UNIVERSITY OF TROMSØ UIT
FACULTY OF HEALTH SCIENCES
DEPARTMENT OF COMMUNITY MEDICINE

The escalating diabetes epidemic: determinants of prevalence disparity between country income groups

Fatimatou Kuhmbou Wefuan

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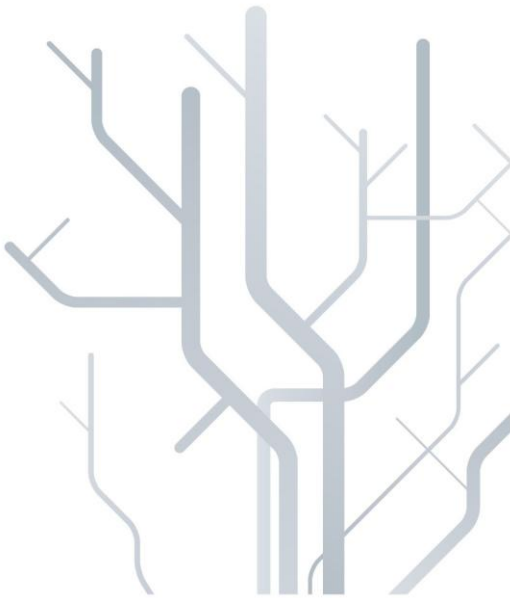
Supervisor: Ass. Prof. Tormod Ola Brenn



DEDICATION

With Love

To My Parents

PREFACE

This thesis is submitted as a partial fulfillment of the requirements for the degree of Master of Public Health (MPh) at the Faculty of Health Sciences, Department of Community Medicine, University of Tromsø, Norway.

The thesis is intended to give more insight into certain factors which are associated with the escalating diabetes epidemic worldwide, and provide recommendations on how to tackle the increasing diabetes prevalence and disparity which occurs across country income groups.

I would like to express my heartfelt gratitude to my supervisor Associate Professor Tormod Ola Brenn, for dedicating his time to read and discuss all my writings, and for providing professional guidance and support to shape my thinking, reading and writing of this thesis.

I am thankful to the University of Tromsø for the opportunity granted me to study in its prestigious institution. I am also grateful to all the staff at the Public Health Master's programme and my fellow course mates for their support, collaboration, constructive discussion, and useful suggestions during the course of our study.

I would like to express my warm thanks to my loving husband (Ekiyie) for his love, care, support, understanding, and patience during my study. Likewise I deeply appreciate with many thanks the moral support and encouragement of my parents and siblings. Their great concern for the progress of my studies pushed me to the end and I am truly grateful.

Most importantly I thank the Eternal, Sovereign, and Supreme God; my God in Whom I trust. I have gone through to the end because You Oh Lord, have been my strength, shield, and comfort through it all.

Fatimatou Kuhmbou Wefuan
Tromsø, Norway
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ABSTRACT

Rationale: Nowadays, diabetes mellitus is continuing to be an increasing international health burden. But greatest increases of this burden are seen particularly in low- and middle-income countries. This thesis attempts to account for the factors associated with the increasing prevalence of diabetes and the disparity in this prevalence across country income groups.

Method: An analytic ecological study was performed using 183 WHO Member States grouped into low-, lower middle-, upper middle- and high-income countries. Linear regression analyses were used to determine possible associations between diabetes mellitus prevalence and health expenditure for diabetes plus other health indicators (that is, life expectancy at birth, prevalence of tuberculosis, population living in urban areas, out-of-pocket health expenditure, adults aged ≥ 20 years who are obese, alcohol consumption among adult aged ≥ 15 years), both in the 183 WHO Member States and within each WHO country income group.

Results: The prevalence of diabetes mellitus is associated with health expenditure for diabetes, life expectancy, tuberculosis prevalence, urban population, out-of-pocket expenditure, adults aged ≥ 20 years who are obese, and alcohol consumption among adults ≥ 15 years. The association between diabetes mellitus and these factors vary depending on the different country income groups.

Conclusion: These findings suggest that since diabetes mellitus prevalence is associated with several factors which vary according to country income groups, strategies for diabetes prevention should not only be person-centered but also income group-specific.

Keywords: Diabetes Mellitus, WHO Member States, Country Income Groups, Low-income, Lower middle-income, Upper middle-income, High-income

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LIST OF ABBREVIATIONS

ALCOHOL: Alcohol consumption among adults ≥ 15 years

DM: Diabetes Mellitus

DMEXP: Health expenditure for Diabetes Mellitus

GNI: Gross National Income

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

ID: International Dollar

IDF: International Diabetes Federation

LIFEEXP: Life Expectancy for both sexes

LMIC: Low- and Middle-Income Countries

OBESE: Adults aged ≥ 20 years who are obese

OOPHEXP: Out-Of-Pocket Health Expenditure

TB: Tuberculosis

TBPREV: Tuberculosis Prevalence

URBAN: Population living in urban areas

USD: United States Dollar

WHO: World Health Organization

CHAPTER 1: INTRODUCTION

1.1: Background

Diabetes, also referred to as diabetes mellitus (DM) is a chronic condition which is considered as the number one killer among all chronic diseases. Presently, it ranks as the fourth most common cause of mortality with coronary artery disease. DM takes an epidemic form and its prevalence is increasing at a scary rate[1]. Diabetes mellitus is influenced by a web of factors, some of which are related to physiology, genetics, health behaviours, social and economic statuses[2].

Diabetes either occurs when the pancreas does not produce enough insulin or when the body cannot effectively use the insulin it produces. As a result, the concentration of glucose in the blood increases, a situation described as hyperglycaemia[3,4]. Three types of diabetes exist, namely: type 1 diabetes, type 2 diabetes, and gestational diabetes[3,5]. Type 1 diabetes is characterized by a lack of insulin production and victims rely on insulin injections for survival[3,6]. Type 2 diabetes is caused by the body's ineffective use of insulin. It occurs often as a result of excess body weight and physical inactivity[3]. Gestational diabetes is characterized by hyperglycaemia, which is first recognized during pregnancy[3].

Type 2 diabetes is the most common type of diabetes because it accounts for up to 90% of all cases of diabetes worldwide. Previously, reports of type 2 diabetes were usual in people over the age of 40 but it is increasingly seen in children too worldwide. Research holds that the occurrence of type 2 diabetes at a younger age is predominantly due to overweight caused by changes in people's lifestyle resulting in unhealthy eating habits and a sedentary lifestyle[5-7]. Although the reasons for developing type 2 diabetes are still not known, several important risk factors for the disease have been identified which include: obesity, poor diet, physical inactivity, increasing age, family history of diabetes, ethnicity, poor nutrition during pregnancy affecting the developing child, just to name a few[5]. Many studies have also

elaborated the associations between several risk factors and the risk of type 2 diabetes. These factors include: body mass index (BMI), lipids, hypertension, smoking, low education, dietary patterns, and recently specific genes[8-15].

Symptoms of diabetes are gradual and typically extreme thirst, frequent passing of water and heavy weight loss over a short period. Others include fatigue, frequent infections, itching and rashes as well as disturbed vision. However, some people show none of these symptoms[6]. As a result, most people remain undiagnosed for a long time until when complications of the disease become evident. Some of which may lead to blindness, numbness/infections in feet, amputation of limbs, kidney failure, or heart disease[5-7].

1.2: Problem Statement

According to a declaration made early 2010 by the United Nations Secretary-General Ban ki-moon, diabetes and other non-communicable diseases are described as "a public health emergency in slow motion"[16] because they now present a greater threat than infectious diseases such as HIV/AIDS, malaria and tuberculosis (TB). Furthermore from statistics, it seems like the world is on the cusp of losing the battle to contain diabetes[16]. The world prevalence of diabetes in 2010 among adults (aged 20-79 years) was estimated to 6.4% affecting 285 million adults. By 2030 it is expected to increase to 7.7% and affecting 438 million adults. Between 2010 and 2030, there is an expected 69% increase in numbers of adults with diabetes in developing countries and a 20% increase in developed countries. 36% of the anticipated absolute global increase of 154 million people with diabetes is projected to occur in India and China alone[17]. These predictions clearly indicate that the global burden of diabetes is growing and the greatest increase is seen particularly in low- and middle-income countries (LMIC)[16-18]. The most affected being the men and women of working age who are at the same time the breadwinners of their families. So in effect, the economic, social and

human burden of the diabetes epidemic has already shifted to LMIC and will begin to reverse gains in prosperity and health in those countries[16].

1.3: Purpose of the study

The purpose of this study was to explore and account for certain factors associated with the increasing prevalence of diabetes in the World Health Organization (WHO) Member States and the disparity in the prevalence of diabetes within each WHO country income group. In particular, the study explored the underlying reasons for the fact that low- and middle-income countries unlike high-income countries continue to bear the brunt of the disease.

1.4: Study Hypothesis

Given the escalating diabetes epidemic and the existing disparity in the disease's prevalence worldwide, this study lays forward the hypothesis that the factors associated with the disparity in the prevalence of diabetes vary across each WHO country income group.

1.5: Methodology

The study employed an analytic ecological study design to determine possible associations between diabetes prevalence (dependent variable) and health expenditure for diabetes (independent variable) across the globe. Other independent variables considered in this study include: life expectancy at birth; prevalence of tuberculosis; population living in urban areas; out-of-pocket health expenditure; adults aged ≥ 20 years who are obese; alcohol consumption among adults aged ≥ 15 years. The study population comprised of 183 WHO Member States which are grouped into 4 country income groups. Primary data for the study was obtained from the available WHO, International Diabetes Federation (IDF) open access sources, and literature analyses. The collected data was statistically analyzed using SPSS 19.

1.6: Motivation

My motivation to undertake this study primarily stems from the fact that research holds that the world prevalence of diabetes is expected to increase as the years go by. This is compounded by the fact that, sadly enough, the greatest increase is seen particularly in LMIC. However, it seemed to be common knowledge a while ago that diabetes was a disease of affluence and not poverty. For these reasons, I am curious about the factors associated with this trend.

1.7: Expected Contribution

This study is fashioned to give more insight into certain factors which are associated with the escalating diabetes epidemic worldwide. It explicitly explores and elaborates on possible causes for the fact that low- and middle-income countries unlike high-income countries have a higher prevalence of diabetes. Based on the study findings, possible recommendations are suggested in order to better tackle the increasing diabetes prevalence and disparity pattern across countries. Thus, the study contributes to expanding literature and discussions on the battle to contain diabetes worldwide.

1.8: Structure of the Thesis

The rest of this thesis is organized as follows.

Chapter 2 describes the methodological framework used in the research.

A brief overview of the research findings/results are provided in *Chapter 3*.

Chapter 4 discusses the key findings from the research.

Chapter 5 concludes the study.

CHAPTER 2: MATERIALS AND METHODS

2.1: Study Design

In order to respond to the research question (study hypothesis), the study employed an analytic ecological study design. Based on the study's purpose, data was collected in order to determine possible associations between diabetes prevalence (dependent variable) and health expenditure for diabetes plus other health indicators (independent variables) across the globe.

2.1.1: Ecological study

Ecological studies are studies which deal with aggregated or grouped data measured on groups of people rather than on individuals[19]. They describe and analyze correlations between variates measured on populations in groups or regions. Thus, ecological analyses employ aggregated data as the basic sampling unit of analysis. In such studies, the grouping variate could be geographical region, ethnicity, socioeconomic class, time period, etc[19]. Types of ecological study designs include explorative vs analytic study (where the primary group is measured); and multi-group study, time-trend study, or mixed study (where subjects are grouped by place, by time, or by place and time, respectively)[20]. Although ecological studies have several practical advantages, they also have many methodological problems that severely limit causal inference. These include cross-level bias, problems of confounder control, within-group misclassification, lack of adequate data, temporal ambiguity, collinearity, and migration across groups[20]. Due to the above limitations of ecological studies which could result in the "ecological fallacy"[1], ecological studies are sometimes regarded as inadequate and unreliable. But, such studies are highly relevant because even when studying individual risk factors, population level studies play a vital role in defining the most important public health problems to be tackled, and in generating hypothesis as to their potential causes[21]. Furthermore, it is increasingly being recognized that some risk factors for disease

[1] An error in the interpretation of statistical data in an ecological study that results when concludions are made about individuals from the aggregated data inappropriately.

genuinely operate at the population level[22-24]. Ecological studies are particularly advantageous because they permit the study of very large populations, and are often relatively easy to conduct using existing databases in a fairly short period of time[19]. They are also useful in describing differences between groups and identifying questions for further investigations[25]. The ecological approach has proven to be quite useful in public health/epidemiologic research for centuries[26]. For example Chadwick employed this approach in his famous report on the sanitary condition of the laboring population of Great Britain in 1842[27].

2.2: Study Population

The study population comprised of 183 Member States of WHO which are grouped into 4 country income groups based on their Gross National Income (GNI) per capita, namely: low-, lower middle-, upper middle-, and high-income groups[28] (Appendix A). But the upper middle- and lower middle-income groups both comprise the middle-income countries[29]. My reason for employing the above grouping of income in this study, was based on another study conducted in the WHO African region which grouped African countries into income groups based on their GNI per capita, in order to estimate the economic burden associated with diabetes mellitus in the countries in the African region[30].

2.3: Independent variables

The main independent variable was health expenditure for diabetes. The other independent variables include: life expectancy at birth, prevalence of tuberculosis, population living in urban areas, out-of-pocket health expenditure, adults aged ≥ 20 years who are obese, and alcohol consumption among adults aged ≥ 15 years. All of these independent variables were included based on their relevance to global public health; possible association with diabetes; availability and quality of the data; and reliability and comparability of the resulting estimates.

2.4: Dependent variable

The dependent variable was the prevalence of diabetes mellitus.

2.4.1: Diagnostic criteria for diabetes mellitus

According to WHO and IDF, the following criteria are recommended for the diagnosis of diabetes mellitus: fasting plasma glucose ≥ 7.0mmol/l (126mg/dl) or 2-h plasma glucose (venous plasma glucose 2 hours after ingestion of 75g oral glucose load) ≥ 11.1mmol/l (200mg/dl). They further recommend that the oral glucose tolerance test is the most preferred diagnostic test for diabetes mellitus[31]. The test should be performed in the morning after an overnight fast of between 8 and 14 hours and after at least 3 days of unrestricted diet (≥ 150g carbohydrate per day) and unlimited physical activity. More so, the subject should remain seated and not smoke throughout the test[32]. In recent times, glycated haemoglobin has also been recommended for the diagnosis of diabetes, with a threshold of ≥ 6.5%[33,34].

2.5: Data Collection

The study included data from 183 Member States of the World Health Organization. This data was included based on its relevance, availability, quality, reliability, and comparability of the resulting estimates. Particular details related to the collection of data pertaining to the various variables considered in this study are explained below.

2.5.1: Data for dependent variable: prevalence of diabetes mellitus

Diabetes mellitus is one of the most common chronic diseases in nearly all countries, and continues to increase in numbers and significance, as urbanization and economic development lead to changing lifestyles characterized by reduced physical activity, and increased obesity[35,36]. Amongst the several previous estimates of the number of persons with diabetes which have been made[37-40], of particular interest is the publication of the fourth edition of the IDF Atlas[41] as seen in the table below.

Table 1: Global burden of diabetes-prevalence and projections, 2010 and 2030[41].

At a glance		
Year	2010	2030
Total world population (billions)	7.0	8.4
Adult population (20-79 years, billions)	4.3	5.6
Diabetes (20-79 years)		
Global prevalence (%)	6.6	7.8
Comparative prevalence (%)	6.4	7.7
Number of people with diabetes (millions)	285	438

According to table 1, the global diabetes epidemic continues to grow. This is illustrated by the fact that in the 20-79 years age group, 285 million out of 4.3 billion people had diabetes in 2010, and this will rise to 438 million out of 5.6 billion people in 2030 (an increase from 6.4% to 7.7%)[41]. An updated report from IDF shows that as of 2012, more than 371 million people aged 20-79 years have diabetes; resulting in a diabetes comparative prevalence of 8.3%, and 50% of these people do not know they have it (that is, they remain undiagnosed)[42].

For this study, the data for the prevalence of diabetes mellitus for each of the WHO Member States was obtained from the IDF Diabetes Atlas website[43]. IDF reported the prevalence estimates of diabetes mellitus for the year 2010 as a percentage (%), and the principal aspects of the determination of prevalence were[44]:

1. Studies were identified through a detailed literature search, and contact made with IDF member organizations.

2. The methodology indicated in Appendix B was employed to create smoothed curves for prevalence (with respect to age).

3. Prevalence rates for a country were applied to the population distribution of that country. But where no data for certain countries were available, their prevalence rates were applied to those of other countries with similar ethnicity and economic circumstances.

4. An urban/rural prevalence ration of 2:1 was assumed for diabetes (but not impaired glucose tolerance), except in those countries classified by WHO[38] as market economies or former socialist economies. The urban proportion of the population was derived from United Nations estimates[45].

5. The data for diabetes rates include both type 1 and type 2 diabetes.

6. The prevalence of diabetes throughout the *Diabetes Atlas* includes both undiagnosed and previously diagnosed diabetes.

For every country, IDF calculated the prevalences in two ways namely: national or regional prevalence, and comparative prevalence[44]. But this study employed the comparative prevalence estimates as explained below. The national or regional prevalence indicates the percentage of each country's population that has diabetes. Although it is ideal for assessing the burden of diabetes for each country, it cannot be used for comparing prevalences between countries. This is because the prevalence of diabetes increases with age and different countries have different age structures. On the other hand, the comparative prevalence was calculated by assuming that every country has the same age profile (the age profile of the world population was used in this calculation). Thus, eliminating the differences of age between countries and making this figure ideal for making comparisons between countries[44].

2.5.2: Data for independent variables

2.5.2.1: Health expenditure for diabetes mellitus

Diabetes is not only a common chronic disease in nearly all countries but it is also costly to health care systems[46]. Thus, IDF refers to the global health expenditure for diabetes as the amount of money spent by different countries across the globe in treating and preventing diabetes and its complications[44]. Based on an IDF study[46], estimates on health expenditures attributable to diabetes for all WHO Member States for the years 2010 and 2030 are reported in the table below.

Table 2: Global health expenditure for diabetes mellitus, 2010 and 2030[46].

At a glance		
Year	2010	2030
Total world population (billions)	7.0	8.4
Adult population (20-79 years, billions)	4.3	5.6
Global health expenditure for diabetes ('000) with R values of 2 and 3 (20-79 years)		
US dollars (USD), R = 2	375,983,944	490,064,566
US dollars (USD), R = 3	672,235,502	893,011,667
International dollars (ID), R = 2	417,817,971	561,334,452
International dollars (ID), R = 3	745,704,963	1,020,410,426

According to table 2, global health expenditure for diabetes mellitus was estimated by employing R values; where R is defined as the age- and sex-specific ratios of health care expenditure for persons with diabetes to persons without diabetes. In most countries, because the average value of R falls between 2 and 3, health expenditure for diabetes was estimated using two alternative average R values, R = 2 and R = 3. More so, since R is sensitive to age and sex, applying age- and sex-specific R should improve health expenditure estimates[46]. From table 2 as well, we observe that diabetes imposes an increasing economic burden on national health care systems worldwide. This is because the total annual global health expenditure for diabetes falls between USD 376.0 billion (R = 2) and USD 672.2 billion (R = 3), or between ID 417.8 billion and ID 745.7 billion in 2010, as opposed to 2030 where it is estimated to fall between USD 490.1 billion (R = 2) and USD 893.0 billion (R = 3), or between ID 561.3 billion (R = 2) and ID 1020.4 billion (R = 3). This implies that the global health expenditures for diabetes in 2030 will be 30-34% larger than those of 2010; thus, exceeding the assumed global population growth (28.6%) among people aged 20-79 years over the same period. Expenditures will grow more quickly than population because the global prevalence of diabetes is expected to increase due to aging and increasing urbanization[46].

This study obtained the data for the health expenditure for diabetes for each of the WHO Member States from the IDF Diabetes Atlas website[43]. For every country, IDF reported the health expenditure for the year 2010, and these estimates are represented as mean health expenditure per person with diabetes (R = 2), measured in United States dollars (USD) (the US dollars served as the unit of measurement because they are best used to compare currency prices or expenditures for diabetes care)[44].

2.5.2.2: Life expectancy at birth

Life expectancy at birth is defined as the average number of years a person can expect to live, if in the future they experience the current age-specific mortality rates in the population[47]. It is

also a measure of overall quality of life in a country and reflects the overall mortality level of a population. It summarizes the mortality pattern that prevails across all age groups in a given year - adults and the elderly, children and adolescents[48,49]. Since 1990 until 2009, life expectancy has increased globally by 4 years[49,50], as illustrated in the table below.

Table 3: Life expectancy at birth for both sexes, 1990, 2000, and 2009[50].

	Both sexes		
Year	1990	2000	2009
Global life expectancy at birth (years)	64	66	68

Human life expectancy patterns are such that on average humans live 49.42 years in Swaziland[51] and 82.6 years in Japan[52]. But the Japanese life expectancy is attributed to equal opportunities and public health as well as diet[53,54]. Worth mentioning is the fact that WHO also makes use of the healthy life expectancy, which is a related statistic estimating the equivalent years in full health that a person can expect to live on the basis of the current mortality rates and prevalence distribution of health states in the population[47].

The data for life expectancy at birth was obtained from the World Health Statistics 2011[50]. This publication contains health-related data for all WHO Member States, and it was compiled using publications and databases produced and maintained by WHO technical programmes and regional offices[50]. For this study life expectancy at birth values were reported for the year 2009, represented for both sexes, and measured in years[50].

2.5.2.3: Prevalence of tuberculosis

Tuberculosis is an infectious bacterial disease caused by *Mycobacterium tuberculosis*, which most commonly affects the lungs. It is transmitted from person to person through droplets from the throat and lungs of people with the active respiratory disease. Symptoms of active

TB of the lung include coughing sometimes with sputum or blood, chest pains, weakness, weight loss, fever and night sweats. But TB is treatable with a six-month course of antibiotics[55]. TB occurs in every part of the world and it remains a major global health problem as it causes ill-health among millions of people each year and ranks as the second after HIV as the leading cause of death from an infectious disease worldwide. In 2011, 8.7 million new TB cases and 1.4 million TB deaths were recorded[56,57]. Generally, most countries are experiencing a drop in TB cases over the years[57], thus, resulting in a decreasing global TB prevalence as illustrated in the table below.

Table 4: Prevalence of TB (per 100 000 population), 2000, 2009, and 2011[50,56].

Year	2000	2009	2011
Global prevalence of TB (per 100 000 population)	231	201	170

The data for prevalence of TB was obtained from the World Health Statistics 2011[50]. This study reported prevalence of TB for the year 2009, and the unit of measurement was per 100 000 population[50].

2.5.2.4: Population living in urban areas

Urbanization is among one of the leading global trends of the 21st century that has a significant impact on health. Certain factors which influence urban health include urban governance; population characteristics; social and economic development; the natural and built environment; services and health emergency management; and food security[58]. While urban areas bring great opportunities, they also bring challenges for better health. Cities of today and those of tomorrow face a triple threat: infectious diseases; noncommunicable diseases; and violence and injuries[58,59]. Urban population has increased over the years[50] (as

seen in table 5) up to the point where in 2009, for the first time in human history, the majority of the world's population was living in urban areas[59,60].

Table 5: Population living in urban areas (%), 1990, 2000, and 2009[50].

Year	1990	2000	2009
Global population living in urban areas (%)	43	47	50

The global urban population is expected to grow approximately 1.5% per year between 2025 and 2030[61]. This trend will continue with 6 in 10 people living in towns and cities by 2030[59], and over 70% of the world's population living in cities by 2050[58].

The data for population living in urban areas was obtained from the World Health Statistics 2011[50]. This study reported population living in urban areas for the year 2009, and the unit of measurement was percentage (%)[50].

2.5.2.5: Out-of-pocket health expenditure

Out-of-pocket health expenditure is a part of private health expenditure, and it refers to any direct outlay by households, including gratuities and in-kind payments, to health practitioners and suppliers of pharmaceuticals, therapeutic appliances, and other goods and services whose primary intent is to contribute to the restoration or enhancement of the health status of individuals or population groups[62]. Out-of-pocket payments for health can cause households to incur catastrophic expenditures, which can in turn push them into poverty. It can also negatively affect individuals' health because they cannot afford for health care when they need it[63]. According to statistics, the global out-of-pocket expenditure as a percentage of private expenditure on health remained at 50.7% in 2000 and 2008[50].

The data for out-of-pocket health expenditure was obtained from the World Health Statistics 2011, which was generated from information collected by WHO for over 10 years[50]. This

study reported out-of-pocket health expenditure as a percentage of private health expenditure, for the year 2008[50].

2.5.2.6: Adults aged ≥ 20 years who are obese

Overweight and obesity are defined as the abnormal or excessive accumulation of fat that presents a risk to health[64]. Overweight and obesity increase the risk of cardiovascular diseases, cancer, and chronic diseases, including diabetes. Previously, overweight and obesity was considered a problem only in high-income countries, but they are now on the rise in LMIC, particularly in urban settings[50,64]. Since 1980 obesity has more than doubled worldwide. In 2008, more than 1.4 billion adults aged ≥ 20 years were overweight; among which nearly 300 million women and over 200 million men were obese[65].

The data for adults aged ≥ 20 years who are obese was obtained from the World Health Statistics 2011[50]. This study reported values for adults aged ≥ 20 years who are obese for the year 2008, represented for both sexes, and measured in percentage (%)[50].

2.5.2.7: Alcohol consumption among adults aged ≥ 15 years

Alcoholic beverages are widely consumed all over the world as a common feature of social gatherings[66,67]. Chronic diseases, neurological impairments, and social problems are likely to develop in those who drink large amounts of alcohol over a number of years[66,68]. Worldwide, there exists a large variation in adult per capita consumption (litres of pure alcohol consumed by every person ≥ 15 years), but the trend has remained stable at around 4.3-4.7 litres of pure alcohol since 1990[67].

The data for alcohol consumption among adults aged ≥ 15 years was obtained from WHO's publications on World Health Statistics[50] and its global status report on alcohol and health[67]. This study reported values for alcohol consumption among adults aged ≥ 15 years for the year 2005, and the unit of measurement was litres of pure alcohol per person per year[50,67].

2.5.3: Data for Gross National Income (GNI) per capita

GNI per capita (formerly GNP per capita) is defined as the gross national income, converted to U.S. dollars (for comparisons across economies) using the World Bank Atlas method, divided by the midyear population[69]. Since WHO employs the World Bank classification system which classifies economies according to 2004 GNI per capita[28] (calculated using the World Bank Atlas method), the 2004 GNI per capita values were obtained from the World Bank website[69] and reported in this study. Based on the above classification system, economies are grouped into: low-income, $975 or less; lower middle-income, $976 - $3,855; upper middle-income, $3,856 - $11,905; and high-income, $11,906 or more[69]. Furthermore, since the upper middle- and lower middle-income groups both comprise the middle-income countries[29], the latter are those countries with GNI per capita ranging from $976 - $11,905. In this study, we had a total of 37 Member States in the low-income group, 51 in the lower middle-income group, 47 in the upper middle-income group, and 48 in the high-income group[50]. Thus, GNI was classified as a categorical variable, with the 4 country income groups namely: low-, lower middle-, upper middle-, and high-income countries being represented as codes 1, 2, 3, and 4 respectively in the data set.

2.6: Analyses

2.6.1: Descriptive analyses

Microsoft Word 2007 and Microsoft Excel 2007 were used to make tables and charts of the distribution of the study variables in the 4 WHO country income groups.

2.6.2: Statistical analyses

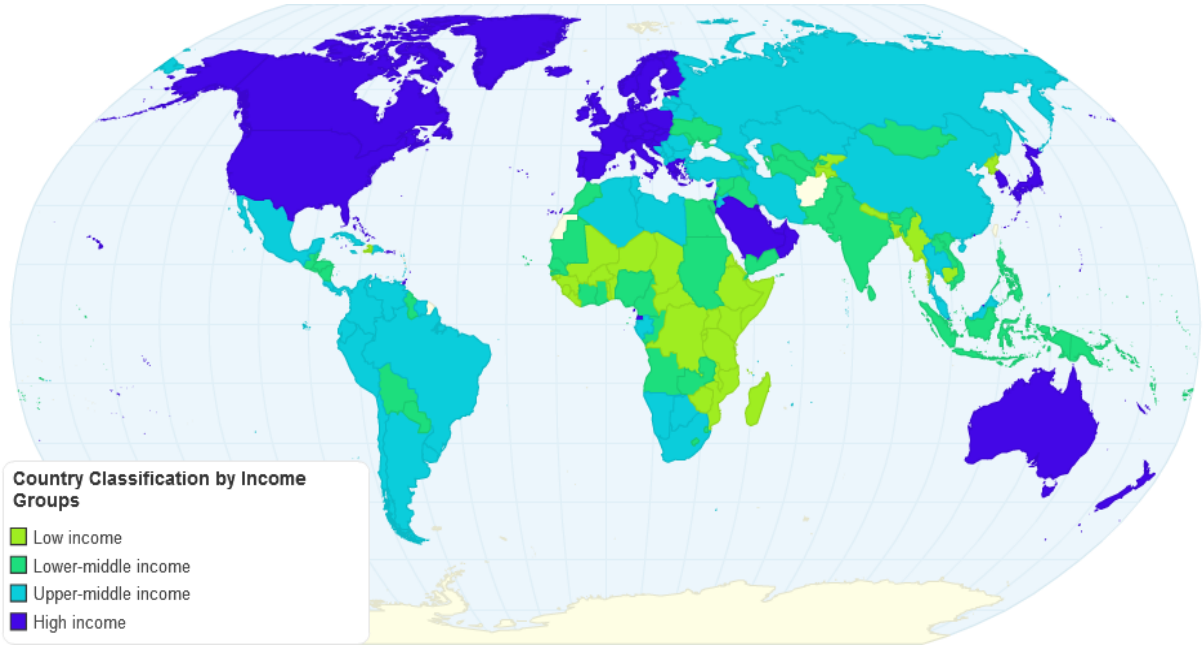
Linear regression analyses were performed to analyze the association between prevalence of diabetes mellitus and health expenditure for diabetes, life expectancy at birth, prevalence of tuberculosis, population living in urban areas, out-of-pocket health expenditure, adults aged ≥ 20 years who are obese, and alcohol consumption among adults aged ≥ 15 years. Two kinds

of linear regression analyses were performed namely: univariate (unadjusted), and multiple (adjusted) analyses. In the univariate linear regression analyses, the impact of each independent variable on the dependent variable was accessed. But in the multiple linear regression analyses, the impact of the independent variables simultaneously on the dependent variable was accessed (implying that the impact of each independent variable was being adjusted for by the other independent variables). GNI per capita was used as a filter in the data set to enable comparisons between the various country income groups to be made. All regression estimates were presented alongside their corresponding p-values. A probability level less than 0.05 was considered statistically significant. The statistical analyses were performed using SPSS 19 software.

CHAPTER 3: RESULTS

The results for this study represent the 4 country income groups of WHO as well as the individual Member States for which data was available. As previously mentioned, WHO comprises of Member States which are grouped into 4 country income groups based on their GNI per capita, namely: low, lower middle, upper middle, and high[28], as shown in figure 1 below.

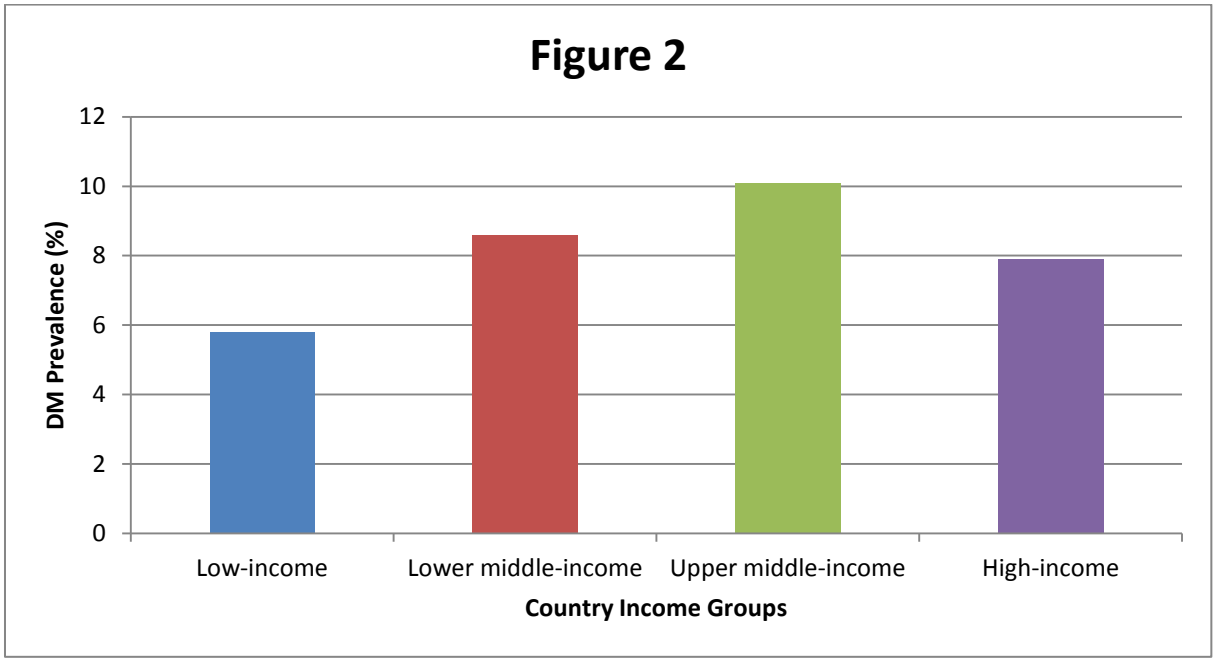
Figure 1: WHO Country Income Groups
(Source: http://chartsbin.com/view/5109)[70]



3.1: Results for the descriptive analyses

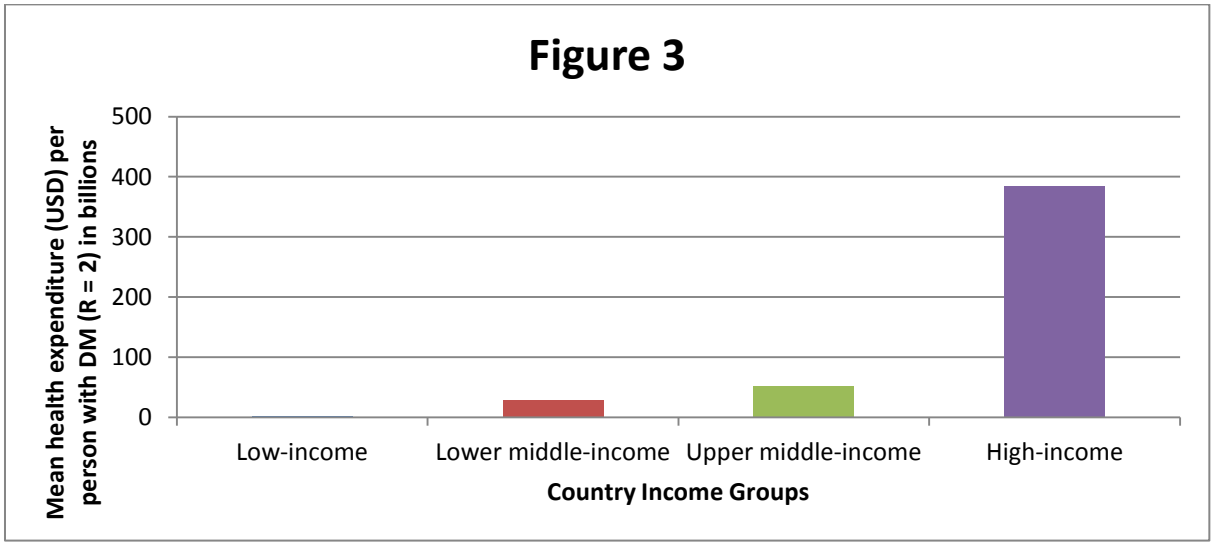
This section represents results pertaining to the distribution of the study variables in each of the four WHO country income groups.

3.1.1: DM Prevalence estimates by income group, 2010



In Figure 2, the prevalence of diabetes mellitus in 2010 is different in each of the four WHO country income groups. It is 5.8% in low-income countries, 8.6% in lower middle-income countries, 10.1% in upper-middle income countries, and 7.9% in high-income countries. On the average, low- and middle income countries have a relatively higher prevalence of diabetes (compared to their total population) than the high-income countries.

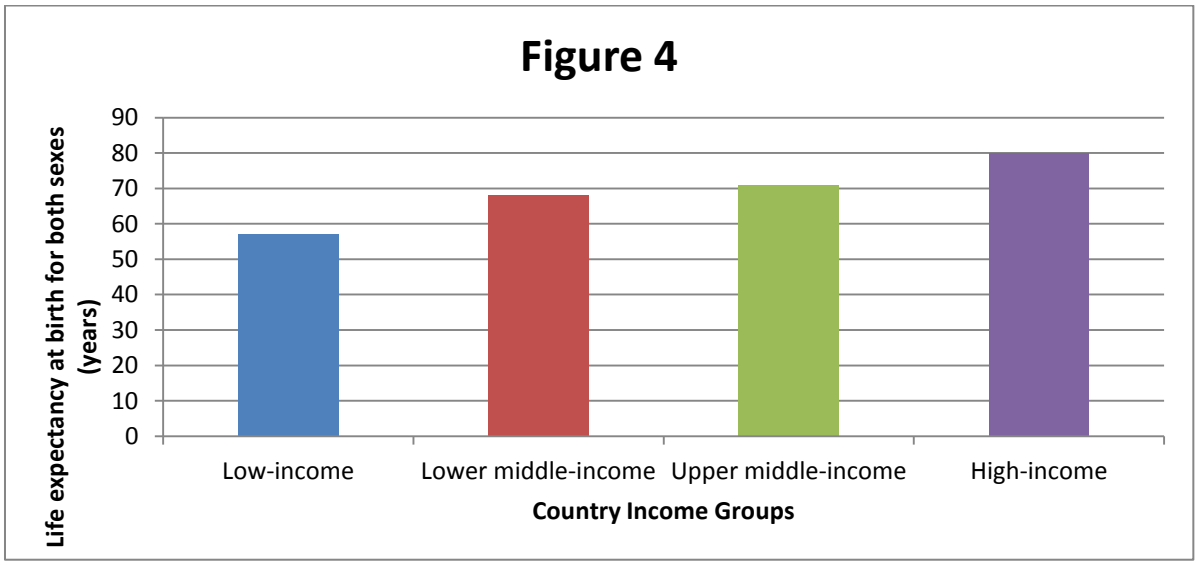
3.1.2: Health expenditure for DM by income group, 2010



In Figure 3, the health expenditure for diabetes mellitus in 2010 is different in each of the four WHO country income groups. It is highest in high-income countries with 383.3 billion USD,

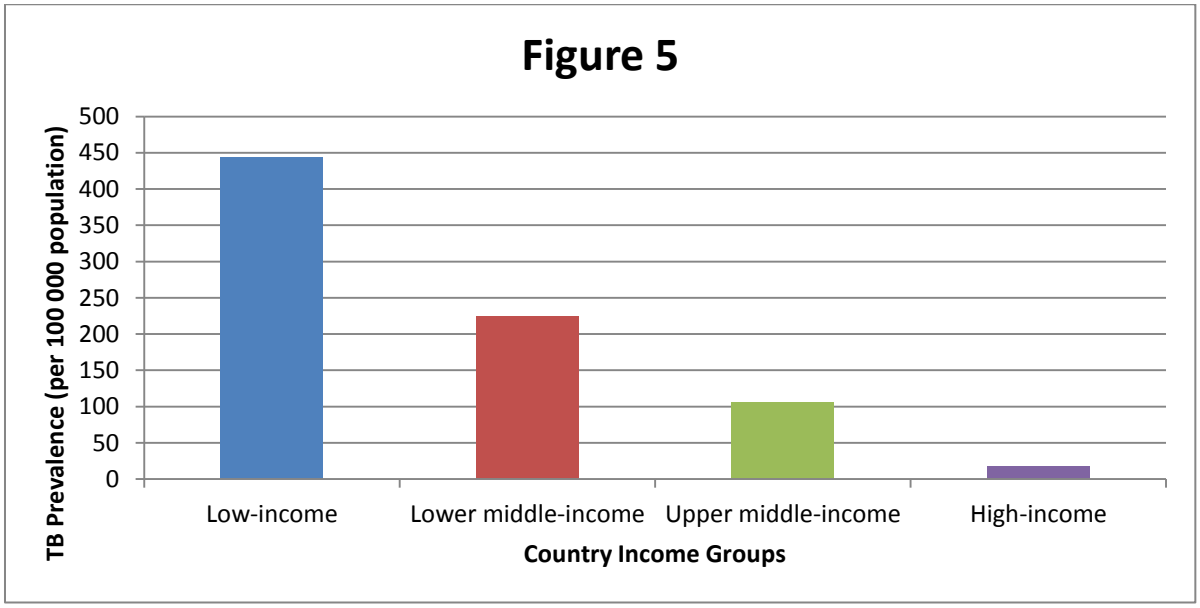
followed by upper middle-income countries with 52.1 billion USD, then lower middle-income countries with 28.3 billion USD, and finally low-income countries with 1.1 billion USD.

3.1.3: Life expectancy at birth for both sexes by income group, 2009



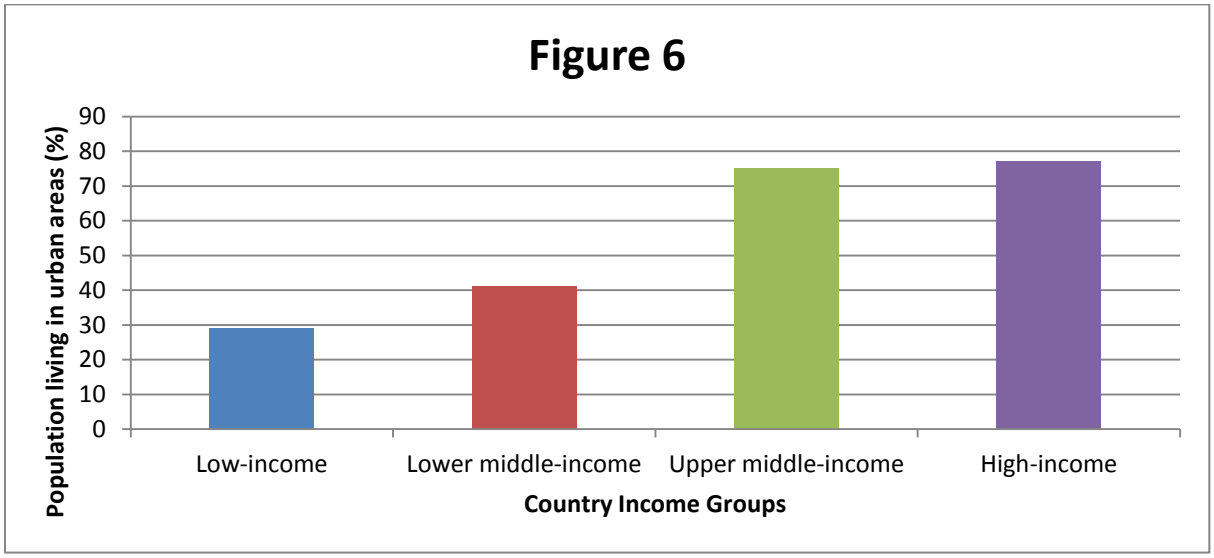
In Figure 4, the life expectancy at birth for both sexes in 2009, varies in the four WHO country income groups. In low-income countries, life expectancy at birth for both sexes is 57 years, 68 years in lower middle-income countries, 71 years in upper middle-income countries, and 80 years in high-income countries. The high-income countries have the highest while the low-income countries have the lowest life expectancy at birth for both sexes.

3.1.4: TB Prevalence by income group, 2009



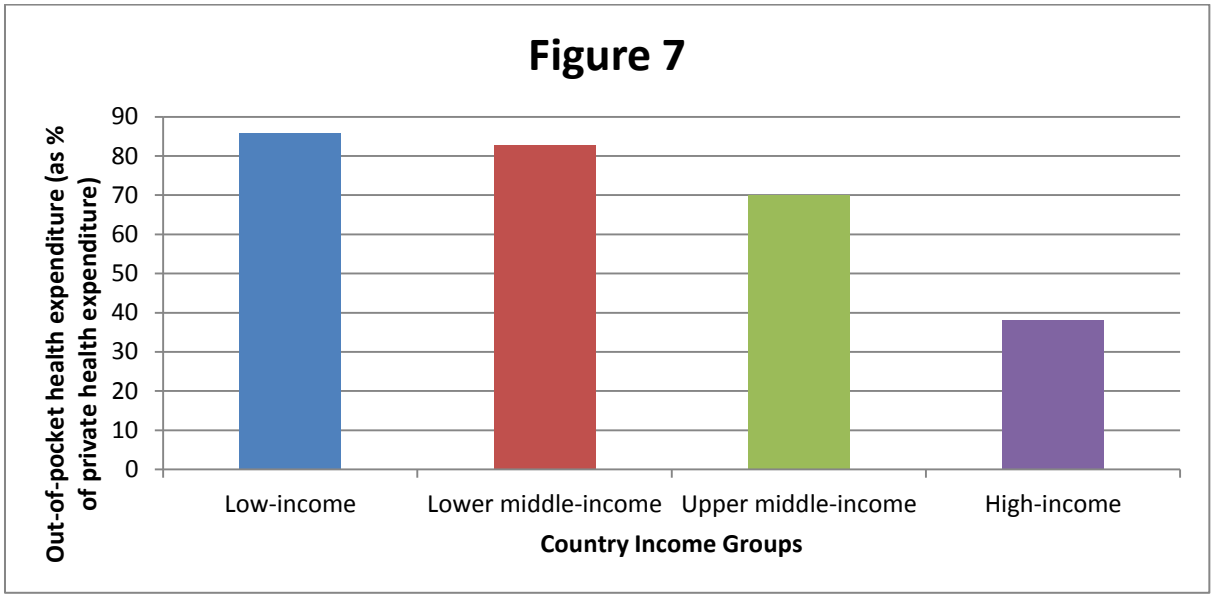
In Figure 5, the prevalence of TB in 2009 is different in each of the four WHO country income groups. It is highest in low-income countries with 444 per 100 000 population, followed by lower middle-income countries with 225 per 100 000 population, then upper middle-income countries with 105 per 100 000 population, and lastly high-income countries with 17 per 100 000 population.

3.1.5: Urban Population by income group, 2009



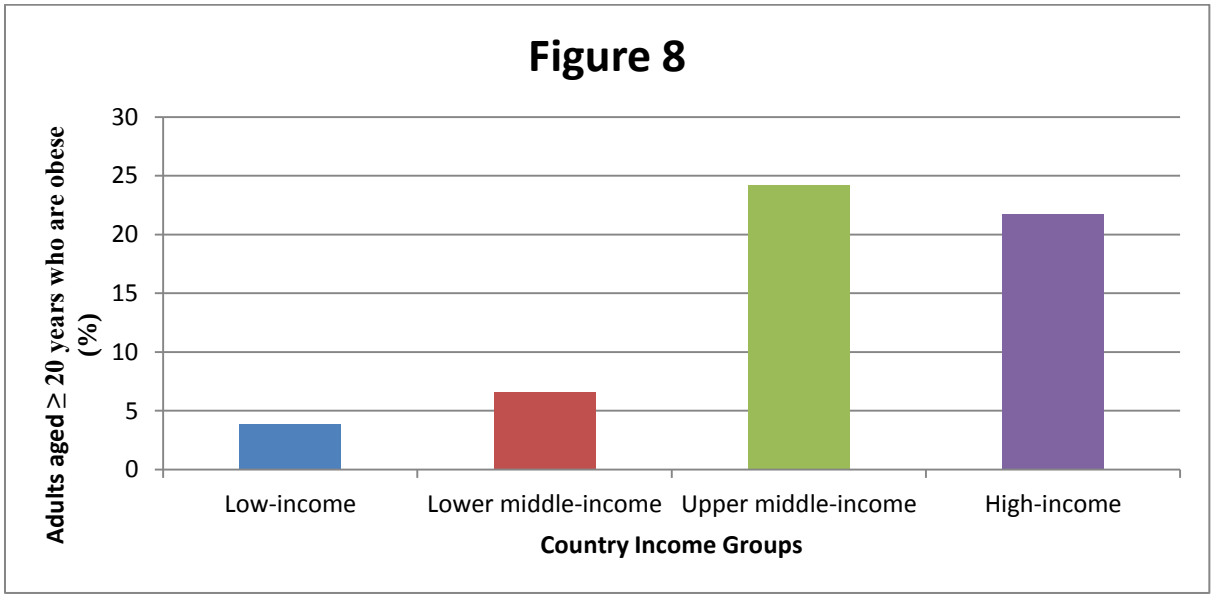
In Figure 6, the population living in urban areas in 2009, varies in the four WHO country income groups. It is 29% in low-income countries, 41% in lower middle-income countries, 75% in upper middle-income countries, and 77% in high-income countries. High-income countries have the highest while low-income countries have the lowest population (%) living in urban areas.

3.1.6: Out-of-pocket health expenditure by income group, 2008



In Figure 7, out-of-pocket health expenditure in 2008 is different in each of the four WHO country income groups. It is highest in low-income countries with 85.7%, followed by lower middle-income countries with 82.7%, then upper middle-income countries with 70.0%, and finally the high-income countries with 38.0%.

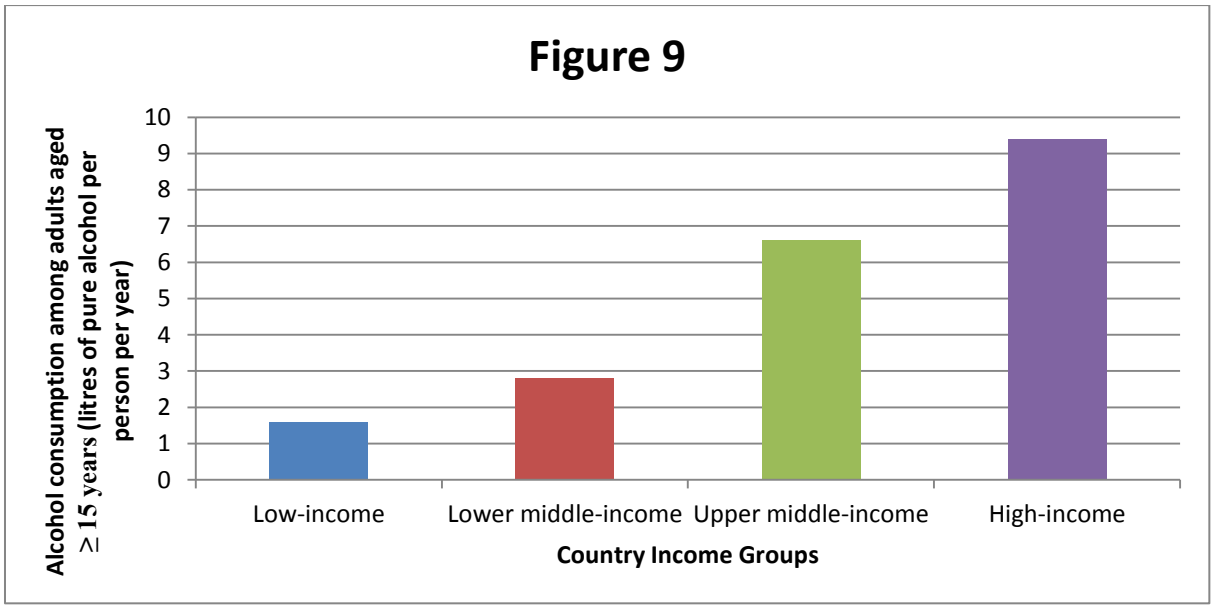
3.1.7: Adults aged ≥ 20 years who are obese by income group, 2008



In Figure 8, the percentage of adults aged ≥ 20 years who are obese in 2008 varies in the each of the four WHO country income groups. In low-income countries it is 3.9%, 6.6% in lower middle-income countries, 24.2% in upper middle-income countries, and 21.7% in high-

income countries. The upper middle-income countries have the highest proportion of obese adults while the low-income countries have the lowest proportion of obese adults, all aged ≥ 20 years.

3.1.8: Alcohol consumption among adults ≥ 15 years by income group, 2005



In Figure 9, alcohol consumption among adults ≥15 years in 2005 is different in each of the four WHO income groups. It is highest in high-income countries with 9.4 litres, followed by the upper middle-income countries with 6.6 litres, then lower middle-income countries with 2.8 litres, and lastly low-income countries with 1.6 litres.

3.1.9: GNI per capita by income group, 2004

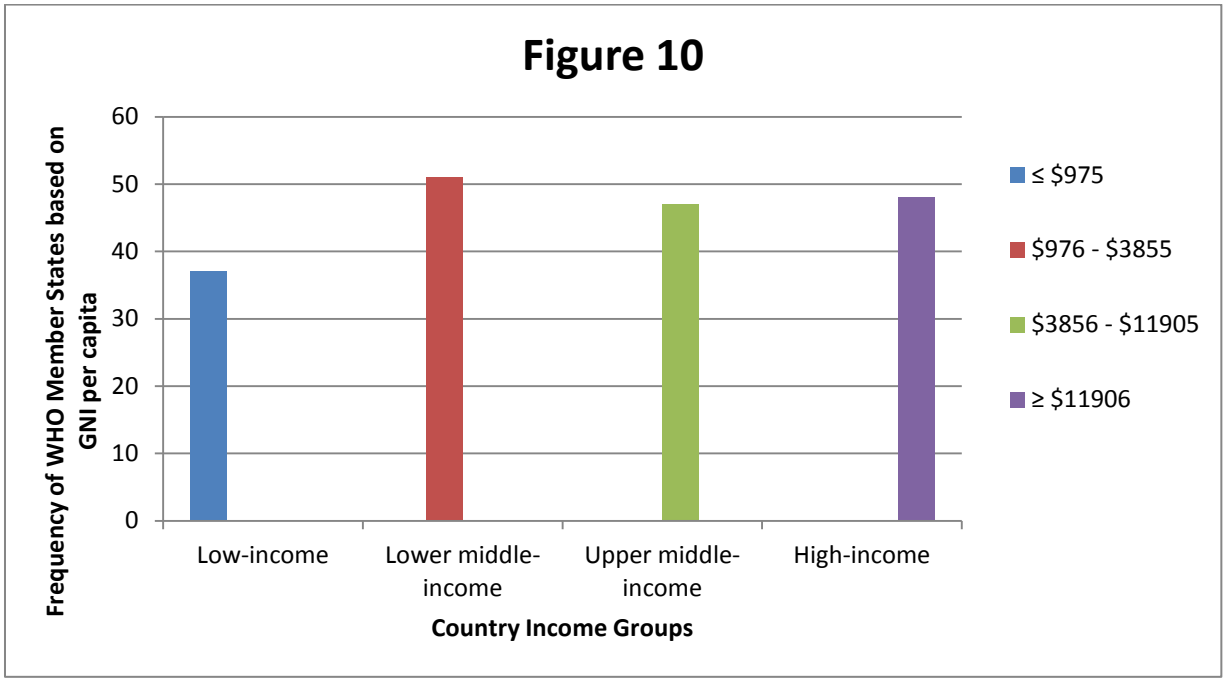


Figure 10 shows the distribution of WHO Member States based on GNI per capita (2004). Based on the study population of 183 WHO Member States, figure 10 represents the following distribution: 37 Member States in the low-income group, 51 in the lower middle-income group, 47 in the upper middle-income group, and 48 in the high-income group[50]. Low-income countries have a GNI per capita of $975 or less; lower middle-income countries: $976 - $3,855; upper middle-income countries: $3,856 - $11,905; and high-income countries: $11,906 or more[69].

3.2: Results for the analyses of association between independent variables and DM prevalence in WHO Member States and within each WHO country income group

Generally WHO comprised of 193 Member States (because data for South Sudan and Sudan are combined)[71] but a total of 10 out of the 193 WHO Member States were not included in the analyses because data for all of the variables was not available for these Member States[2]. The distribution of these 10 Member States is as follows: 3 low-, 3 lower middle-, 2 upper middle-, and 2 high-income countries. Therefore, the analyses comprised only of 183 Member States:

[2] The 10 excluded Member States: Democratic People's Republic of Korea, Maldives, Marshall Islands, Monaco, Montenegro, Niue, San Marino, Somalia, Tuvalu, Zimbabwe.

37 in the low-income group, 51 in the lower middle-income group, 47 in the upper middle-income group, and 48 in the high-income group[50].

In order to analyze the association between the prevalence of diabetes mellitus with all the independent variables that is, health expenditure for diabetes; life expectancy at birth; prevalence of tuberculosis; population living in urban areas; out-of-pocket health expenditure; adults aged ≥ 20 years who are obese; and alcohol consumption among adults aged ≥ 15 years, linear regression analyses were performed. The tables below represent the results from these analyses. Worth mentioning is the fact that the variables in the tables are coded as such:

- DMEXP: Health expenditure for diabetes mellitus
- LIFEEXP: Life expectancy for both sexes
- TBPREV: Tuberculosis prevalence
- URBAN: Population living in urban areas
- OOPHEXP: Out-of-pocket health expenditure
- OBESE: Adults aged ≥ 20 years who are obese
- ALCOHOL: Alcohol consumption among adults ≥ 15 years

Table 6: Linear regression analysis to observe association between DM prevalence with all independent variables in the 183 WHO Member States

	Univariate (unadjusted) analysis, n = 183		**Multiple (adjusted) analysis, n = 183**	
Variables	**B Coefficient**	**P-value**	**B Coefficient**	**P-value**
DMEXP	0.00008	.644	-.0005	.011
LIFEEXP	.133	.001	.011	.768
TBPREV	-.007	.001	-.004	.010
URBAN	.059	.001	.034	.004
OOPHEXP	-.027	.022	-.021	.030
OBESE	.169	.001	.119	.001
ALCOHOL	.006	.926	-.150	.009

Interpretation of table 6:

According to the univariate analysis, the variables: LIFEEXP, TBPREV, URBAN, OOPHEXP, OBESE, are statistically significant. This implies that 1% increase in DM prevalence is associated with the following: .133 years increase in LIFEEXP; .007 per 100,000 population decrease in TBPREV; .059% increase in URBAN; .027% decrease in OOPHEXP; .169% increase in OBESE.

According to the multivariate analysis, the variables: DMEXP, TBPREV, URBAN, OOPHEXP, OBESE, ALCOHOL, are statistically significant. This implies that 1% increase in DM prevalence is associated with the following: .0005 USD decrease in DMEXP; .004 per 100,000 population decrease in TBPREV; .034% increase in URBAN; .021% decrease in OOPHEXP; .119% increase in OBESE; .15 litres increase in ALCOHOL.

Table 7: Linear regression analysis to observe association between DM prevalence with all independent variables in the low-income country group

	Univariate (unadjusted) analysis, n = 37		**Multiple (adjusted) analysis, n = 37**	
Variables	**B Coefficient**	**P-value**	**B Coefficient**	**P-value**
DMEXP	.015	.323	.012	.446
LIFEEXP	.022	.520	.013	.726
TBPREV	-0.00006	.959	-.001	.544
URBAN	.049	.011	.053	.009
OOPHEXP	.022	.063	.023	.075
OBESE	.014	.753	-.014	.767
ALCOHOL	-.129	.153	-.024	.797

Interpretation of table 7:

According to both the univariate and multivariate analysis, only the variable URBAN is statistically significant. The univariate analysis denotes that 1% increase in DM prevalence is

associated with .049% increase in URBAN, and the multivariate analysis denotes that 1% increase in DM prevalence is associated with .053% increase in URBAN.

Table 8: Linear regression analysis to observe association between DM prevalence with all independent variables in the lower middle-income country group

	Univariate (unadjusted) analysis, n = 51		Multiple (adjusted) analysis, n = 51	
Variables	**B Coefficient**	**P-value**	**B Coefficient**	**P-value**
DMEXP	.008	.041	-.003	.417
LIFEEXP	.175	.001	.100	.091
TBPREV	-.007	.001	-.001	.671
URBAN	.018	.440	.007	.722
OOPHEXP	.030	.119	.033	.093
OBESE	.104	.001	.099	.004
ALCOHOL	.041	.772	-.012	.918

Interpretation of table 8:

According to the univariate analysis, the variables: DMEXP, LIFEEXP, TBPREV, OBESE, are statistically significant. This implies that 1% increase in DM prevalence is associated with the following: .008 USD increase in DMEXP; .175 years increase in LIFEEXP; .007 per 100,000 population decrease in TBPREV; .104% increase in OBESE.

According to the multivariate analysis, only the variable OBESE is statistically significant. This implies that 1% increase in DM prevalence is associated with .099% increase in OBESE.

Table 9: Linear regression analysis to observe association between DM prevalence with all independent variables in the upper middle-income country group

	Univariate (unadjusted) analysis, n = 47		Multiple (adjusted) analysis, n = 47	
Variables	**B Coefficient**	**P-value**	**B Coefficient**	**P-value**
DMEXP	.004	.244	.001	.866
LIFEEXP	-.074	.520	-.545	.006
TBPREV	-.007	.065	-.022	.001
URBAN	.028	.419	-.007	.819
OOPHEXP	-.048	.036	-.041	.078
OBESE	.178	.001	.079	.195
ALCOHOL	-.227	.192	-.162	.258

Interpretation of table 9:

According to the univariate analysis, the variables: OOPHEXP, OBESE, are statistically significant. This implies that 1% increase in DM prevalence is associated with the following: .048% decrease in OOPHEXP; .178% increase in OBESE.

According to the multivariate analysis, the variables: LIFEEXP, TBPREV, are statistically significant. This implies that 1% increase in DM prevalence is associated with the following: .545 years decrease in LIFEEXP; .022 per 100,000 population decrease in TBPREV.

Table 10: Linear regression analysis to observe association between DM prevalence with all independent variables in the high-income country group

	Univariate (unadjusted) analysis, n = 48		Multiple (adjusted) analysis, n = 48	
Variables	**B Coefficient**	**P-value**	**B Coefficient**	**P-value**
DMEXP	-.001	.003	-.001	.013
LIFEEXP	-.161	.141	.167	.156
TBPREV	.028	.160	.031	.129
URBAN	.015	.645	-.016	.551
OOPHEXP	-.055	.026	-.048	.005
OBESE	.220	.001	.185	.001
ALCOHOL	-.537	.001	-.359	.001

Interpretation of table 10:

According to the univariate analysis, the variables: DMEXP, OOPHEXP, OBESE, ALCOHOL are statistically significant. This implies that 1% increase in DM prevalence is associated with the following: .001 USD decrease in DMEXP; .055% decrease in OOPHEXP; .22% increase in OBESE; .537 litres decrease in ALCOHOL.

According to the multivariate analysis, the variables: DMEXP, OBESE, ALCOHOL, are statistically significant. This implies that 1% increase in DM prevalence is associated with the following: .001 USD decrease in DMEXP; .185% increase in OBESE; .359 litres decrease in ALCOHOL.

Table 11: Multiple (adjusted) linear regression analysis to observe association between DM prevalence with all independent variables in the WHO Member States and country income groups

	WHO Member States, n=183	Low-income group, n=37	Lower middle-income group, n=51	Upper middle-income group, n=47	High-income group, n=48
Variables	**B Coefficient**	**B Coefficient**	**B Coefficient**	**B Coefficient**	**B Coefficient**
DMEXP	-.0005	.012	-.003	.001	-.001
LIFEEXP	.011	.013	.100	-.545	.167
TBPREV	-.004	-.001	-.001	-.022	.031
URBAN	.034	.053	.007	-.007	-.016
OOPHEXP	-.021	.023	.033	-.041	-.048
OBESE	.119	-.014	.099	.079	.185
ALCOHOL	-.150	-.024	-.012	-.162	-.359

Table 11 in particular is a summary table of the regression analyses represented in Tables 6 to 10, in order to ease comparison between the country income groups. The multiple linear regression analyses were chosen for this comparison because its results are more accurate, since the impact of each independent variable has been adjusted for by the other independent variables.

CHAPTER 4: DISCUSSION

The main finding of this study is that the prevalence of diabetes mellitus is associated with health expenditure for DM, life expectancy, TB prevalence, urban population, out-of-pocket expenditure, adults aged ≥ 20 years who are obese, and alcohol consumption among adults ≥ 15 years. But the patterns of association are different with respect to the 183 WHO Member States as well as the individual country income groups.

4.1: Associations among the 183 WHO Member States

4.1.1: Positive associations

Based on the study revelations, the prevalence of diabetes is positively associated with population living in urban areas, and adults aged ≥ 20 years who are obese. This implies that an increase in % population living in urban areas, and % adults aged ≥ 20 years who are obese respectively, results in an increase in the prevalence of diabetes mellitus, and vice versa. These results are expected because according to research, the number of people with diabetes is increasing due to population growth, aging, urbanization, and increasing prevalence of obesity and physical inactivity. Between 2000 and 2030 most of the expected population growth will be concentrated in urban areas of the world[72-73]. Most studies also show that diabetes increases with migration and urbanization[74]. This increasing prevalence of diabetes is attributed to factors related to lifestyle changes which are in turn related to modernization. In urbanizing populations, sedentary lifestyle is an important determinant for the higher prevalence of diabetes[75]. Similarly research holds that obesity is a strong risk factor for type 2 diabetes[1,76-80]; thus the prevalence of diabetes is expected to increase with increasing obesity percentages. This is because obesity promotes insulin resistance which prevents the body's cells from using insulin properly and could be a risk for developing type 2 diabetes[81].

4.1.2: Negative associations

The study revealed that, the prevalence of diabetes is negatively associated with health expenditure for DM, TB prevalence, out-of-pocket health expenditure, and alcohol

consumption among adults ≥ 15 years. This implies that an increase in health expenditure for DM, TB prevalence, out-of-pocket health expenditure, and alcohol consumption among adults ≥ 15 years respectively, results in a decrease in the prevalence of diabetes mellitus, and vice versa. According to research, the associations between diabetes and health expenditure for DM, out-of-pocket health expenditure, and alcohol consumption among adults ≥ 15 years, are expected. This is because studies show that the prevalence of diabetes decreases steadily as income goes up[2], implying that the higher the health expenditure for DM, the more reduced the prevalence of diabetes and vice versa[46]. Evidence in the literature also shows that diabetes is associated with low socioeconomic position in industrialized countries[82-84]. Similar findings are reported in developing countries with differences between rural and urban areas[85,86]. With respect to out-of-pocket expenditure, although the burden of out-of-pocket spending can create barriers to health care access and use[87,88], this burden in theory, is shifted towards those who use services more[89]. By inference, those who use health services more spend more income on health, and should therefore have a decreased prevalence of diabetes mellitus[2]. Regarding alcohol consumption, research also argues that because of the effect of alcohol on insulin sensitivity, moderate alcohol consumption may reduce the risk of diabetes by augmenting insulin sensitivity[90]. However, excessive alcohol intake reduces insulin sensitivity, thereby increasing insulin resistance and the risk of diabetes[90-92]. Thus, a U-shaped association appears to exist between alcohol consumption and diabetes[93]. With respect to the association between diabetes and TB, research holds that physicians have been aware of this association since ancient times[94-101], which could be in either, or both, directions[102]. Active TB can cause glucose intolerance and worsen glycaemic control in diabetics[102-106]. Alternatively, diabetes increases the risk of lower respiratory tract infection and susceptibility to other infections[102,107-110]. However, most studies which have investigated the association of TB and DM report an elevated risk of TB among diabetes patients[111]. The prevalence and

incidence of TB increase most likely in countries with an increased diabetes prevalence[112]. This implies that diabetes is a strong risk factor for pulmonary TB[104] or that TB occurs with an increased frequency in diabetics[98,113]. Recent systematic reviews[114,115] also suggest that type 2 diabetes mellitus increases individual risk of *Mycobacterium tuberculosis* (TB) disease. Thus, this particular study finding is strange and contrary to the above evidence.

4.2: Associations in low-income group

Based on the study revelations, the prevalence of diabetes mellitus is positively associated with the population living in urban areas. This implies that an increase in % population living in urban areas results in an increase in the prevalence of diabetes mellitus, and vice versa. This result was expected because according to research, diabetes is less prevalent in rural than in urban areas[116]. More so, the rising prevalence of diabetes in the developing world (low-income countries) is chiefly attributed to the dramatic increase in urbanization[117-120]. Between 2007 and 2050, it is expected that the world's urban population will likely increase by 3.1 billion. Consequently, people will adapt the lifestyle from industrialized countries, causing diseases such as diabetes which are related to an urban lifestyle[117]. The increasing concentration of diabetes in urban areas of developing countries may also be largely accounted for by the rapid growth in size of major urban conglomerates of developing countries, as well as by the ageing of their populations[121].

4.3: Associations in lower middle-income group

The study revealed that the prevalence of diabetes mellitus is positively associated with adults aged ≥ 20 years who are obese. This implies that an increase in % adults aged ≥ 20 years who are obese results in an increase in the prevalence of diabetes mellitus, and vice versa. This result is in line with literature which mentions that obesity is a strong risk factor for type 2 diabetes[1,76-80]. Furthermore, middle-income countries are now experiencing a rapid upsurge in

obesity, particularly in urban settings because of their dietary patterns and lower levels of physical activity[122].

4.4: Associations in upper middle-income group

Based on the study findings, the prevalence of diabetes mellitus is negatively associated with life expectancy and TB prevalence. This implies that an increase in life expectancy and TB prevalence respectively, results in a decrease in the prevalence of diabetes mellitus, and vice versa. These both results are rather strange and contrary because, in the case of life expectancy, research shows that the prevalence of chronic diseases increases with age. This means that increased longevity is a major contributor to the high and steadily rising prevalence of chronic diseases because when people live longer, many diseases and conditions have time to manifest. Moreover, many diseases which were considered fatal in the past, like type 1 diabetes, have been converted to chronic conditions with prolonged courses and resulting in substantially improved life expectancy. This phenomenon greatly contributes to the increasing prevalence of chronic diseases[72,123]. Furthermore, according to the IDF President Professor Jean Claude Mbanya, the increasing prevalence of the diabetes epidemic is inevitable due to ageing. Our contemporary world has been heralded 'the century of ageing', with life expectancy soaring worldwide. But unfortunately, as the age of populations increase, their risk of type 2 diabetes increases as well[124]. In the case of TB prevalence, most research argue that although the association between DM and TB prevalences is positive and can be in either or both directions[102], most often, diabetes acts as a strong risk factor for TB[111].

4.5: Associations in high-income group

4.5.1: Positive association

The study revealed that the prevalence of diabetes mellitus is positively associated with adults aged ≥ 20 years who are obese. This implies that an increase in % adults aged ≥ 20 years who

are obese results in an increase in the prevalence of diabetes mellitus, and vice versa. This result agrees with research evidence which reveals that obesity is a strong risk factor for type 2 diabetes[1,76-80]. More so, because obesity had always been associated with high-income countries[125], this study finding was expected.

4.5.2: Negative associations

Based on the study findings, the prevalence of diabetes mellitus is negatively associated with health expenditure for DM, and alcohol consumption among adults ≥ 15 years. This means that an increase in health expenditure for DM and alcohol consumption among adults ≥ 15 years, respectively results in a decrease in DM prevalence and vice versa. These both results are expected because, in the case of health expenditure for DM research shows that the prevalence of diabetes decreases steadily as income goes up[2], implying that the higher the health expenditure for DM, the more reduced the prevalence of diabetes and vice versa[46]. In addition, evidence shows that high-income countries have a greater expenditure for DM[46]. With respect to alcohol consumption among adults ≥ 15 years, studies argue that a U-shaped association exists between alcohol consumption and diabetes, that is, moderate alcohol reduces the risk of diabetes but alcohol taken in excess rather increases that risk[90-93]. The prominence of this association was most expected in high-income countries because they generally have the highest alcohol consumption, as proven by the fact that the developed world including Western and Eastern Europe is the world's highest consumer of alcohol[67].

4.6: Strengths and Limitations

Generally, very few ecological studies have been performed to explore the association between DM prevalence and several factors. But one was found which explored the association between diabetes and TB[112]. Another study was also found which explored the association between diabetes mellitus and sugar consumption, and revealed that sugar consumption is positively associated with the prevalence of diabetes mellitus[126]. Thus, based

on these previously conducted ecological studies, I was encouraged to carry out mine. Viewing my study in the context of ecological studies, its strengths and limitations are discussed in the proceeding sections.

The strength of this study lies in the fact that it accounts for the possible factors associated with the disparity in the prevalence of diabetes across different countries and income groups all over the world. Thus, enabling me assess the relationship between diabetes mellitus and those factors: health expenditure for diabetes mellitus; life expectancy; TB prevalence; urban population; out-of-pocket health expenditure; adults aged ≥ 20 years who are obese; alcohol consumption among adults ≥ 15 years. Furthermore, some of the associations between variables identified in the study tallied with those from previous researches conducted. Another strength lies in the fact that since the study data was obtained from credible sources like WHO and IDF, the study is likely to be representative of diabetes mellitus and its possible associations in various countries across the world.

For weaknesses, a major limitation of this study is the fact that it is an ecological study. Thus, because of the use of aggregate data, this study is subject to the "ecological fallacy" which caused the analyses of some associations made between populations in groups (or countries, in our case) to be strange and contrary to existing literature and expected outcomes. Furthermore, multicollinearity was exhibited by some of the variables employed in the study, that is, strong correlations existed between two or more of some of the independent variables. This was most common with the variable, life expectancy. This most probably resulted in the unadjusted and adjusted analyses being quite different from each other in most cases, as well as the interpretation of the effects of some of the independent variables being intricate. Another limitation was that, although the data for prevalence of diabetes included both type 1 and type 2 diabetes, it did not distinguish among the types of diabetes. Consequently, without this distinction being made, the validity of the relationship between the determinants and

diabetes prevalence could be affected. Finally, considering the fact that 10 out of 193 Member States were excluded from the study because data for all their variables were not available, the results of the study could be affected. More so, for the 183 Member States included in the study, the distribution of countries across income groups was different. Thus, this could affect the analyses and results of the study.

CHAPTER 5: CONCLUSION

In spite of the study limitations, the estimates reported here show that the prevalence of diabetes mellitus is associated with several factors like health expenditure for DM, life expectancy, TB prevalence, urban population, out-of-pocket expenditure, adults aged ≥ 20 years who are obese, and alcohol consumption among adults ≥ 15 years. The association between DM and these factors vary depending on the different country income groups.

In summary, these results serve as another piece of evidence that the growing burden of diabetes mellitus differs according to country income groups. Therefore, strategies for diabetes prevention should address the different countries based on their income group, in addition to being person-centered approaches. The study findings suggest that attention should be paid to considering the determinants such as health expenditure for DM, urban population, adults aged ≥ 20 years who are obese, and alcohol consumption among adults ≥ 15 years, in further investigations of the etiology of diabetes mellitus among the different country income groups.

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APPENDICES

Appendix A

Income groups[3,4]

Low-income: Afghanistan, Bangladesh, Benin, Burkina Faso, Burundi, Cambodia, Central African Republic, Chad, Comoros, Democratic People's Republic of Korea, Democratic Republic of the Congo, Eritrea, Ethiopia, Gambia, Ghana, Guinea, Guinea-Bissau, Haiti, Kenya, Kyrgyzstan, Lao People's Democratic Republic, Liberia, Madagascar, Malawi, Mali, Mauritania, Mozambique, Myanmar, Nepal, Niger, Rwanda, Sierra Leone, Solomon Islands, Somalia, Tajikistan, Togo, Uganda, United Republic of Tanzania, Zambia, Zimbabwe.

Lower middle-income: Angola, Armenia, Belize, Bhutan, Bolivia (Plurinational State of), Cameroon, Cape Verde, China, Congo, Cote d'Ivoire, Djibouti, Ecuador, Egypt, El Salvador, Georgia, Guatemala, Guyana, Honduras, India, Indonesia, Iraq, Jordan, Kiribati, Lesotho, Maldives, Marshall Islands, Micronesia (Federated States of), Mongolia, Morocco, Nicaragua, Nigeria, Pakistan, Papua New Guinea, Paraguay, Philippines, Republic of Moldova, Samoa, Sao Tome and Principe, Senegal, Sri Lanka, Sudan, Swaziland, Syrian Arab Republic, Thailand, Timor-Leste, Tonga, Tunisia, Turkmenistan, Tuvalu**, Ukraine, Uzbekistan, Vanuatu, Viet Nam, Yemen.

Upper middle-income: Albania, Algeria, Antigua and Barbuda, Argentina, Azerbaijan, Belarus, Bosnia and Herzegovina, Botswana, Brazil, Bulgaria, Chile, Colombia, Cook Islands**, Costa Rica, Cuba, Dominica, Dominican Republic, Fiji, Gabon, Grenada, Iran (Islamic Republic of), Jamaica, Kazakhstan, Lebanon, Libyan Arab Jamahiriya, Lithuania, Malaysia, Mauritius, Mexico, Montenegro, Namibia, Nauru**, Niue**, Palau, Panama, Peru, Romania, Russian Federation, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines, Serbia, Seychelles, South Africa, Suriname, The former Yugoslav Republic of Macedonia, Turkey, Uruguay, Venezuela (Bolivarian Republic of).

High-income: Andorra, Australia, Austria, Bahamas, Bahrain, Barbados, Belgium, Brunei Darussalam, Canada, Croatia, Cyprus, Czech Republic, Denmark, Equatorial Guinea, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Japan, Kuwait, Latvia, Luxembourg, Malta, Monaco, Netherlands, New Zealand, Norway, Oman, Poland, Portugal, Qatar, Republic of Korea, San Marino, Saudi Arabia, Singapore, Slovakia, Slovenia, Spain, Sweden, Switzerland, Trinidad and Tobago, United Arab Emirates, United Kingdom, United States of America.

[3] *World Bank list of economies* (December 2010). Washington, DC, World Bank, December 2010 (http://siteresources.worldbank.org/DATASTATISTICS/Resources/CLASS.XLS).

[4] Member States marked with an ** have been classified into income groups using gross domestic product.

Appendix B

Data Search

The search for data was limited to studies published after 1979. This cut-off was chosen as data collected prior to 1980 may no longer reflect the current prevalence of diabetes. Selection of articles was limited to those published pre-
March 2006.
The Medline database and internet were used for the literature search. Systematic searches were conducted for each country using the following search formulae:
1. Country name (all the countries of the world were entered for separate searches) together with 'diabetes' or 'impaired glucose tolerance' and 'prevalence' or 'incidence'; and
2. 'NIDDM' or 'IDDM' or 'non-insulin-dependent diabetes mellitus' or 'insulin-dependent diabetes mellitus' or 'Type 1 diabetes' or 'Type 2 diabetes', combined with 'prevalence' or 'incidence'.

Relevant citations from each article were also obtained. A number of other avenues were explored in the search for relevant data. Diabetes researchers in each major IDF geographical region were contacted and requested to provide information on the prevalence of diabetes for countries within their region. In addition, IDF member associations in each member country were asked about relevant data. In the absence of data for a country, the member association was further asked to comment on the use of data from another country (see section on Extrapolation below).

Data Selection

The search obtained data in a variety of forms such as prevalence studies, registry reports, hospital statistics, government estimates, etc. Studies for a particular country were included based on their level of reliability. The following factors were taken into account when assessing a study's level of reliability:
• The year of the study — more recent studies were preferred.
• The screening method used — the oral glucose tolerance test (OGTT) was the preferred method of screening, followed by two-hour blood glucose (2hBG) alone, then the fasting blood glucose (FBG) alone, and then self-report (SR).
• Sample size — studies with larger sample sizes and higher response rates were preferred.

EXAMPLES OF MODELLED AND PUBLISHED DIABETES PREVALENCES

FIGURE A1.1

Jordanian males and females combined (urban)

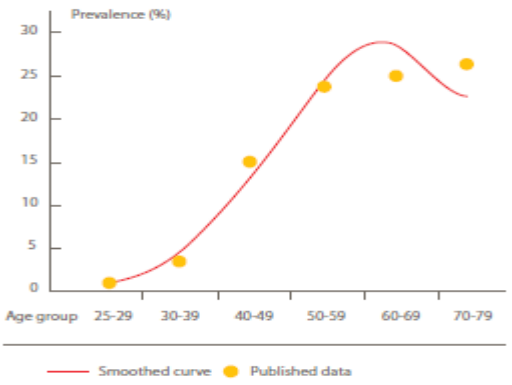
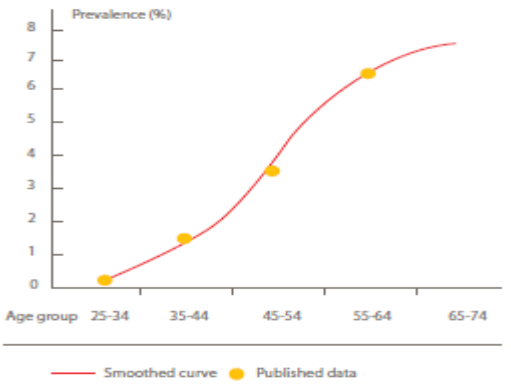


FIGURE A1.2

Chinese males



When more than one study was available for a country, and there was no clear superiority of one over the other, the results from the available studies were averaged, and then applied to the national population.

Extrapolation

If there were no data available for a particular country, prevalence rates from a published study from the socioeconomically, ethnically, and geographically most similar country were applied to that country's age and sex-specific (and in the case of low/middle-income countries, urban/rural-specific) population distribution. Socio-economic comparisons were based on gross national product (GNP) per capita. Ethnic comparisons were based on ethnicity data from the *CIA World Factbook 2005*[5]. If a dataset did not provide sex-specific data, the data were disaggregated and assigned 50% to females and 50% to males.

[5] Central Intelligence Agency. *The World Factbook*. CIA. 2005.