pressure, f=female, SD=standard deviation, mmHg=millimetre mercury, NR=not reported in original paper. Country income group is classified according to World Bank indicators

APPENDIX VII: RISK OF BIAS ASSESSMENT FOR EACH STUDY

Publication year	First Author	Country	Selection (sampling)	Selection (sample size)	Detection (outcome exposure)	Control confounders	Detection (outcome assessment)
1994	Gupta	India	D	A	C	A	D
1995	Gupta	India	A	A	A	A	D
1995	Ibrahim	Egypt	A	B	A	A	D
1996	Kaufman	Nigeria	A	A	A	A	D
1996	Goel	India	B	B	A	A	D
1998	Singh	India	A	B	A	A	D
1998	Ordunez-Garcia	Cuba	D	B	A	A	C
1999	Malhotra	India	A	A	A	A	D
2000	Edwards	Tanzania	A	B	C	A	D
2001	Barreto	Brazil	B	A	A	A	D
2001	Gurav	India	A	A	A	A	D
2001	Shmulewitz	Federated States of Micronesia	A	A	A	A	D
2001	Freitas	Brazil	A	B	A	A	D
2001	Wu	China	A	A	B	A	C
2002	Swami	India	A	B	A	A	D
2002	Hazarika	India	D	B	A	A	D
2002	Reddy	India	B	B	B	A	C
2002	Lorenzo	Mexico	B	A	D	B	D
2002	Gupta	India	B	A	A	A	D
2002	Gu	China	B	B	A	A	D
2003	Shapo	Albania	B	A	A	A	D
2003	Amoah	Ghana	C	B	A	A	D
2003	Matos	Brazil	A	A	C	A	D
2003	Bharucha	India	A	A	A	A	D
2003	Shanthirani	India	A	A	A	A	D
2003	Deepa	India	B	A	A	A	D
2003	Hazarika	India	D	B	A	A	D
2004	Onal	Turkey	A	B	A	A	D
2004	Cappuccio	Ghana	A	B	A	A	D
2004	Gus	Brazil	B	B	A	A	D
2004	Lim	Malaysia	A	A	A	A	D
2004	Gupta	India	C	B	A	A	D
2004	Hazarika	India	D	B	A	A	D
2005	Erhun	Nigeria	B	B	A	A	D
2005	Ordunez	Cuba	B	B	A	A	D
2005	Ahmad	Pakistan	B	A	C	A	C
2005	Siddiqui	Pakistan	A	A	A	A	D
2005	Das	India	A	B	A	A	D
2005	Prabhakaran	India	B	B	A	A	D
2006	Bahrami	Iran	A	A	A	A	D
2006	Agyemang	Ghana	B	B	A	A	D
2006	Lessa	Brazil	A	A	A	A	D
2006	Jean-Baptiste	Haiti	D	B	A	A	D
2006	Kamadjeu	Cameroon	A	A	A	A	D
2006	Minh	Vietnam	A	A	A	A	D
2006	Almeida-Pititto	Brazil	A	A	A	A	D
2006	Mishra	Uzbekistan	A	A	A	A	D
2006	Thankappan	India	A	A	A	A	D
2007	Jardim	Brazil	B	B	C	A	C
2007	Niakara	Burkina Faso	B	B	A	A	D
2007	Medina-Lezama	Peru	C	B	A	A	D
2007	Duda	Ghana	A	A	A	A	D
2007	Kengme	Cameroon	B	B	A	A	D

Publication year	First Author	Country	Selection (sampling)	Selection (sample size)	Detection (outcome exposure)	Control confounders	Detection (outcome assessment)
2007	Thorogood	South Africa	D	A	A	A	D
2007	Omuemu	Nigeria	A	B	A	A	D
2007	Vaidya	Nepal	B	A	A	A	D
2007	Mohan	India	A	A	A	A	D
2007	Wijewardene	SriLanka	B	A	A	A	D
2007	Reddyet	India	B	A	A	A	D
2007	Gupta	India	D	B	A	A	D
2007	Chaturvedi	India	A	B	B	A	D
2008	Rampal	Malaysia	D	B	A	A	D
2008	Ordunez	Cuba	C	B	B	A	D
2008	Capilheira	Brazil	A	B	A	A	D
2008	Sun	China	A	A	A	A	D
2008	Sparrenberger	Brazil	A	A	A	A	D
2008	Erem	Turkey	A	A	A	A	D
2008	Agrawal	India	D	B	A	A	D
2008	Yadav	India	D	B	A	A	D
2009	Azimi-Nezhad	Iran	A	A	A	A	D
2009	Ramezani	Iran	D	B	C	A	D
2009	Longo	Brazil	D	B	A	A	D
2009	Rosario	Brazil	B	A	A	A	D
2009	Zhang	China	A	B	B	A	D
2009	Rodrigues	Brazil	B	B	B	A	C
2009	Reichert	Brazil	B	B	B	A	C
2009	Diaz	Cuba	B	B	B	A	C
2009	Grimsrud	South Africa	B	B	B	A	C
2009	Wamala	Uganda	B	B	B	A	C
2009	Tesfaye	Ethiopia	B	B	B	A	C
2009	Damasceno	Mozambique	B	B	B	A	C
2009	Kusuma	India	B	B	B	A	C
2009	Pednekar	India	A	B	A	A	D
2009	Pednekar	India	B	A	A	A	D
2009	Midha	India	A	B	A	A	D
2010	Ebrahimi	Iran	B	B	A	A	D
2010	Cipullo	Brazil	A	B	C	A	D
2010	Nascente	Brazil	B	B	A	A	D
2010	Lee	China	B	B	A	A	D
2010	Swaddiwudhipong	Thailand	D	B	C	A	D
2010	Thuy	Vietnam	B	B	A	A	D
2010	Wu	China	D	B	A	A	D
2010	Dorobantu	Romania	D	B	A	A	D
2010	Ulasi	Nigeria	B	A	C	A	D
2010	Ekwunife	Nigeria	B	B	A	A	D
2010	Oladapo	Nigeria	B	B	A	A	D
2010	Sani	Nigeria	A	B	A	A	D
2010	Bhardwaj	India	D	B	A	A	D
2010	Jonas	India	A	A	C	A	D
2010	Kinra	India	A	B	A	A	D
2010	Kar	India	A	B	A	A	D
2011	Maher	Uganda	A	B	A	A	D
2011	Ulasi	Nigeria	A	B	A	A	D
2011	Wokoma	Nigeria	B	B	C	A	D
2011	Chataut	Nepal	D	B	A	A	D
2011	Norboo	India	D	B	C	A	D
2011	Manimunda	India	B	B	A	A	D
2011	Thrift	India	A	B	A	A	D
2012	Lyra	Brazil	A	B	C	A	D
Publication year	First Author	Country	Selection	Selection	Detection	Control	Detection

			(sampling)	(sample size)	(outcome exposure)	confounders	(outcome assessment)
2012	Berraho	Morocco	B	B	A	A	D
2012	Hofelmann	Brazil	A	B	A	A	D
2012	Kerkhoff	Brazil	A	A	A	A	D
2012	Altun	Turkey	A	A	A	A	D
2012	Prince	Cuba	D	B	A	A	D
2012	Dogan	Turkey	C	B	A	A	D
2012	Prince	Dominican Republic	A	A	C	A	D
2012	Prince	Peru	A	B	A	A	D
2012	Prince	Venezuela	A	B	A	A	D
2012	Prince	Mexico	A	B	A	A	D
2012	Prince	China	A	B	A	A	D
2012	Macia	Senegal	A	B	A	A	D
2012	Awoke	Ethiopia	B	A	A	A	D
2012	Mayega	Uganda	B	B	A	A	D
2012	Msyamboza	Malawi	A	B	C	A	D
2012	Hendriks	Nigeria	B	B	A	A	D
2012	Hendriks	Kenya	D	A	A	A	D
2012	Hendriks	Tanzania	D	B	A	A	D
2012	Hendriks	Namibia	D	B	A	A	D
2012	Dzudie	Cameroon	B	B	C	A	D
2012	Oladimeji	Nigeria	A	A	A	A	D
2012	Bharati	India	D	B	A	A	D
2012	Bansal	India	A	A	A	A	D
2012	Vaidya	Nepal	D	B	A	A	D
2012	Vaidya	Nepal	A	A	A	A	D
2012	Esam	India	D	B	A	A	D
2012	Dutta	India	D	A	A	B	D
2012	Prasad	India	D	B	A	A	D
2012	Prince	India	D	B	C	B	D
2012	Meshram	India	A	B	A	B	D
2012	Samuel	India	A	B	C	A	D
2012	Kaur	India	D	B	A	A	D
2012	Jeemon	India	A	B	A	A	D
2012	Gupta	India	D	A	A	A	D
2012	Gupta	India	A	A	A	B	D
2012	Chinnakali	India	B	B	A	B	D
2012	Kokiwar	India	A	B	A	A	D
2012	Borah	India	A	B	A	B	D
2012	Kaur	India	B	B	A	B	D
2013	Modesti	Yemen	A	B	A	A	D
2013	Harhay	Albania	B	B	A	A	D
2013	Harhay	Armenia	A	B	A	B	D
2013	Harhay	Azerbaijan	A	B	A	A	D
2013	Mendes	Brazil	B	B	A	A	D
2013	Selem	Brazil	A	A	C	A	D
2013	Ha	Vietnam	A	B	A	A	D
2013	Kiau	Malaysia	A	B	A	A	D
2013	Silva	Brazil	A	B	A	A	D
2013	Harhay	Ukraine	A	B	A	A	D
2013	Ogah	Nigeria	A	B	A	A	D
2013	Pessinaba	Senegal	B	A	A	A	D
2013	Peltzer	South Africa	B	B	A	A	D
2013	Kandala	South Africa	A	B	C	A	D
2013	Asekun-Olarinmoye	Nigeria	B	B	A	A	D
2013	Okpechi	Nigeria	D	A	A	A	D
2013	Veghari	Iran	D	B	A	A	D

Publication year	First Author	Country	Selection (sampling)	Selection (sample size)	Detection (outcome exposure)	Control confounders	Detection (outcome assessment)
2013	Ogunmola	Nigeria	D	B	A	A	D
2013	Ekanem	Nigeria	B	B	C	A	D
2013	Adebayo	Nigeria	A	A	A	A	D
2013	Peer	South Africa	D	B	A	A	D
2013	Musinguzi	Uganda	A	A	A	A	D
2013	Bhagyalaxmi	India	D	B	A	A	D
2013	Gupta	India	A	A	A	A	D
2013	Khan	Nepal	D	B	A	A	D
2014	Wang	China	D	A	A	B	D
2014	Feng	China	D	B	A	A	D
2014	Lloyd-Sherlock	China	D	B	C	B	D
2014	Fan	China	A	B	A	B	D
2014	Posso	Panama	A	B	C	A	D
2014	Awosan	Nigeria	D	B	A	A	D
2014	Lloyd-Sherlock	Ghana	A	B	A	A	D
2014	Lloyd-Sherlock	South Africa	D	A	A	A	D
2014	Helelo	Ethiopia	A	A	A	B	D
2014	Moges	Ethiopia	B	B	A	B	D
2014	Duboz	Senegal	A	B	A	A	D
2014	Doulougou	Burkina Faso	A	B	A	B	D
2014	Awuah	Ghana	B	B	A	B	D
2014	Doulougou	Burkina Faso	A	B	A	A	D
2014	Oluyombo	Nigeria	B	B	A	A	D
2014	Nguyen	Vietnam	A	B	A	B	D
2014	Lloyd-Sherlock	Mexico	A	B	A	A	D
2014	Amiri	Malaysia	B	B	A	A	D
2014	Zhao	China	A	A	C	A	D
2014	Adhikari	Nepal	A	B	A	A	D
2014	Lloyd-Sherlock	India	A	B	A	A	D
2014	Zaman	Bangladesh	A	B	A	A	D
2015	Abebe	Ethiopia	A	B	A	A	D
2015	Akpan	Nigeria	A	B	A	A	D
2015	Angaw	Ethiopia	B	A	A	A	D
2015	Bernabe Ortiz	Peru	B	B	A	A	D
2015	Bresan	Brazil	A	B	C	A	D
2015	De Souza	Brazil	B	B	A	A	D
2015	Anteneh	Ethiopia	D	A	A	A	D
2015	Asiki	Uganda	D	B	A	A	D
2015	Isara	Nigeria	D	B	A	A	D
2015	Muusinguzi	Uganda	B	B	C	A	D
2015	Khalifeh	Lebanon	A	A	A	A	D
2015	Matar	Lebanon	D	B	A	A	D
2015	Minicuci	Ghana	A	A	A	A	D
2015	Sepanlou	Iran	D	B	A	A	D
2015	Supiyev	Kazakhstan	A	A	A	A	D
2015	Oguoma	Nigeria	D	B	A	A	D
2015	Wandera	Uganda	D	A	A	B	D
2015	Hou	China	D	B	A	A	D
2015	Chen	China	D	B	C	B	D
2015	Lim	China	A	B	A	B	D
2015	Iazdanpanah	Iran	A	B	C	A	D
2015	Wang	China	D	B	A	A	D
2015	Sowemimo	Nigeria	A	B	A	A	D
2015	Guo	China	D	A	A	A	D
2015	Kingue	Cameroon	A	A	A	B	D
2015	Bushara	Sudan	B	B	A	B	D
Publication year	First Author	Country	Selection	Selection	Detection	Control	Detection

			(sampling)	(sample size)	(outcome exposure)	confounders	(outcome assessment)
2015	Seck	Senegal	A	B	A	A	D
2015	Ezeala-Adekaibe	Nigeria	A	B	A	B	D
2015	Li	China	B	B	A	B	D
2015	Unger	Brazil	A	B	A	A	D
2015	Ibekwe	Nigeria	B	B	A	A	D
2015	Ugwuja	Nigeria	A	B	A	A	D
2015	Botha	South Africa	A	A	A	A	D
2015	Vieira	Brazil	A	A	A	A	D
2015	Gu	China	A	A	A	A	D
2015	Almeida	Brazil	D	B	A	A	D
2015	Sander	Uganda	D	B	A	A	D
2015	Lu	China	A	A	A	A	D
2015	Ke	China	D	B	C	A	D
2015	Wei	China	D	B	A	A	D
2015	Do	Vietnam	B	A	A	A	D
2015	Gupta	India	A	B	B	A	D
2015	Menon	India	B	B	B	A	C
2015	Ranasighe	Sri Lanka	B	B	B	A	C
2015	Rahman	Bangladesh	B	B	B	A	C
2015	Bhansali	India	B	B	B	A	C

APPENDIX VIII: SUPPLEMENTARY FIGURES 1-11 SHOWING SUBGROUP ANALYSIS

Figure 1: Prevalence estimate of hypertension in the Latin America and Caribbean region

Pooled estimate of hypertension prevalence (39.1%) is displayed in forest plot. I^2 is greater than 75%, suggesting considerable heterogeneity across included studies. However, prevalence estimates were pooled using random effects meta-analysis. ES=effect size.

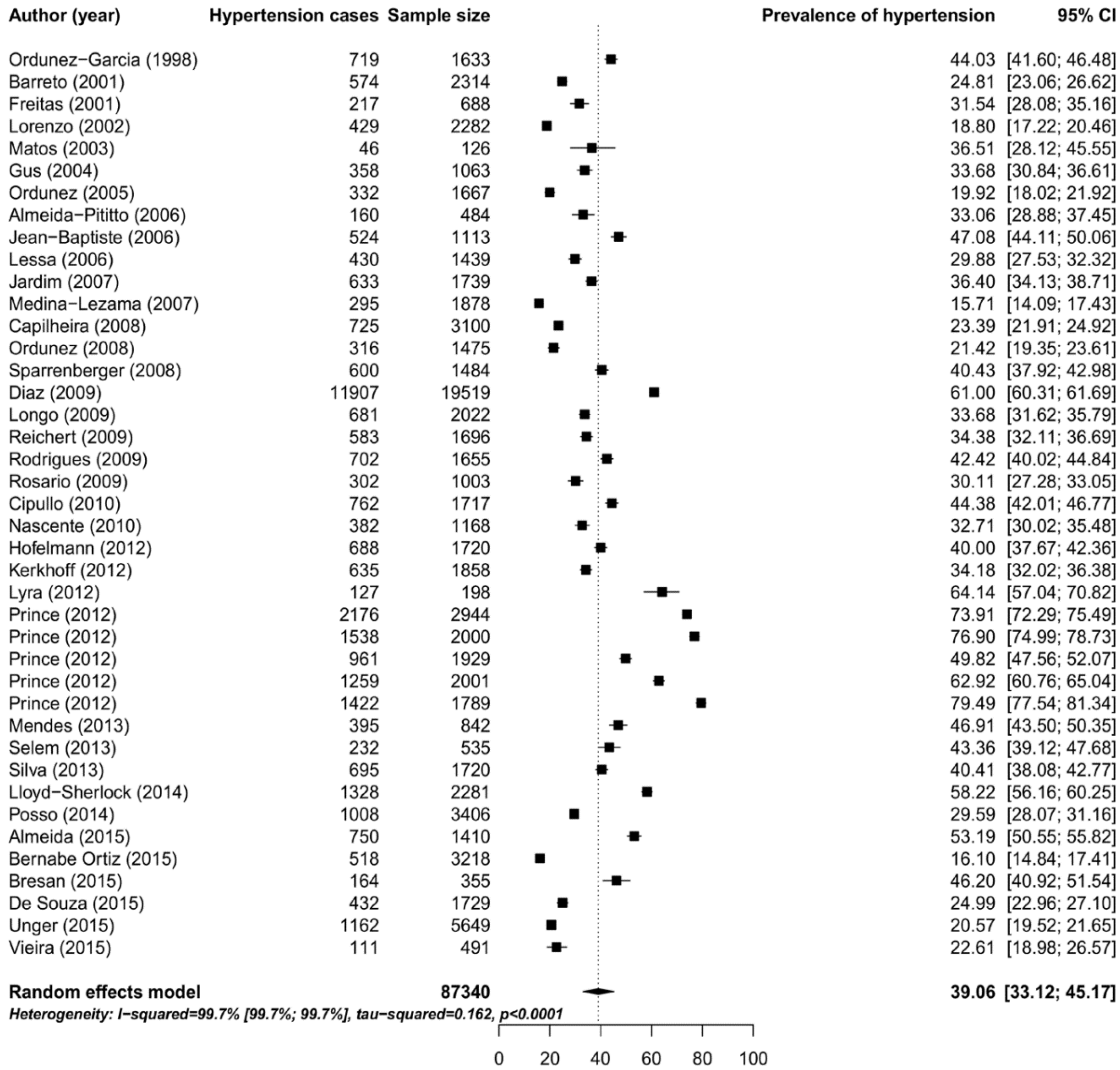


Figure 2: Prevalence estimate of hypertension in the Middle East and North Africa region

Pooled estimate of hypertension prevalence (26.9%) is displayed in forest plot. I^2 is greater than 75%, suggesting considerable heterogeneity across included studies.

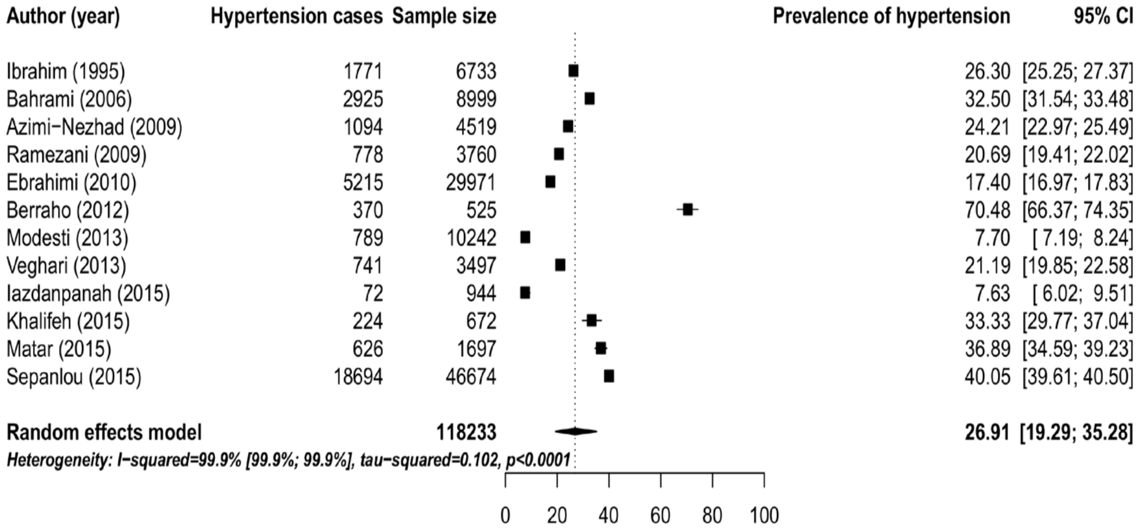


Figure 3: Prevalence estimate of hypertension in the East Asia and Pacific region

Pooled estimate of hypertension prevalence (35.8%) is displayed in forest plot. I^2 greater than 75% suggesting considerable heterogeneity across included studies.

Author (year)	Hypertension cases	Sample size	Prevalence of hypertension	95% CI
Shmulewitz (2001)	372	2188	17.00	[15.45; 18.64]
Wu (2001)	1358	2272	59.77	[57.72; 61.80]
Gu (2002)	3287	13199	24.90	[24.17; 25.65]
Lim (2004)	7059	21391	33.00	[32.37; 33.63]
Minh (2006)	281	1996	14.08	[12.58; 15.68]
Rampal (2008)	4570	16440	27.80	[27.11; 28.49]
Sun (2008)	17929	45390	39.50	[39.05; 39.95]
Zhang (2009)	2008	4141	48.49	[46.96; 50.03]
Lee (2010)	9852	39252	25.10	[24.67; 25.53]
Swaddiwudhipong (2010)	1571	5273	29.79	[28.56; 31.05]
Thuy (2010)	320	910	35.16	[32.06; 38.37]
Wu (2010)	869	2074	41.90	[39.76; 44.06]
Prince (2012)	1303	2157	60.41	[58.31; 62.48]
Ha (2013)	552	2368	23.31	[21.62; 25.07]
Kiau (2013)	3650	4933	73.99	[72.74; 75.21]
Amiri (2014)	431	1096	39.32	[36.42; 42.29]
Fan (2014)	4673	18772	24.89	[24.28; 25.52]
Feng (2014)	5295	13707	38.63	[37.81; 39.45]
Lloyd−Sherlock (2014)	7942	13348	59.50	[58.66; 60.33]
Nguyen (2014)	442	3779	11.70	[10.69; 12.76]
Wang (2014)	11905	37141	32.05	[31.58; 32.53]
Zhao (2014)	3086	6324	48.80	[47.56; 50.04]
Chen (2015)	850	2208	38.50	[36.46; 40.56]
Do (2015)	3560	17199	20.70	[20.10; 21.31]
Gu (2015)	2922	7137	40.94	[39.80; 42.09]
Guo (2015)	6981	24410	28.60	[28.03; 29.17]
Hou (2015)	1754	3797	46.19	[44.60; 47.80]
Ke (2015)	479	1410	33.97	[31.50; 36.51]
Li (2015)	545	2026	26.90	[24.98; 28.89]
Lim (2015)	22060	58985	37.40	[37.01; 37.79]
Lu (2015)	1477	4675	31.59	[30.26; 32.95]
Wang (2015)	6372	15172	42.00	[41.21; 42.79]
Wei (2015)	1549	3778	41.00	[39.43; 42.59]
Random effects model		**398948**	**35.75**	**[32.15; 39.43]**

Heterogeneity: I−squared=99.8% [99.8%; 99.8%], tau−squared=0.0493, p<0.0001

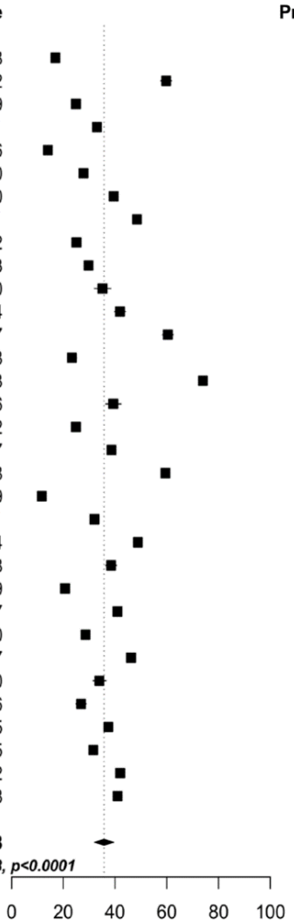


Figure 4: Prevalence estimate of hypertension in the Sub-Saharan Africa region

Pooled estimate of hypertension prevalence (31.0%) is displayed in forest plot. I^2 greater than 75% suggesting considerable heterogeneity across included studies.

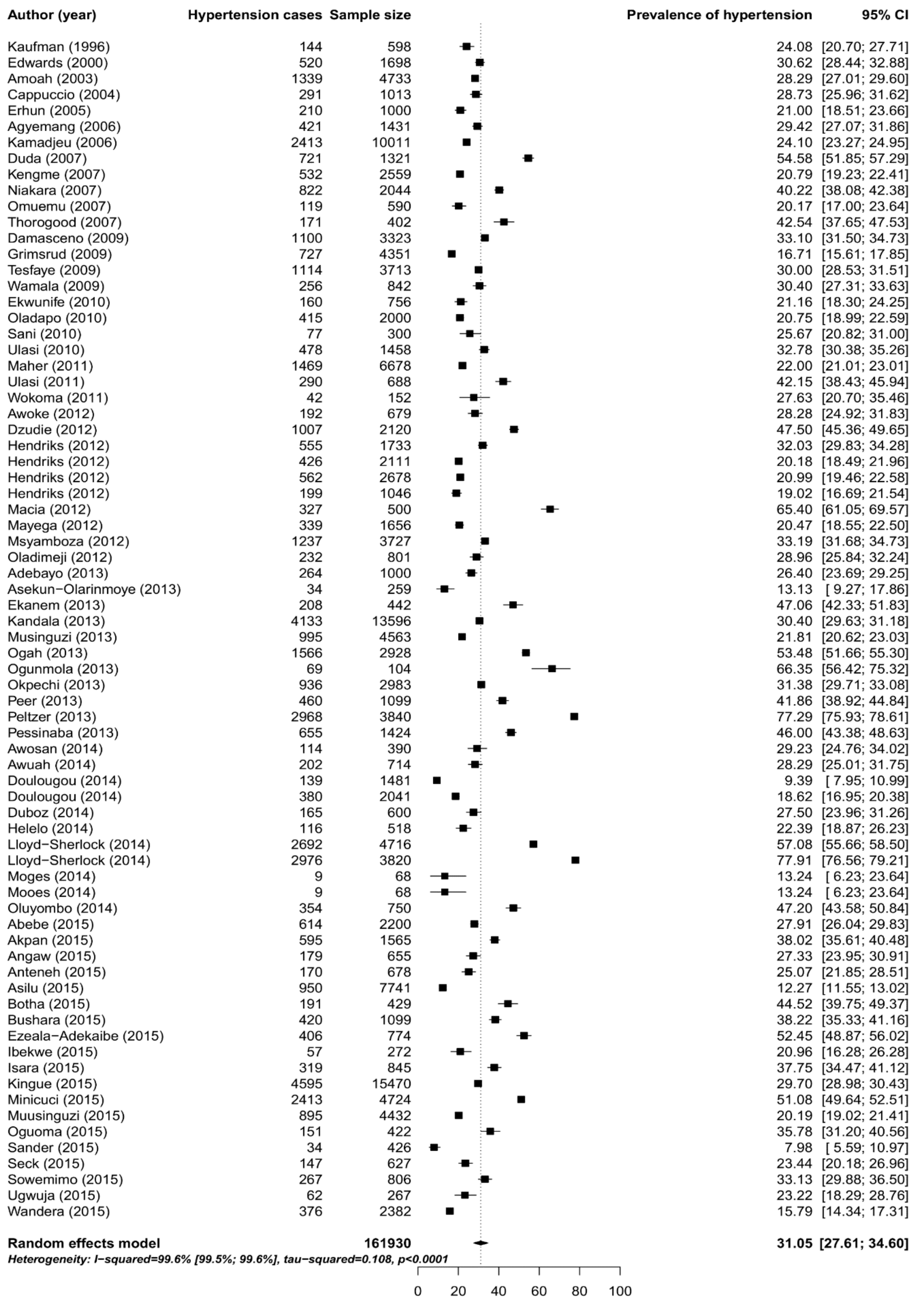


Figure 5: Prevalence estimate of hypertension in the Europe and Central Asia region

Pooled estimate of hypertension prevalence (31.5%) is displayed in forest plot. I^2 greater than 75% suggesting considerable heterogeneity across included studies.

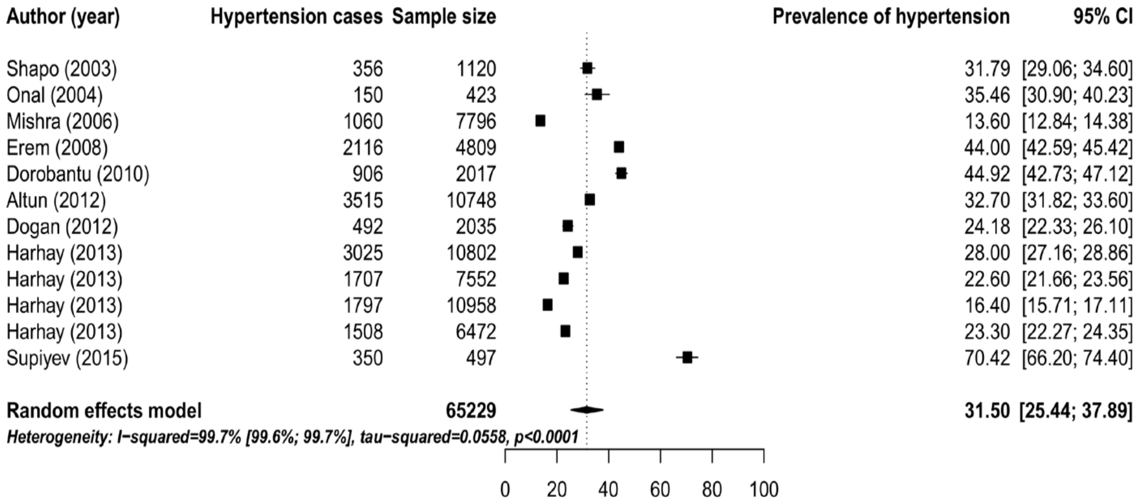


Figure 6: Prevalence estimate of hypertension in the South Asia region

Pooled estimate of hypertension prevalence (29.4%) is displayed in forest plot. I^2 greater than 75% suggesting considerable heterogeneity across included studies.

Author (year)	Hypertension cases	Sample size	Prevalence of hypertension	95% CI
Gupta (1994)	674	3148	21.41	[19.99; 22.89]
Gupta (1995)	688	2122	32.42	[30.43; 34.46]
Goel (1996)	113	1572	7.19	[5.96; 8.58]
Singh (1998)	822	3212	25.59	[24.09; 27.14]
Malhotra (1999)	114	2559	4.45	[3.69; 5.33]
Gurav (2001)	199	1432	13.90	[12.15; 15.80]
Gupta (2002)	415	1123	36.95	[34.12; 39.85]
Hazarika (2002)	617	1015	60.79	[57.71; 63.81]
Reddy (2002)	924	3307	27.94	[26.42; 29.50]
Swami (2002)	210	362	58.01	[52.74; 63.15]
Bharucha (2003)	879	2415	36.40	[34.48; 38.35]
Deepa (2003)	279	1262	22.11	[19.85; 24.50]
Hazarika (2003)	565	888	63.63	[60.36; 66.80]
Shanthirani (2003)	266	1262	21.08	[18.86; 23.43]
Gupta (2004)	42591	88653	48.04	[47.71; 48.37]
Hazarika (2004)	1059	3180	33.30	[31.66; 34.97]
Ahmad (2005)	1745	8432	20.69	[19.83; 21.58]
Das (2005)	401	1609	24.92	[22.82; 27.11]
Prabhakaran (2005)	637	2122	30.02	[28.07; 32.02]
Siddiqui (2005)	49	327	14.98	[11.30; 19.32]
Thankappan (2006)	1818	4955	36.69	[35.35; 38.05]
Chaturvedi (2007)	1039	2318	44.82	[42.78; 46.87]
Gupta (2007)	591	1127	52.44	[49.48; 55.39]
Mohan (2007)	470	2350	20.00	[18.40; 21.68]
Reddyet (2007)	6751	19975	33.80	[33.14; 34.46]
Vaidya (2007)	227	1000	22.70	[20.14; 25.42]
Wijewardene (2007)	1155	6047	19.10	[18.12; 20.11]
Agrawal (2008)	136	406	33.50	[28.92; 38.32]
Yadav (2008)	116	294	39.46	[33.83; 45.30]
Kusuma (2009)	83	453	18.32	[14.87; 22.20]
Midha (2009)	189	800	23.62	[20.72; 26.73]
Pednekar (2009)	132144	146827	90.00	[89.85; 90.15]
Pednekar (2009)	68498	148173	46.23	[45.97; 46.48]
Bhardwaj (2010)	392	1092	35.90	[33.05; 38.82]
Jonas (2010)	1041	4711	22.10	[20.92; 23.31]
Kar (2010)	143	400	35.75	[31.05; 40.66]
Kinra (2010)	401	1983	20.22	[18.47; 22.06]
Chataut (2011)	118	527	22.39	[18.90; 26.19]
Manimunda (2011)	492	975	50.46	[47.27; 53.65]
Norboo (2011)	1037	2800	37.04	[35.24; 38.86]
Thrift (2011)	169	1479	11.43	[9.85; 13.16]
Bansal (2012)	313	968	32.33	[29.39; 35.38]
Bharati (2012)	236	856	27.57	[24.60; 30.70]
Borah (2012)	407	916	44.43	[41.18; 47.72]
Chinnakali (2012)	85	211	40.28	[33.61; 47.24]
Dutta (2012)	293	1186	24.70	[22.27; 27.26]
Esam (2012)	138	504	27.38	[23.53; 31.50]
Gupta (2012)	1672	4073	41.05	[39.53; 42.58]
Gupta (2012)	248	739	33.56	[30.16; 37.09]
Jeemon (2012)	3564	10543	33.80	[32.90; 34.72]
Kaur (2012)	2247	10463	21.48	[20.69; 22.28]
Kaur (2012)	108	600	18.00	[15.01; 21.31]
Kokiwar (2012)	176	924	19.05	[16.56; 21.73]
Meshram (2012)	1671	4192	39.86	[38.38; 41.36]
Prasad (2012)	431	1178	36.59	[33.83; 39.41]
Prince (2012)	1133	1977	57.31	[55.09; 59.50]
Samuel (2012)	55	2218	2.48	[1.87; 3.22]
Vaidya (2012)	412	1218	33.83	[31.17; 36.56]
Vaidya (2012)	112	641	17.47	[14.61; 20.64]
Bhagyalaxmi (2013)	785	3489	22.50	[21.12; 23.92]
Gupta (2013)	2613	6106	42.79	[41.55; 44.05]
Khan (2013)	55	1679	3.28	[2.48; 4.24]
Adhikari (2014)	276	1240	22.26	[19.97; 24.68]
Lloyd−Sherlock (2014)	2338	7238	32.30	[31.22; 33.39]
Zaman (2014)	941	4073	23.10	[21.82; 24.43]
Bhansali (2015)	3698	14059	26.30	[25.58; 27.04]
Gupta (2015)	1959	6198	31.61	[30.45; 32.78]
Menon (2015)	5005	84456	5.93	[5.77; 6.09]
Rahman (2015)	1922	7876	24.40	[23.46; 25.37]
Ranasighe (2015)	1189	4482	26.53	[25.24; 27.85]
Random effects model		**662997**	**29.40**	**[22.34; 37.00]**

Heterogeneity: I−squared=100% [100%; 100%], tau−squared=0.4741, p<0.0001

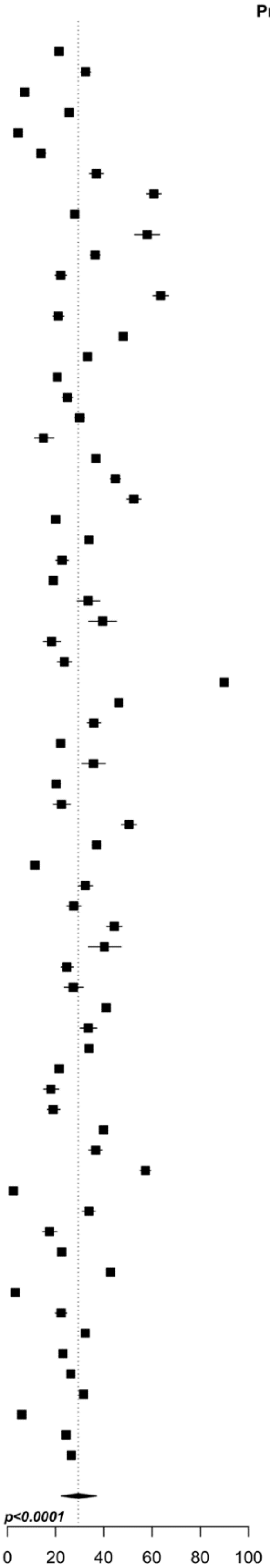


Figure 7: Prevalence estimate of hypertension in upper-middle income countries

Pooled estimate of hypertension prevalence (37.8%) is displayed in forest plot. I^2 greater than 75% suggesting considerable heterogeneity across included studies.

Author (year)	Hypertension cases	Sample size	Prevalence of hypertension	95% CI
Ordunez−Garcia (1998)	719	1633	44.03	[41.60; 46.48]
Barreto (2001)	574	2314	24.81	[23.06; 26.62]
Freitas (2001)	217	688	31.54	[28.08; 35.16]
Wu (2001)	1358	2272	59.77	[57.72; 61.80]
Gu (2002)	3287	13199	24.90	[24.17; 25.65]
Lorenzo (2002)	429	2282	18.80	[17.22; 20.46]
Matos (2003)	46	126	36.51	[28.12; 45.55]
Shapo (2003)	356	1120	31.79	[29.06; 34.60]
Gus (2004)	358	1063	33.68	[30.84; 36.61]
Lim (2004)	7059	21391	33.00	[32.37; 33.63]
Onal (2004)	150	423	35.46	[30.90; 40.23]
Ordunez (2005)	332	1667	19.92	[18.02; 21.92]
Almeida−Pititto (2006)	160	484	33.06	[28.88; 37.45]
Bahrami (2006)	2925	8999	32.50	[31.54; 33.48]
Lessa (2006)	430	1439	29.88	[27.53; 32.32]
Jardim (2007)	633	1739	36.40	[34.13; 38.71]
Medina−Lezama (2007)	295	1878	15.71	[14.09; 17.43]
Thorogood (2007)	171	402	42.54	[37.65; 47.53]
Capilheira (2008)	725	3100	23.39	[21.91; 24.92]
Erem (2008)	2116	4809	44.00	[42.59; 45.42]
Ordunez (2008)	316	1475	21.42	[19.35; 23.61]
Rampal (2008)	4570	16440	27.80	[27.11; 28.49]
Sparrenberger (2008)	600	1484	40.43	[37.92; 42.98]
Sun (2008)	17929	45390	39.50	[39.05; 39.95]
Azimi−Nezhad (2009)	1094	4519	24.21	[22.97; 25.49]
Grimsrud (2009)	727	4351	16.71	[15.61; 17.85]
Longo (2009)	681	2022	33.68	[31.62; 35.79]
Ramezani (2009)	778	3760	20.69	[19.41; 22.02]
Reichert (2009)	583	1696	34.38	[32.11; 36.69]
Rodrigues (2009)	702	1655	42.42	[40.02; 44.84]
Rosario (2009)	302	1003	30.11	[27.28; 33.05]
Zhang (2009)	2008	4141	48.49	[46.96; 50.03]
Cipullo (2010)	762	1717	44.38	[42.01; 46.77]
Dorobantu (2010)	906	2017	44.92	[42.73; 47.12]
Ebrahimi (2010)	5215	29971	17.40	[16.97; 17.83]
Lee (2010)	9852	39252	25.10	[24.67; 25.53]
Nascente (2010)	382	1168	32.71	[30.02; 35.48]
Swaddiwudhipong (2010)	1571	5273	29.79	[28.56; 31.05]
Wu (2010)	869	2074	41.90	[39.76; 44.06]
Altun (2012)	3515	10748	32.70	[31.82; 33.60]
Dogan (2012)	492	2035	24.18	[22.33; 26.10]
Hendriks (2012)	555	1733	32.03	[29.83; 34.28]
Hofelmann (2012)	688	1720	40.00	[37.67; 42.36]
Kerkhoff (2012)	635	1858	34.18	[32.02; 36.38]
Lyra (2012)	127	198	64.14	[57.04; 70.82]
Prince (2012)	2176	2944	73.91	[72.29; 75.49]
Prince (2012)	1538	2000	76.90	[74.99; 78.73]
Prince (2012)	1422	1789	79.49	[77.54; 81.34]
Prince (2012)	1303	2157	60.41	[58.31; 62.48]
Prince (2012)	1259	2001	62.92	[60.76; 65.04]
Prince (2012)	961	1929	49.82	[47.56; 52.07]
Harhay (2013)	1797	10958	16.40	[15.71; 17.11]
Harhay (2013)	1508	6472	23.30	[22.27; 24.35]
Kandala (2013)	4133	13596	30.40	[29.63; 31.18]
Kiau (2013)	3650	4933	73.99	[72.74; 75.21]
Mendes (2013)	395	842	46.91	[43.50; 50.35]
Peer (2013)	460	1099	41.86	[38.92; 44.84]
Peltzer (2013)	2968	3840	77.29	[75.93; 78.61]
Selem (2013)	232	535	43.36	[39.12; 47.68]
Silva (2013)	695	1720	40.41	[38.08; 42.77]
Veghari (2013)	741	3497	21.19	[19.85; 22.58]
Amiri (2014)	431	1096	39.32	[36.42; 42.29]
Fan (2014)	4673	18772	24.89	[24.28; 25.52]
Feng (2014)	5295	13707	38.63	[37.81; 39.45]
Lloyd−Sherlock (2014)	7942	13348	59.50	[58.66; 60.33]
Lloyd−Sherlock (2014)	1328	2281	58.22	[56.16; 60.25]
Lloyd−Sherlock (2014)	2976	3820	77.91	[76.56; 79.21]
Posso (2014)	1008	3406	29.59	[28.07; 31.16]
Wang (2014)	11905	37141	32.05	[31.58; 32.53]
Zhao (2014)	3086	6324	48.80	[47.56; 50.04]
Almeida (2015)	750	1410	53.19	[50.55; 55.82]
Bernabe Ortiz (2015)	518	3218	16.10	[14.84; 17.41]
Botha (2015)	191	429	44.52	[39.75; 49.37]
Bresan (2015)	164	355	46.20	[40.92; 51.54]
Chen (2015)	850	2208	38.50	[36.46; 40.56]
Gu (2015)	2922	7137	40.94	[39.80; 42.09]
Guo (2015)	6981	24410	28.60	[28.03; 29.17]
Hou (2015)	1754	3797	46.19	[44.60; 47.80]
Iazdanpanah (2015)	72	944	7.63	[6.02; 9.51]
Ke (2015)	479	1410	33.97	[31.50; 36.51]
Khalifeh (2015)	224	672	33.33	[29.77; 37.04]
Li (2015)	545	2026	26.90	[24.98; 28.89]
Lu (2015)	1477	4675	31.59	[30.26; 32.95]
Matar (2015)	626	1697	36.89	[34.59; 39.23]
Sepanlou (2015)	18694	46674	40.05	[39.61; 40.50]
Supiyev (2015)	350	497	70.42	[66.20; 74.40]
Unger (2015)	1162	5649	20.57	[19.52; 21.65]
Vieira (2015)	111	491	22.61	[18.98; 26.57]
Wang (2015)	6372	15172	42.00	[41.21; 42.79]
Wei (2015)	1549	3778	41.00	[39.43; 42.59]
Random effects model		**545584**	**37.79**	**[35.01; 40.61]**

Heterogeneity: I−squared=99.8% [99.8%; 99.8%], tau−squared=0.0773, p<0.0001

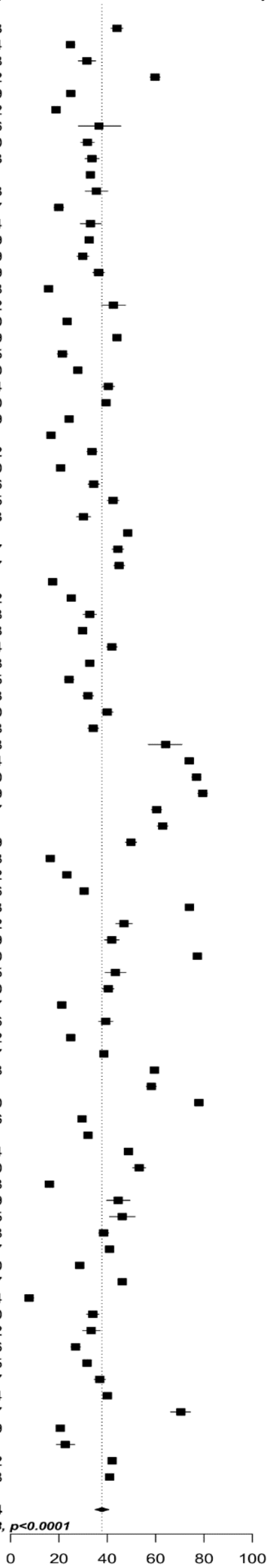
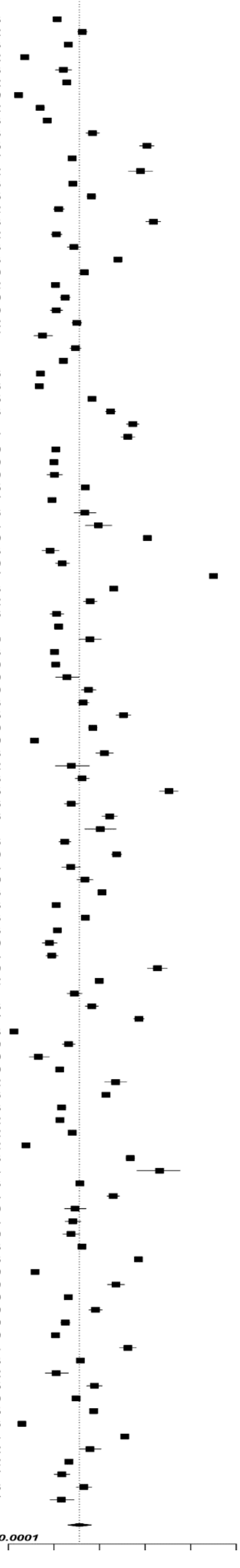


Figure 8: Prevalence estimate of hypertension in lower-middle income countries

Pooled estimate of hypertension prevalence (31.1%) is displayed in forest plot. I^2 greater than 75% suggesting considerable heterogeneity across included studies.



Author (year)	Hypertension cases	Sample size	Prevalence of hypertension	95% CI
Gupta (1994)	674	3148	21.41	[19.99; 22.89]
Gupta (1995)	688	2122	32.42	[30.43; 34.46]
Ibrahim (1995)	1771	6733	26.30	[25.25; 27.37]
Goel (1996)	113	1572	7.19	[5.96; 8.58]
Kaufman (1996)	144	598	24.08	[20.70; 27.71]
Singh (1998)	822	3212	25.59	[24.09; 27.14]
Malhotra (1999)	114	2559	4.45	[3.69; 5.33]
Gurav (2001)	199	1432	13.90	[12.15; 15.80]
Shmulewitz (2001)	372	2188	17.00	[15.45; 18.64]
Gupta (2002)	415	1123	36.95	[34.12; 39.85]
Hazarika (2002)	617	1015	60.79	[57.71; 63.81]
Reddy (2002)	924	3307	27.94	[26.42; 29.50]
Swami (2002)	210	362	58.01	[52.74; 63.15]
Amoah (2003)	1339	4733	28.29	[27.01; 29.60]
Bharucha (2003)	879	2415	36.40	[34.48; 38.35]
Deepa (2003)	279	1262	22.11	[19.85; 24.50]
Hazarika (2003)	565	888	63.63	[60.36; 66.80]
Shanthirani (2003)	266	1262	21.08	[18.86; 23.43]
Cappuccio (2004)	291	1013	28.73	[25.96; 31.62]
Gupta (2004)	42591	88653	48.04	[47.71; 48.37]
Hazarika (2004)	1059	3180	33.30	[31.66; 34.97]
Ahmad (2005)	1745	8432	20.69	[19.83; 21.58]
Das (2005)	401	1609	24.92	[22.82; 27.11]
Erhun (2005)	210	1000	21.00	[18.51; 23.66]
Prabhakaran (2005)	637	2122	30.02	[28.07; 32.02]
Siddiqui (2005)	49	327	14.98	[11.30; 19.32]
Agyemang (2006)	421	1431	29.42	[27.07; 31.86]
Kamadjeu (2006)	2413	10011	24.10	[23.27; 24.95]
Minh (2006)	281	1996	14.08	[12.58; 15.68]
Mishra (2006)	1060	7796	13.60	[12.84; 14.38]
Thankappan (2006)	1818	4955	36.69	[35.35; 38.05]
Chaturvedi (2007)	1039	2318	44.82	[42.78; 46.87]
Duda (2007)	721	1321	54.58	[51.85; 57.29]
Gupta (2007)	591	1127	52.44	[49.48; 55.39]
Kengme (2007)	532	2559	20.79	[19.23; 22.41]
Mohan (2007)	470	2350	20.00	[18.40; 21.68]
Omuemu (2007)	119	590	20.17	[17.00; 23.64]
Reddyet (2007)	6751	19975	33.80	[33.14; 34.46]
Wijewardene (2007)	1155	6047	19.10	[18.12; 20.11]
Agrawal (2008)	136	406	33.50	[28.92; 38.32]
Yadav (2008)	116	294	39.46	[33.83; 45.30]
Diaz (2009)	11907	19519	61.00	[60.31; 61.69]
Kusuma (2009)	83	453	18.32	[14.87; 22.20]
Midha (2009)	189	800	23.62	[20.72; 26.73]
Pednekar (2009)	132144	146827	90.00	[89.85; 90.15]
Pednekar (2009)	68498	148173	46.23	[45.97; 46.48]
Bhardwaj (2010)	392	1092	35.90	[33.05; 38.82]
Ekwunife (2010)	160	756	21.16	[18.30; 24.25]
Jonas (2010)	1041	4711	22.10	[20.92; 23.31]
Kar (2010)	143	400	35.75	[31.05; 40.66]
Kinra (2010)	401	1983	20.22	[18.47; 22.06]
Oladapo (2010)	415	2000	20.75	[18.99; 22.59]
Sani (2010)	77	300	25.67	[20.82; 31.00]
Thuy (2010)	320	910	35.16	[32.06; 38.37]
Ulasi (2010)	478	1458	32.78	[30.38; 35.26]
Manimunda (2011)	492	975	50.46	[47.27; 53.65]
Norboo (2011)	1037	2800	37.04	[35.24; 38.86]
Thrift (2011)	169	1479	11.43	[9.85; 13.16]
Ulasi (2011)	290	688	42.15	[38.43; 45.94]
Wokoma (2011)	42	152	27.63	[20.70; 35.46]
Bansal (2012)	313	968	32.33	[29.39; 35.38]
Berraho (2012)	370	525	70.48	[66.37; 74.35]
Bharati (2012)	236	856	27.57	[24.60; 30.70]
Borah (2012)	407	916	44.43	[41.18; 47.72]
Chinnakali (2012)	85	211	40.28	[33.61; 47.24]
Dutta (2012)	293	1186	24.70	[22.27; 27.26]
Dzudie (2012)	1007	2120	47.50	[45.36; 49.65]
Esam (2012)	138	504	27.38	[23.53; 31.50]
Gupta (2012)	248	739	33.56	[30.16; 37.09]
Gupta (2012)	1672	4073	41.05	[39.53; 42.58]
Hendriks (2012)	562	2678	20.99	[19.46; 22.58]
Jeemon (2012)	3564	10543	33.80	[32.90; 34.72]
Kaur (2012)	2247	10463	21.48	[20.69; 22.28]
Kaur (2012)	108	600	18.00	[15.01; 21.31]
Kokiwar (2012)	176	924	19.05	[16.56; 21.73]
Macia (2012)	327	500	65.40	[61.05; 69.57]
Meshram (2012)	1671	4192	39.86	[38.38; 41.36]
Oladimeji (2012)	232	801	28.96	[25.84; 32.24]
Prasad (2012)	431	1178	36.59	[33.83; 39.41]
Prince (2012)	1133	1977	57.31	[55.09; 59.50]
Samuel (2012)	55	2218	2.48	[1.87; 3.22]
Adebayo (2013)	264	1000	26.40	[23.69; 29.25]
Asekun−Olarinmoye (2013)	34	259	13.13	[9.27; 17.86]
Bhagyalaxmi (2013)	785	3489	22.50	[21.12; 23.92]
Ekanem (2013)	208	442	47.06	[42.33; 51.83]
Gupta (2013)	2613	6106	42.79	[41.55; 44.05]
Ha (2013)	552	2368	23.31	[21.62; 25.07]
Harhay (2013)	1707	7552	22.60	[21.66; 23.56]
Harhay (2013)	3025	10802	28.00	[27.16; 28.86]
Modesti (2013)	789	10242	7.70	[7.19; 8.24]
Ogah (2013)	1566	2928	53.48	[51.66; 55.30]
Ogunmola (2013)	69	104	66.35	[56.42; 75.32]
Okpechi (2013)	936	2983	31.38	[29.71; 33.08]
Pessinaba (2013)	655	1424	46.00	[43.38; 48.63]
Awosan (2014)	114	390	29.23	[24.76; 34.02]
Awuah (2014)	202	714	28.29	[25.01; 31.75]
Duboz (2014)	165	600	27.50	[23.96; 31.26]
Lloyd−Sherlock (2014)	2338	7238	32.30	[31.22; 33.39]
Lloyd−Sherlock (2014)	2692	4716	57.08	[55.66; 58.50]
Nguyen (2014)	442	3779	11.70	[10.69; 12.76]
Oluyombo (2014)	354	750	47.20	[43.58; 50.84]
Bhansali (2015)	3698	14059	26.30	[25.58; 27.04]
Bushara (2015)	420	1099	38.22	[35.33; 41.16]
De Souza (2015)	432	1729	24.99	[22.96; 27.10]
Do (2015)	3560	17199	20.70	[20.10; 21.31]
Ezeala−Adekaibe (2015)	406	774	52.45	[48.87; 56.02]
Gupta (2015)	1959	6198	31.61	[30.45; 32.78]
Ibekwe (2015)	57	272	20.96	[16.28; 26.28]
Isara (2015)	319	845	37.75	[34.47; 41.12]
Kingue (2015)	4595	15470	29.70	[28.98; 30.43]
Lim (2015)	22060	58985	37.40	[37.01; 37.79]
Menon (2015)	5005	84456	5.93	[5.77; 6.09]
Minicuci (2015)	2413	4724	51.08	[49.64; 52.51]
Oguoma (2015)	151	422	35.78	[31.20; 40.56]
Ranasighe (2015)	1189	4482	26.53	[25.24; 27.85]
Seck (2015)	147	627	23.44	[20.18; 26.96]
Sowemimo (2015)	267	806	33.13	[29.88; 36.50]
Ugwuja (2015)	62	267	23.22	[18.29; 28.76]
Random effects model		**873391**	**31.14**	**[26.11; 36.41]**

Heterogeneity: I−squared=100% [100%; 100%], tau−squared=0.3789, p<0.0001

Figure 9: Prevalence estimate of hypertension in low-income countries

Pooled estimate of hypertension prevalence (23.1%) is displayed in forest plot. I^2 greater than 75% suggesting considerable heterogeneity across included studies.

Author (year)	Hypertension cases	Sample size	Prevalence of hypertension	95% CI
Edwards (2000)	520	1698	30.62	[28.44; 32.88]
Jean−Baptiste (2006)	524	1113	47.08	[44.11; 50.06]
Niakara (2007)	822	2044	40.22	[38.08; 42.38]
Vaidya (2007)	227	1000	22.70	[20.14; 25.42]
Damasceno (2009)	1100	3323	33.10	[31.50; 34.73]
Tesfaye (2009)	1114	3713	30.00	[28.53; 31.51]
Wamala (2009)	256	842	30.40	[27.31; 33.63]
Chataut (2011)	118	527	22.39	[18.90; 26.19]
Maher (2011)	1469	6678	22.00	[21.01; 23.01]
Awoke (2012)	192	679	28.28	[24.92; 31.83]
Hendriks (2012)	426	2111	20.18	[18.49; 21.96]
Hendriks (2012)	199	1046	19.02	[16.69; 21.54]
Mayega (2012)	339	1656	20.47	[18.55; 22.50]
Msyamboza (2012)	1237	3727	33.19	[31.68; 34.73]
Vaidya (2012)	412	1218	33.83	[31.17; 36.56]
Vaidya (2012)	112	641	17.47	[14.61; 20.64]
Khan (2013)	55	1679	3.28	[2.48; 4.24]
Musinguzi (2013)	995	4563	21.81	[20.62; 23.03]
Adhikari (2014)	276	1240	22.26	[19.97; 24.68]
Doulougou (2014)	380	2041	18.62	[16.95; 20.38]
Doulougou (2014)	139	1481	9.39	[7.95; 10.99]
Helelo (2014)	116	518	22.39	[18.87; 26.23]
Moges (2014)	9	68	13.24	[6.23; 23.64]
Zaman (2014)	941	4073	23.10	[21.82; 24.43]
Abebe (2015)	614	2200	27.91	[26.04; 29.83]
Akpan (2015)	595	1565	38.02	[35.61; 40.48]
Angaw (2015)	179	655	27.33	[23.95; 30.91]
Anteneh (2015)	170	678	25.07	[21.85; 28.51]
Asilu (2015)	950	7741	12.27	[11.55; 13.02]
Muusinguzi (2015)	895	4432	20.19	[19.02; 21.41]
Rahman (2015)	1922	7876	24.40	[23.46; 25.37]
Sander (2015)	34	426	7.98	[5.59; 10.97]
Wandera (2015)	376	2382	15.79	[14.34; 17.31]
Random effects model		**75634**	**23.11**	**[20.13; 26.23]**

Heterogeneity: I−squared=99% [98.9%; 99.1%], tau−squared=0.0438, p<0.0001

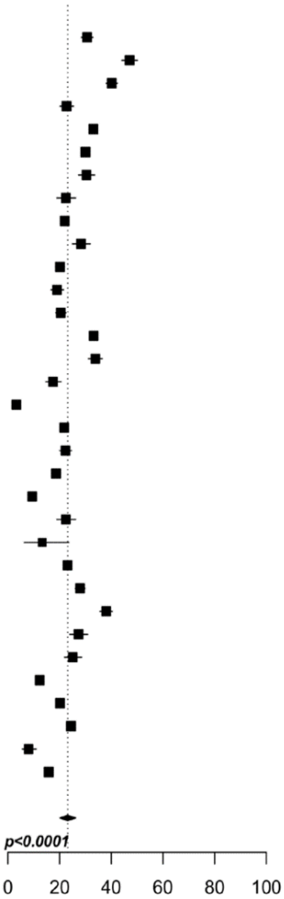


Figure 10: Prevalence of hypertension in urban settings

Pooled estimate of hypertension prevalence in urban settings (32.7%) is displayed in forest plot. I^2 greater than 75% suggesting considerable heterogeneity across included studies.

Author (year)	Hypertension cases	Sample size	Prevalence of hypertension	95% CI
Gupta (1995)	688	2122	32.42	[30.43; 34.46]
Ordunez−Garcia (1998)	719	1633	44.03	[41.60; 46.48]
Singh (1998)	822	3212	25.59	[24.09; 27.14]
Freitas (2001)	217	688	31.54	[28.08; 35.16]
Gurav (2001)	199	1432	13.90	[12.15; 15.80]
Gupta (2002)	415	1123	36.95	[34.12; 39.85]
Hazarika (2002)	617	1015	60.79	[57.71; 63.81]
Lorenzo (2002)	429	2282	18.80	[17.22; 20.46]
Reddy (2002)	924	3307	27.94	[26.42; 29.50]
Amoah (2003)	1339	4733	28.29	[27.01; 29.60]
Deepa (2003)	279	1262	22.11	[19.85; 24.50]
Shanthirani (2003)	266	1262	21.08	[18.86; 23.43]
Shapo (2003)	356	1120	31.79	[29.06; 34.60]
Gupta (2004)	42591	88653	48.04	[47.71; 48.37]
Onal (2004)	150	423	35.46	[30.90; 40.23]
Das (2005)	401	1609	24.92	[22.82; 27.11]
Erhun (2005)	210	1000	21.00	[18.51; 23.66]
Ordunez (2005)	332	1667	19.92	[18.02; 21.92]
Prabhakaran (2005)	637	2122	30.02	[28.07; 32.02]
Siddiqui (2005)	49	327	14.98	[11.30; 19.32]
Almeida−Pititto (2006)	160	484	33.06	[28.88; 37.45]
Jean−Baptiste (2006)	524	1113	47.08	[44.11; 50.06]
Chaturvedi (2007)	1039	2318	44.82	[42.78; 46.87]
Duda (2007)	721	1321	54.58	[51.85; 57.29]
Gupta (2007)	591	1127	52.44	[49.48; 55.39]
Jardim (2007)	633	1739	36.40	[34.13; 38.71]
Kengme (2007)	532	2559	20.79	[19.23; 22.41]
Medina−Lezama (2007)	295	1878	15.71	[14.09; 17.43]
Niakara (2007)	822	2044	40.22	[38.08; 42.38]
Capilheira (2008)	725	3100	23.39	[21.91; 24.92]
Sparrenberger (2008)	600	1484	40.43	[37.92; 42.98]
Sun (2008)	17929	45390	39.50	[39.05; 39.95]
Yadav (2008)	116	294	39.46	[33.83; 45.30]
Kusuma (2009)	83	453	18.32	[14.87; 22.20]
Longo (2009)	681	2022	33.68	[31.62; 35.79]
Reichert (2009)	583	1696	34.38	[32.11; 36.69]
Rodrigues (2009)	702	1655	42.42	[40.02; 44.84]
Tesfaye (2009)	1114	3713	30.00	[28.53; 31.51]
Zhang (2009)	2008	4141	48.49	[46.96; 50.03]
Cipullo (2010)	762	1717	44.38	[42.01; 46.77]
Ekwunife (2010)	160	756	21.16	[18.30; 24.25]
Jonas (2010)	1041	4711	22.10	[20.92; 23.31]
Lee (2010)	9852	39252	25.10	[24.67; 25.53]
Sani (2010)	77	300	25.67	[20.82; 31.00]
Thuy (2010)	320	910	35.16	[32.06; 38.37]
Ulasi (2011)	290	688	42.15	[38.43; 45.94]
Awoke (2012)	192	679	28.28	[24.92; 31.83]
Dzudie (2012)	1007	2120	47.50	[45.36; 49.65]
Gupta (2012)	248	739	33.56	[30.16; 37.09]
Hendriks (2012)	199	1046	19.02	[16.69; 21.54]
Hendriks (2012)	555	1733	32.03	[29.83; 34.28]
Hofelmann (2012)	688	1720	40.00	[37.67; 42.36]
Kerkhoff (2012)	635	1858	34.18	[32.02; 36.38]
Lyra (2012)	127	198	64.14	[57.04; 70.82]
Oladimeji (2012)	232	801	28.96	[25.84; 32.24]
Prasad (2012)	431	1178	36.59	[33.83; 39.41]
Ekanem (2013)	208	442	47.06	[42.33; 51.83]
Mendes (2013)	395	842	46.91	[43.50; 50.35]
Peer (2013)	460	1099	41.86	[38.92; 44.84]
Pessinaba (2013)	655	1424	46.00	[43.38; 48.63]
Selem (2013)	232	535	43.36	[39.12; 47.68]
Silva (2013)	695	1720	40.41	[38.08; 42.77]
Veghari (2013)	741	3497	21.19	[19.85; 22.58]
Amiri (2014)	431	1096	39.32	[36.42; 42.29]
Awosan (2014)	114	390	29.23	[24.76; 34.02]
Awuah (2014)	202	714	28.29	[25.01; 31.75]
Doulougou (2014)	380	2041	18.62	[16.95; 20.38]
Duboz (2014)	165	600	27.50	[23.96; 31.26]
Moges (2014)	9	68	13.24	[6.23; 23.64]
Mooes (2014)	9	68	13.24	[6.23; 23.64]
Wang (2014)	11905	37141	32.05	[31.58; 32.53]
Ezeala−Adekaibe (2015)	406	774	52.45	[48.87; 56.02]
Gupta (2015)	1959	6198	31.61	[30.45; 32.78]
Ke (2015)	479	1410	33.97	[31.50; 36.51]
Kingue (2015)	4595	15470	29.70	[28.98; 30.43]
Li (2015)	545	2026	26.90	[24.98; 28.89]
Lu (2015)	1477	4675	31.59	[30.26; 32.95]
Unger (2015)	1162	5649	20.57	[19.52; 21.65]
Vieira (2015)	111	491	22.61	[18.98; 26.57]
Wei (2015)	1549	3778	41.00	[39.43; 42.59]
Random effects model		**352077**	**32.65**	**[30.37; 34.97]**

Heterogeneity: I−squared=99.5% [99.5%; 99.5%], tau−squared=0.0487, p<0.0001

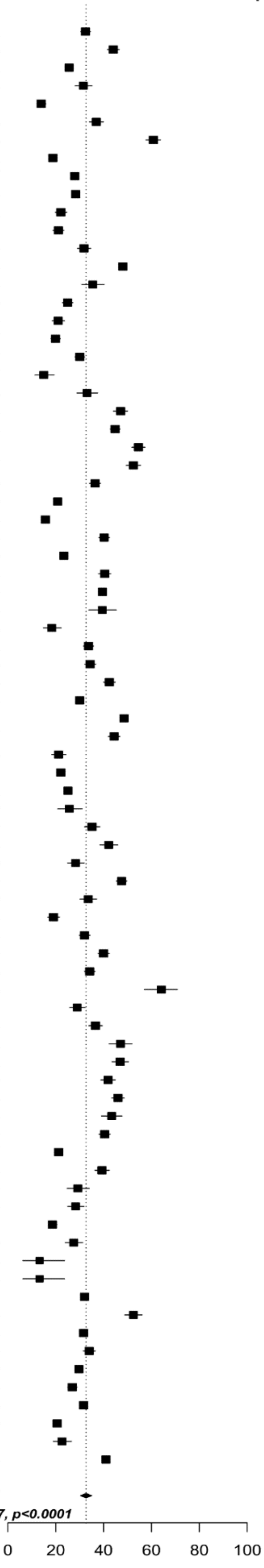


Figure 11: Prevalence of hypertension in rural settings

Pooled estimate of hypertension prevalence in rural settings (25.2%) is displayed in forest plot. I^2 greater than 75% suggesting considerable heterogeneity across included studies.