INFLUENCE OF SOCIOECONOMIC BACKGROUND ON CARDIOVASCULAR DISEASE RISK FACTORS AMONG ADULT MALAYSIANS

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ABSTRACT

Developing countries are experiencing more serious cardiovascular disease (CVD) related mortality and morbidity rates than the developed economies, which has been argued to be caused primarily by low education levels and limited access to healthcare facilities. As a developing nation, Malaysia is no different as it has experienced a dramatic increase in the prevalence of CVD risk factors that has raised concerns among policy makers. In light of the aforementioned concerns, this study aims to: i) provide a comprehensive assessment of CVD risk factors (CVDRF), both individually and cumulatively, based on socioeconomic status (SES) determinants (i.e., educational attainment, income level, and occupational status); ii) estimate a ten-year CVD risk (CVDR) assessment based on demographic and SES stratifications; and, iii) evaluate and propose a socioeconomic intervention framework to tackle CVDRF in Malaysia. A representative sample of Malaysian adults participated in the REDISCOVER Study in 2007-2010. Important CVDRFs were included, namely, hypertension, diabetes, and smoking [which constitute cumulative CVDRF1 (CCVDRF1)], and overweight/obesity and hypercholesterolemia [which constitute cumulative CVDRF2 (CCVDRF2)]. The SES indicators were obtained from face-to-face interviews. Various statistical methods, including age-standardization, binary logistic regression and the Karlson, Holm and Breen mediation method were deployed for this study. The prevalence of CCVDRF1 was greater in men than women, while women experienced higher CCVDRF2 than men. Middle-income Malaysians are more likely to be hypertensive, hypercholesterolemic, and obese compared to low-income Malaysians. Skilled professionals are more likely to smoke compared to persons holding other occupations. While the ten-year CVDR increased by age, men had higher predicted risk of CVD compared to women. Ethnically, Malays' likelihood of having CVDRF was greater than Chinese and Others. Respondents with lower levels of income and education had the highest mean and median predicted CVDR factors compared to others. Occupations related to elementary education levels had the highest CVDR compared to other job types. The CCVDRF findings varied in which CCVDRF1 was inversely associated with SES levels, while CCVDRF2 had a direct relationship with SES levels. The results also show that income can mediate the association between education and CCVDRFs. The strongest mediation effect of income level in CCVDRFs was among secondary educated females (52%), Malays (44%), and all sample respondents (37%). Whereas income accounted for 50, 48, and 42 percent of the mediation effect among tertiary males, overall sample respondents, and rural residents respectively in the association between education and CCVDRF2. The results show that low SES respondents will experience greater CVDR in ten years from now. In conclusion, the findings of this study lead to three types of policies that can help the reduction and prevention of CVDR. First, policies must focus more on the lower SES Malaysians to reduce their CVDRFs. Reducing future CVDR, policies should target males, Malays, and the low SES population. Finally, increasing both income and education levels may enhance a reduction in CCVDR morbidities in Malaysia in particular, and the developing world in general.

ABSTRAK

Negara-negara membangun menghadapi paras morbiditi berkaitan jantung (CVD) yang lebih serius daripada negara-negara maju, yang dihujah sebagai berpuncakan paras pendidikan yang rendah dan kekurangan kemudahan kesihatan. Sebagai sebuah Negara membangun, pengalaman Malaysia tidak berbeza kerana ia telah mencatatkan pertumbuhan pesat dalam insiden factor risiko CVD yang telah menaikkan kebimbangan dikalangan pembentuk dasar. Atas kebimbangan berkenaan, kajian ini bermatlamat untuk: i) memberi suatu penilaian menyeluruh faktor risiko CVD (CVDRF) baik diperingkat individu mahupun secara kumulatif, penentu status sosioekonomi (SES); ii) menganggarkan suatu faktor risiko bektempuh sepuluh tahun (CVDR) berasaskan lapisan demografi dan SES; dan, iii) menghurai dan mencadangkan suatu kerangka sosioekonomi untuk menaksir dan mencadangkan campurtangan socioekonomi demi menangani CVDRF di Malaysia. Suatu sampel penduduk dewasa Malaysia menyertai tinjauan REDISCOVER dalam tempuh 2007-2010. CVDRF mustahak dimasukkan, termasuk, darah tinggi, kencing manis, dan penghisapan rokok dalam kumulatif CVDRF1 (CCVDRF1), dan penyakit kolestrol tinggi dan badan gemuk dalam kumulatif CVDRF 2 (CCVDRF2). Petanda SES diperolehi menerusi temuduga langsung daripada responden. Berbagai kaedah statistik, termasuk pelurusan-umur, regresi logistik binari dan kaedah perantara Karlson, Holm and Breen, digunakan dalam kajian ini. Insiden CCVDRF1 lebih tinggi dalam lelaki, sementara wanita mengalami CCVDRF2 yang lebih tinggi. Penduduk Malaysia berpendapatan sederhana lebih berkemungkinan mengalami penyakit darah tinggi, hypercholesterolemia, dan badan gemuk berbanding dengan penduduk Malaysia berpendapatan rendah. Profesional mahir menunjukan kemungkinan merokok yang lebih tinggi berbanding dengan orang yang menyandang jawatan lain. Sementara CVDR dalam janka-masa sepuluh bertambah berasaskan umur, lelaki menunjukkan CVDR yang lebih tinggi daripada wanita women. Berdasarkan kaum, kebarangkalian Melayu

memperlihatkan faktor CVDR lebih tinggi daripada kaum Cina. Responden berpendapatan dan berpendidikan rendah mempunyai anggaran purata dan penengah tertinggi faktor CVDR berbanding dengan yang lain. Jawatan berhubungan dengan paras pendidikan yang rendah menunjukkan CVDR yang tertinggi berbanding dengan jawatan lain. Penemuan CCVDRF berbeza dalam mana CCVDRF1 berhubungan terbalik dengan paras SES, sementara CCVDRF2 berhubung secara langsung dengan paras SES. Penemuan juga memperlihatkan bahawa pendapatan boleh mengantara hubungan antara pendidikan dan CCVDRF. Kesan perantara terkuat pendapatan dalam CCVDRF berlaku dikalangan wanita berpendidikan menengah (52%), kaum Melayu (44%), dan responden sampel keseluruhan (37%). Sementara pendapatan menjelaskan 50, 48, dan 42 peratus kesan perantara dikalangan lelaki berpendikan iktisas, responden sampel keseluruhan, dan penghuni luarbandar masing-masing dalam hubungan antara pendidikan dan CCVDRF2. Penemuan menunjukkan bahawa responden SES rendah akan menghadapi CVDR yang lebih tinggi dalam tempuh masa sepuluh tahun akan datang nanti. Dalam kesimpulan, penemuan kajian ini membawa kepada tiga jenis dasar yang boleh membantu mengurangkan dan mencegah CVDR. Pertamanya, dasar seharusnya lebih memfokas pada penduduk Malaysia bertaraf SES yang rendah demi mengurangkan CVDRFs. Untuk menangani CVDR pada masa depan, dasar harus mensasarkan lelaki, Melayu, dan penduduk bertaraf SES yang rendah. Akhirkata, usaha menaikkan pendapatan dan pendidikan boleh mengurangkan morbidity CCVDRF, di Malaysia khasnya, dan dunia membangun amnya.

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LIST OF ABBREVIATIONS

CVD	:	Cardiovascular Disease
CVDR	:	Cardiovascular Disease Risk
CVDRF	:	Cardiovascular Disease Risk Factor
CCVD	:	Cumulative Cardiovascular Disease
CCVDRF	:	Cumulative Cardiovascular Disease Risk Factors
CCVDRF1	:	Cumulative Cardiovascular Disease Risk Factor 1
CCVDRF2	:	Cumulative Cardiovascular Disease Risk Factor 1
NCD	:	Non-communicable disease
BMI	:	Body Mass Index
HDL	:	High-density Lipoprotein
LDL	:	Low-density Lipoprotein
TC	:	Total Cholesterol
LMC	:	Low- and Middle-Income Countries

CHAPTER 1

INTRODUCTION

1.1 Introduction

Cardiovascular diseases (CVD) refer to diseases that encompass heart and blood vessels (Maton, 1997), or diseases that affect the cardiovascular system (Fuster & Kelly, 2010). Since the 1970s, the mortality rate due to CVDs has declined in developed nations, while it has been the leading cause of deaths worldwide especially in developing countries (Fuster & Kelly, 2010). During the same period, cardiovascular-related deaths and morbidities have drastically increased in low- and middle-income countries (Yusuf *et al.*, 2004a; Yusuf *et al.*, 2011; Yusuf *et al.*, 2004b). Hence, diagnosis of the determinants, prevention of the incidents, and intervention policies to tackle the prevalence by modifying risk factors of CVDs are the contemporary challenge in developing economies.

Various factors can cause CVDs. For instance, the most common contributors to CVDs are hypertension and obesity (Cooper *et al.*, 2000; Hubert *et al.*, 1983). In addition, if no preventive actions taken into consideration aging too can contribute to not only CVDs but also many physiological and morphological changes in the human body. The aging process affects the cardiovascular functioning that ultimately leads to elevated risk of developing CVD even in healthy individuals (Dantas *et al.*, 2012).

1.2 Study background

Health status plays a significant role in productivity of individuals leading to society's progress and improvement (Weil, 2005). This is because healthy individuals tend to be active and present in the society rather than passive and absent (Grossman, 1972b). Therefore, how a country improves is dependent on its human capital that must be adequately healthy to be influential and productive (Cole & Neumayer, 2006).

Diseases are called to the state that the health is absent and they cause economic contraction (Jenkinson *et al.*, 1995). There are two main types of diseases (WHO, 2008): i) communicable diseases (i.e., infectious diseases); and, ii) non-communicable diseases (NCD; i.e., non-infectious diseases). Instances for communicable diseases are human immunodeficiency virus (HIV: over time acquired immunodeficiency syndrome AIDS), Malaria, etc. and examples for NCDs are high blood pressure (hypertension), excessive blood cholesterol (hypercholesterolemia), high blood glucose (diabetes), high body mass index (BMI: obesity), etc.

Individual's genetic background and lifestyle habits (e.g., dietary habits, level of physical activity, etc.) may increase the likelihood of developing NCDs. However apart from genetic history (i.e., also classified as family history), the socioeconomic status (SES) of the household/individual also plays a significant role in determination of the health/disease status of the individuals (Subramanian *et al.*, 2013). A previous systematic review (Subramanian *et al.*, 2013) stated that results from developing countries were mixed on the association of SES and several diseases. However, it is believed there is a direct association between SES and risk factors contributing to CVDs (Subramanian *et al.*, 2013).

Lower SES and its associates, i.e., poverty or lower income level, lower educational attainment, and poor health, ultimately affect societies as a whole. Wealth and resource distribution gaps as well as quality of life inequities are exacerbating globally but with a higher pace in LMC's. Significant efforts to tackle the basis of the socioeconomic inequities will definitely reduce these large gaps in SES gradients existed among people around the world.

Socioeconomic status is chosen as an indicator for measuring inequalities in the distribution of risk factors for cardiovascular disease among adolescents so that the vulnerable groups on the socioeconomic scale can be differentiated from the well-off groups. The indicators also play an important role to measure the direct and indirect association between SES and the occurrence of risk factors of cardiovascular disease. The three standard indicators of socioeconomic status that will be used in this study are household income, the highest level of educational attainment of parents and occupational ranking of parents. The household income is categorized into eight income quintiles according to the income classification in the National Health and Morbidity Survey (NHMS). Educational attainment is ranked according to four categories: no formal education, primary education, secondary education and tertiary education. Occupations of parents are broadly classified according to the skill and educational level required to perform the tasks of a given occupation: farmers, manual workers, service and sales personnel, clerks and professionals.

In addition to SES factors, many other variables may influence CVD risk factors. Demographic variables such as age, gender, ethnic group and area of residence were identified to affect the prevalence of CVD risk factors (Zhang & Wang, 2004). However, because SES may also be correlated with gender, ethnic group and area of residence, it is necessary to control these variables when measuring the SES factors and associations with the occurrence of cardiovascular risk factors. Thus, the measures of inequalities and associations are deemed necessary to be stratified by these demographic variables of gender, ethnic group and area of residence which are further divided into male/female, Malay/Chinese/Indian/others and urban/rural respectively.

1.3 Current Study

Classified among the upper middle-income countries by the World Bank (2013), Malaysia is a developing economy (World Bank, 2013). It is a multi-ethnic nation, has a growing population (Department of Statistics Malaysia, 2013b), and has been modernizing and urbanizing rapidly in the recent decades (Sim, 2003). Malaysia's economic transition has been accompanied by high prevalence of CVD risk factors in recent years (Ministry of Health Malaysia, 2006b, 2011). In addition, it is expected that the risk of CVD will be higher in the coming decades (Chin & Pengal, 2009; Ng & Chia, 2008). Hence, it is crucial to predict the risk of CVD and tackle it with effective public health policies and interventions.

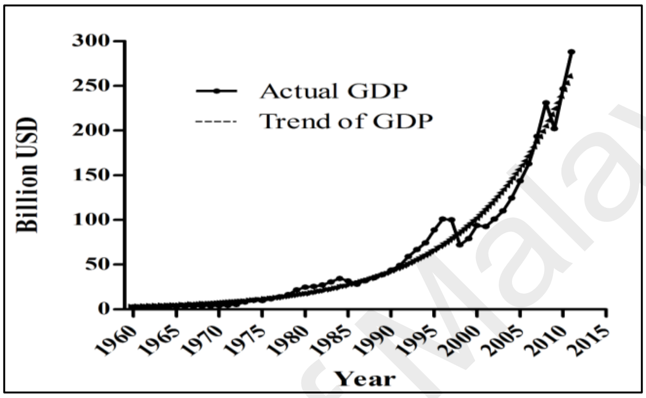

Figure 1.1: Malaysia's Gross Domestic Product (GDP; USD billion)

Source: Data were compiled by author from World Bank (2013).

According to a meta-analysis conducted in 80 developed and developing countries (Kim *et al.*, 2008), the Gross Domestic Product (GDP) level is directly associated with the prevalence of CVD risk factors in both economy settings. However, the incidence of these risk factors in developing countries is increasing at a faster pace than in the developed countries (Yusuf *et al.*, 2014). Malaysia is an excellent case to study as it is not only an upper middle-income country, but has also experienced rapid epidemiologic transition (World Bank, 2013) following relatively high GDP growth (see Figure 1.1). Besides, previous literature showed a high prevalence of CVD risk factors in Malaysia. For instance, a semi-rural study revealed that the prevalence of CVD risk factors were remarkably high in Malaysia with males showing higher prevalence than females (Chin & Pengal, 2009). In addition, Khoo *et al.* (1991) found that the first cause of mortality in 1970s was CVDs in the Peninsular Malaysia. Their results also showed that the Malays, Chinese, Indians, and other ethnic minorities had different prevalence of CVD risk factors with the worst prevalence among Indians.

The evaluation of the association between socioeconomic status (SES) and health conditions of Malaysians based on the Malaysian Family Life Survey (MFLS-2) by Wu and Rudkin (2000) showed that among Malays, Chinese and Indians, CVD risk factors were inversely associated with SES. While, Indians and Malays' occupational level was the best identifier of their SES levels, education of Chinese was the best predictor of SES levels.

The Amplavanar *et al.* (2010) study showed that 87% of respondents had at least one of the CVDRF's while more than 60 percent had at least two of the risk factors in Malaysia. In addition, ethnicity had a strong bearing on being overweight and obesity (Amplavanar *et al.*, 2010; Hong *et al.*, 2004; Ismail *et al.*, 2002), and on diabetes (Hong *et al.*, 2004). Age had a strong influence on hypertension (Amplavanar *et al.*, 2010), while gender played a significant role in all CVD risk factors (Amplavanar *et al.*, 2010; Chin & Pengal, 2009; Ismail *et al.*, 2002). Besides, past studies also showed that hypertension was highly correlated with education and obesity (Rampal *et al.*, 2008), while the prevalence of obesity in rural areas had increased drastically over the previous decades in Malaysia (Ismail *et al.*, 2002).

Malaysia consists of different ethnic and socioeconomic groups (Department of Statistics Malaysia, 2013a, 2013b). It is believed that SES can determine the health condition (Abegunde *et al.*, 2007; Adler & Ostrove, 1999; Blane *et al.*, 1996). In addition, higher socioeconomic inequalities (Scholes *et al.*, 2012) and lower levels of income (Kim *et al.*, 2008), education (Kivimaki *et al.*, 2009; Stelmach *et al.*, 2004), and occupational status (Barbeau *et al.*, 2004; Yusuf *et al.*, 2001b) are significant associates CVD risk. Living in urban areas may increase the risk of CVDs (Torun *et al.*, 2002) as inequalities are wider, the health expenditures are higher, and the living environment is worse compared to rural areas. Finally, besides environmental transitions, the urban development also influences on the living lifestyle, including living costs, higher stress, dietary habits, physical activity, and smoking habits, which are more damaging to the health condition (Teo *et al.*, 2009).

The primary objective of most literature that studied determinants of health was to highlight ways that result in a healthier society (Gwatkin, 2002). Clearly, there is a broad range of evidence worldwide showing significant and consistent patterns of inequalities in health in terms of SES. In some situations, these inequalities are in favor of people from higher statuses. Higher SES people usually have a lower prevalence of risk factors and suffer less from the burden of diseases hence putting disadvantaged groups at further disadvantage with relation to their socioeconomic position. However, this has a matter of full stop here and study the case of Malaysia in this regard. Thus, to reach ultimate results from monitoring risk factor trends in population subgroups and to effectively target intervention we analyzed the Malaysian health condition in relation to social and economic standing of its citizens. However, since the mortality rates due to CVDs in Malaysian hospitals showed a dramatic rise from 15.7% in 1996 to 25.4% in 2006 (Ministry of Health Malaysia, 1996b, 2006b), we also were keen to estimate the future risk of each individual according to demographic and socioeconomic class variables. Subsequently, the determinants of the predicted cardiovascular disease risk profile will be identified.

Nonetheless, since previous literature indicated that in the subsequent decades the mortality and morbidity in Malaysia will increase (Ministry of Health Malaysia, 2011), we tend to reveal a socioeconomic intervening solution to reduce the rate of CVD risk factors incidents.

To sum up, we aimed at identifying the prevalence and determinants of the most established CVD risk factors (i.e. hypertension, hypercholesterolemia, smoking, and obesity (Choiniere *et al.*, 2000; Gaziano *et al.*, 2006; Lim *et al.*, 2007) and diabetes mellitus (Tai *et al.*, 2009; Tully *et al.*, 2005) among Malaysians. This study has several advantages compared to previous research. First, it is an unprecedented research studying a representative sample of urban and rural residents in Malaysia. Second, this study not only covers as many CVD risk factors as previous nation-wide studies included (Ministry of Health Malaysia, 1996b, 2006b, 2011, 2015), but it in fact has more risk factors compared to many other studies (Azmi *et al.*, 2009; Tan *et al.*, 2009). Finally, this study is the baseline for a-nine-year longitudinal research and findings from this study will address future interventions for vulnerable lower socioeconomic population in all parts of Malaysia.

1.4 Problem statement

One of the main contemporary concerns of societies is the health issues regarding the increasing prevalence and incidents of NCDs. In this era, more people suffer from NCDs comparing to any other ages. Therefore, as large number of CVD and cancer related mortality happen in developing countries (i.e., about 80 percent), a serious attention is required to prevent future incidents by proper interventions (WHO, 2010a, 2014c).

People in lower SES gradients contribute more to the annual CVD related deaths figures annually (WHO, 2009a, 2014c). In addition, people with different levels of SES associate differently with CVDRFs in developed economies. However, not only the future CVD risk is predicted to be higher in developing countries as accessibility to health care is lower comparing to higher income nations (WHO, 2010a), but CVDs decrease the GDP due to premature deaths and productivity loss (Heidenreich *et al.*, 2011). Therefore, there is a need of effective diagnosis of the current health status of populations living in developing countries followed by an accurate prediction of the future situation of diseases threatening their lives. These two steps must be accompanied by a diagnosis of an efficient intervention policy to tackle/reduce future prevalence/incidents of cardiovascular diseases.

The alarming mortality and morbidity caused by NCDs in Malaysia have raised serious concerns. The effects of socioeconomic background on the cardiovascular disease risk factors have been studied extensively in the developed countries. However, the few studies that have been conducted among the developing countries produced mixed results. Also, very little is known regarding the prediction of cardiovascular disease risk based on SES and demographic determinants. Finally, no previous research studied the usage of socioeconomic mediators to tackle CVDRFs in developing countries.

1.5 Research questions

In light of the above concerns, in this study we sought the answers to the following questions. First, to analyze the current status of cardiovascular disease risk factors of hypertension, hypercholesterolemia, diabetes mellitus, smoking and overweight/obesity according to the levels of socioeconomic background in Malaysia's urban and rural locations.

Second, to predict the ten-year risk of cardiovascular disease in various demographic and socioeconomic positions in urban and rural locations in Malaysia.

Third, to recommend a possible socioeconomic solution to intervene the association between socioeconomic status and cardiovascular disease risk factors.

1.6 Research objectives

This study will identify the current status of cardiovascular disease risk factors based on not only sociodemographic variables but also based on socioeconomic background determinants of a population representative of a rapidly developing country (i.e., Malaysia).

We put further steps in assessment of the future status of cardiovascular health by estimating the ten-year cardiovascular disease risk focusing on the socioeconomic background of the people living in Malaysia.

To diagnose a possible socioeconomic intervention to tackle the future cardiovascular diseases, we will test whether income level acts as a legit socioeconomic intervention to tackle cardiovascular disease risk factors.

Therefore, we seek to analyze comprehensively the cumulative prevalence of cardiovascular disease risk factors (CVDRF) according to various sociodemographic, place of residents (i.e., location and region), and socioeconomic status (SES) in Malaysia. Second, according to current existing data we will predict the future (i.e., ten years interval) of cardiovascular disease risk in Malaysia focusing more on the socioeconomic background of Malaysians. Finally, we will diagnose an influential socioeconomic intervention to tackle cardiovascular disease prevalence in Malaysia.

1.7 Contributions

This study seeks to contribute to the body of existing literature in many ways. Firstly, the country of focus is Malaysia, which is a developing country with a high prevalence of mortality and morbidity caused by NCDs. Therefore, this study will further the knowledge of what causes and contributes to the high incidence and prevalence of CVD risk factors among the developing countries.

Secondly, the age-standardized prevalence of CVDRFs provided in this study can act as a baseline for future comparisons of prevalence of the risk factors studied here. The population structure of Malaysia is changing rapidly, and therefore, the prevalence of disease and risk factors contributing to disease must be age-adjusted so that it reduces the bias/error in reporting for later comparisons.

Using an internationally well-known and highly validated algorithm (i.e., in Asia and Malaysia too) for prediction of the cardiovascular disease risk, we estimated the risk for each specific sociodemographic and socioeconomic determinants of the Malaysians (D'Agostino *et al.*, 2001; D'Agostino *et al.*, 2008; Wilson *et al.*, 1998). This prediction (which has a high precision ability) is a great means for health policy makers in Malaysia to make decisions with more accurate picture of the future of the diseases in Malaysia.

Finally, having diagnosed a socioeconomic intervention to tackle the future incidents and prevalence of CVDs in Malaysia, in this study we provided a tool for interventional studies for the health policy makers that may help urban and rural dwellers in Malaysia to prevent CVD incidents.

1.8 Structure of the study

In Chapter 1, we included a brief introduction for the background of the study as well as problem statement, research questions and objectives, and contributions of the study.

Chapter 2 presents a general background of the studies conducted in developed as well as developing economic in the context of cardiovascular diseases and socioeconomic background, risk factors for cardiovascular disease details, and the history of cardiovascular disease in Malaysia. The consecutive chapters 3, chapter 4, and chapter 5 were the analytical chapters of this study each representing one specific objective of this study.

In Chapter 3, an introduction to the topic, in details literature review, methodology used, results, and discussion were provided that have followed by a summary of the chapter.

Chapter 4 introduces the prediction of CVD risk profile algorithms as well as methodology used for predicting the CVD risk among our study sample. Then, results and discussion, and the summary of the chapter were included.

In Chapter 5, we introduced the topic, and included literature review, methodology, results and discussion, and the summary of the chapter.

Finally, in the final chapter, Chapter 6, we included the remarking results as well as policy implications and limitation for the study and the recommendations for the future studies.

CHAPTER 2

LITERATURE REVIEW

2.1 Mortality and morbidity due to cardiovascular disease

Cardiovascular disease (CVD) is the most common cause of morbidity and mortality in the world (Damiani *et al.*, 2011; WHO, 2010a). In 2008, an estimated 17.3 million people died from CVDs, representing 30% of all global deaths with an estimated 7.3 million deaths caused by heart attacks and another 6.2 million caused by stroke (WHO, 2012b). In 2014, however, the global mortalities due to NCD reached 38 million from which 28 million deaths occurred in low- and middle-income countries (WHO, 2014c). Besides, CVDs alone caused 17.5 million deaths, while 1.5 million individuals died due to diabetes (WHO, 2014c) Low and middle-income countries accounted for over 80% of CVD deaths, most of which could have been prevented by controlling for risk factors, such as, smoking, unhealthy diet, obesity, physical inactivity, blood pressure, diabetes, alcohol and cholesterol.

While declining trends in mortality due to CVD have been observed in developed nations in the recent decades, there has been a dramatic rise in low- and middle-income countries instead (Yusuf *et al.*, 2001a, 2001b). As the transition towards developed economies increases living standards, it may jeopardize the health condition of lower socioeconomic groups. In addition, economic growth and urbanization are associated with higher prevalence of chronic non-communicable diseases (NCD) in developing countries (Yasin *et al.*, 2012). Hence, population in developing nations is at higher risk of getting CVDs (Callow, 2006; Cooper *et al.*, 2000; Hamer & Chida, 2008).

In 2008, about 17 million people died because of CVD, which reached 17.5 million souls in 2012 (WHO, 2014c). This figure represents 30% of the deaths which includes an estimated 7.3 million deaths caused only by coronary heart disease and 6.2 million due to stroke (WHO, 2012a). Cardiovascular diseases are now contributing to significant and rising burdens of death and disability in many developing countries, as well as developed ones. Low and middle-income countries are more exposed to CVD risk factors as their populations have less access to preventive efforts than people in high-income countries have. Low and middle-income countries contributed the highest percentage of CVD deaths worldwide, which rose from 14.4 million in 1990 to 16.5 million in 2005 (WHO, 2009b). Of 17.1 million deaths of CVD reported in 2004, 80% were from low and middle-income countries.

In Malaysia, CVD is the number one killer and is accounted for 25% of all deaths every year. Between years 2000 and 2004, 20-25% of deaths in government hospitals were reported due to CVD (Ministry of Health Malaysia, 2013). Between years 2006 and 2009, in-hospital CVD deaths increased from 15.7% in 2006 to 25.4% in 2009 (Ministry of Health Malaysia, 2006a). The most prominent risk factor for cardiovascular disease is hypertension. Hypertension is a global epidemic and it has created an alarming trend in Malaysia. This is in accordance with the rise in the prevalence of hypertension among adults aged 30 years and above from 33% in 1996 to 43% in 2006 whereas the overall prevalence of hypertension was 11.6% among children aged 13-17 years. According to the report from the Ministry of Health, Malaysia, inpatient hospital admissions due to hypertension in government hospitals increased from 26,876 cases in 1990 to 37,580 cases in 2005, which is an increase of 40% over the span of 15 years (Ministry of Health Malaysia, 1996a). Diabetes Mellitus (DM) is also a chronic disease that incurs several complications such as CVD and coronary artery diseases. The NHMS I and NHMS II conducted in 1986 and 1996 respectively, observed the overall prevalence of diabetes increasing by 2% over the span of 10 years, from 6.3% in 1986 to 8.3% in 1996. The overall prevalence of diabetes among 18 years old and above in 2006 in Malaysia was 11.6% (Ministry of Health Malaysia, 1996a). Apart from that, the prevalence of obesity increased from 4.4% in 1996 to 14.2% in 2006 whereas the prevalence of 'at risk of overweight' and overweight is 12.5% and 11.7% respectively among school children aged 13-17 years. The overall prevalence of physical inactivity among adults in Malaysia in 2006 was reported to be 43.7%.

2.2 Cardiovascular disease risk factors

Age, gender, high blood pressure, hyperlipidemia, diabetes mellitus, tobacco smoking, and excessive alcohol consumption, family history, obesity, lack of physical activity, psychosocial factors, and air pollution (Choiniere *et al.*, 2000) are few of the suggested risk factors contributing to CVDs (Amal *et al.*, 2011; Amiri *et al.*, 2014; Choiniere *et al.*, 2000; Howard & Wylie-Rosett, 2002; Yasin *et al.*, 2012; Yusuf *et al.*, 2004a). Individual effect of these risk factors vary in different populations. However, high consistency in the overall contribution of these risk factors was found in epidemiological studies (Yusuf *et al.*, 2004a). Risk factors, such as age, gender or family history, are unmodifiable/immutable; whereas, lifestyle change, social change, hypertension, hyperlipidemia, and diabetes are considered as modifiable risk factors (WHO, 2009a, 2010a; WHO & UNAIDS, 2007).

2.2.1 Non-modifiable risk factors

2.2.1.1 Age

In developing cardiovascular or heart diseases, age is by far the most significant risk factor with approximately a tripling of risk with each decade of life (Finegold *et al.*, 2013). The highest mortality rate due to coronary heart disease (CHD) is among 65 and older Americans (American Heart Association, 2011). At the same time, the risk of stroke doubles every decade after age 55 (Mackay & Mensah, 2004). Multiple explanations have been proposed to explain why age increases the risk of cardiovascular/heart diseases. One of them is related to serum cholesterol level (Jousilahti *et al.*, 1999). In most countries, serum total cholesterol increases by ageing. In men, this increase levels off around age 45 to 50 years. In women, the increase continues sharply until age 60 to 65 years (Jousilahti *et al.*, 1999). The ageing process results in reduction of arterial elasticity and compliance that subsequently result in coronary artery disease (Jani & Rajkumar, 2006).

2.2.1.2 Gender

Men are at greater risk of heart disease than pre-menopausal women (Finegold *et al.*, 2013; WHO, 2014a). Once past menopause, it has been argued that a woman's risk is similar to a man's (WHO, 2014a), although these claims are disputed by WHO and UN findings (Finegold *et al.*, 2013). A diabetic female is more likely to develop heart disease than a male with diabetes (National Public Radio, 2014). Middle-aged men are two to five times higher likely to develop CHD than women (Jousilahti *et al.*, 1999). In a study done by WHO, gender contributes to approximately 40% of the variation in gender ratios of coronary heart disease mortality (WHO MONICA Project Principal Investigators, 1988). Another study reports similar results finding that gender differences explain nearly half the risk associated with cardiovascular diseases (Jousilahti *et al.*, 1999). Hormonal difference is one of the proposed explanations for gender differences in CVD development (Jousilahti *et al.*, 1999). After menopause, the production of estrogen decreases that may change the female lipid metabolism toward a more atherogenic form by decreasing the HDL cholesterol level while increasing LDL and total cholesterol levels (Jousilahti *et al.*, 1999). Among men and women, there are notable differences in body weight, height, body fat distribution, heart rate, stroke volume, and arterial compliance (Jani & Rajkumar, 2006).

2.2.2 Modifiable risk factors

2.2.2.1 Hypertension

High blood pressure or hypertension is the state of elevation of the blood pressure in the arteries. Two measurements summarize the blood pressure: systolic and diastolic. When heart muscle contracts (systole), the maximum BP is defined; when the heart muscle is relaxed between beats (diastole) the minimum BP is read. There are different definitions of the normal range of blood pressure. Resting blood pressure is within the range of 100–140 mmHg systolic (top reading) and 60–90 mmHg diastolic (bottom reading). High blood pressure is said to be present if it is often at or above 140/90 mmHg.

2.2.2.2 Hypercholesterolemia

Hypercholesterolemia (also spelled hypercholesterolemia also called dyslipidemia) is the presence of high levels of cholesterol in the blood (Durrington, 2003). It is a form of "hyperlipidemia" (elevated levels of lipids in the blood) and "hyperlipoproteinemia" (elevated levels of lipoproteins in the blood) (Durrington, 2003).

Cholesterol is a sterol. It is one of the three major classes of lipids that all animal cells utilize to construct their membranes and is thus manufactured by all animal cells. Plant cells do not manufacture cholesterol. It is also the precursor of the steroid hormones, bile acids and vitamin D (Durrington, 2003).

Insolubility of cholesterol in water allows it to be transported in the blood plasma within protein particles (lipoproteins). Major lipoprotein density classifications are: low-density lipoprotein (LDL) and high-density lipoprotein (HDL) (Biggerstaff & Wooten, 2004). All the lipoproteins carry cholesterol, but elevated levels of non-HDL cholesterol are associated with an increased risk of CHD and atherosclerosis (Carmena *et al.*, 2004). In contrast, higher levels of HDL cholesterol are protective (Kontush & Chapman, 2006). Dietary intake, genetic characteristics that carry diseases (such as LDL receptor mutations in familial hypercholesterolemia), or the presence of other diseases such as diabetes and obesity and an underactive thyroid elevate the levels of non-HDL cholesterol and LDL in the blood (Biggerstaff & Wooten, 2004; Carmena *et al.*, 2004; Durrington, 2003).

2.2.2.3 Diabetes Mellitus

Diabetes mellitus (DM; also known as diabetes) is a group of metabolic diseases in which there are high blood sugar levels over a prolonged period (Alberti & Zimmet, 1998). Frequent urination, increased thirst, and increased hunger are the major symptoms of elevated level of sugar and diabetes. If left untreated, diabetes can cause many complications (Alberti & Zimmet, 1998). Acute complications include diabetic ketoacidosis and nonketotic hyperosmolar coma (WHO, 2014b). Serious long-term complications include cardiovascular disease, stroke, kidney failure, foot ulcers and damage to the eyes (Alberti & Zimmet, 1998). There are three main types of diabetes mellitus: Type 1 DM results from the body's failure to produce enough insulin. This form was previously referred to as "insulin-dependent diabetes mellitus" (IDDM) or "juvenile diabetes". The cause is unknown (Alberti & Zimmet, 1998). Type 2 DM begins with insulin resistance, a condition in which cells fail to respond to insulin properly (Alberti & Zimmet, 1998). As the disease progresses, a lack of insulin may also develop. This form was previously referred to as "non-insulin-dependent diabetes mellitus" (NIDDM) or "adult-onset diabetes". The primary cause is excessive body weight and not enough exercise (Alberti & Zimmet, 1998). Gestational diabetes is the third dominant form and occurs when pregnant women without a previous history of diabetes develop a high blood glucose level (Alberti & Zimmet, 1998).

Increasing physical activity level, adaptation to healthy lifestyle, smoking cessation and retaining a normal weight are the major prevention and treatment of diabetes. Blood pressure control and proper foot care are also essential for people with the disease (WHO, 2014b).

As of 2014, an estimated 387 million people have diabetes worldwide, with type 2 diabetes making up about 90% of the cases (WHO, 2010a). This is equal to 8.3% of the adult population, with similar rates in both women and men (Shi & Hu, 2014). In the years 2012 to 2014, diabetes is estimated to have resulted in 1.5 to 4.9 million deaths per year (WHO, 2014d). Diabetes at least doubles the risk of dying (WHO, 2014b). The number of people with diabetes is expected to rise to 592 million by 2035 (Wild *et al.*, 2004). The global economic cost of diabetes in 2014 was estimated to be $612 billion USD (Whiting *et al.*, 2011).

2.2.2.4 Tobacco smoking

Tobacco smoking consists of burning tobacco and inhaling the smoke (i.e. including particle and hazardous gasses). In other words, using tobacco pipes and inhaling the smoke through the mouth, and then releasing it also address tobacco smoking.

Scientists have found various links between smoking and diseases such as lung cancer (Peto *et al.*, 2000), as well as various other cancers (Stewart *et al.*, 2003). However, while evidence shows the consumption of tobacco in developed nations are declining (Peto *et al.*, 1996), it is continuing to climb in developing nations (Jha & Chaloupka, 2000). As of 2008 to 2010, tobacco is used by about 3 billion people (about 49% of men and 11% of women) with about 80% of this usage in the form of smoking (Giovino *et al.*, 2012).

2.2.2.5 Obesity

Obesity is a medical condition in which excess body fat has accumulated (Raymond *et al.*, 2006). This disease has an adverse effect on health since it leads to reduction of life expectancy rate and increasing health problems. It is one of the leading preventable causes of death worldwide, with increasing rates in adults and children (WHO Expert Consultation, 2004). In authorities' perspective, obesity is one of the most serious public health problems of the 21st century (Swinburn *et al.*, 2011). Populations with obesity in Western countries are considered obese when their BMI, a measurement obtained by dividing a person's weight by the square of the individual's height, exceeds 30 kg/m^2, with the range 25-30 kg/m^2 defined as overweight. Some East Asian countries use stricter criteria (WHO Expert Consultation, 2004). Based on the classification from the Malaysian Clinical Practice Guidelines of Obesity (Ministry of Health Malaysia, 2004), BMI was classified into 6 categories; underweight (<18.50 kg/m^2), normal (18.50 - 22.99 kg/m^2), overweight (23.00 - 27.49 kg/m^2), obese I (27.50 - 34.99 kg/m^2), obese II (35.00 - 39.99 kg/m^2) and obese III (>40 kg/m^2).

The likelihood of various diseases increase by obesity. To name a few: heart disease, type 2 diabetes, obstructive sleep apnea, certain types of cancer, and osteoarthritis (Hedblad *et al.*, 2002). Healthy diet and physical exercises are the main treatments for obesity. Improving diet quality by reducing calorie intake and by increasing the intake of dietary fiber. With a suitable diet, anti-obesity drugs may be taken to reduce appetite or decrease fat absorption. If diet, exercise, and medication are not effective, a gastric balloon may assist with weight loss, or surgery may be performed to reduce stomach volume and/or bowel length, leading to feeling full earlier and a reduced ability to absorb nutrients from food (Rodgers, 2003).

2.3 Cardiovascular disease risk factors in Malaysia

Since 1986, the Institute of Public Health Malaysia has conducted National Health and Morbidity Surveys (NHMS) in Malaysia (Ministry of Health Malaysia, 1986, 1996b, 2006b, 2011). The first (NHMS I), second (NHMS II), and third (NHMS III) cycles of the NHMS were conducted in 1986, 1996, and 2006 respectively. However, NHMS IV was conducted in 2011 from which the next cycles will be conducted in four years intervals (Ministry of Health Malaysia, 2011) instead of ten years cycles. The most recent of NHMS studies is NHMS V which was conducted in 2015 (Ministry of Health Malaysia, 2015)In addition, data of various topics will be collected annually based on needs. Furthermore, each cycle's first year will be dedicated to data collection of same areas, which have been emphasized on since 1986. This is to pursue and follow up the trends in specific diseases' prevalence and incidents (Ministry of Health Malaysia, 2011).

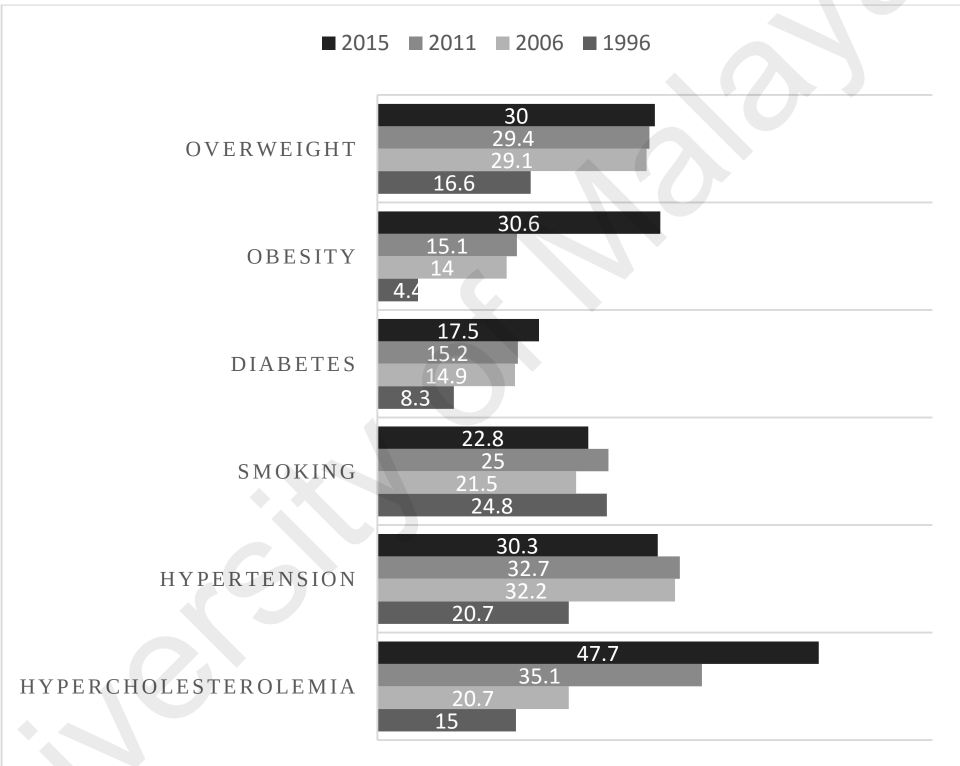

Figure 2.1: Prevalence of cardiovascular disease risk factors in Malaysia

Source: NHMS II (1996), NHMS III (2006), NHMS IV (2011), and NHMS V (2015).

The objectives of NHMS studies include collection of health related data from the communities and deliver information obtained to Ministry of Health Malaysia to help them address program strategies as well as urgent health interventions in the country. This process have definitely helped policies and interventions to be much more efficiently target the more disadvantaged communities in Malaysia to further seek the health goals of the government.

The results obtained from the NHMS studies include CVDRFs that are also included in this study such as smoking status, hypertension, hypercholesterolemia, etc. However, the prevalence rates reported in NHMS studies were crude and not age-standardized. Therefore, comparing prevalence rates across various NHMS studies does not bear with scrutiny as age distribution in Malaysia has faced tremendous changes across previous decades since the advent of NHMS studies. However, herewith we referred to NHMS prevalence rate in Figure 2.1.

Malaysia is comprised of different ethnic groups (Department of Statistics Malaysia, 2013b), and has a developing economy and fast economic growth (World Bank, 2013). Malaysia's population has been growing rapidly since 1950's and still it is expected to expand more (Department of Statistics Malaysia, 2013b). In addition to the demographic changes in the country of Malaysia, other life-style changes due to rapid modernization and fast urbanization of the country is being diagnosed (Sim, 2003). All these versatile changes have been proven to cause expansion of cardiovascular disease risk factors (WHO, 2009a; Yusuf *et al.*, 2014; Yusuf *et al.*, 2001a).

Cardiovascular diseases are not only the number one killer in Malaysia [i.e., accounted for 25% of all mortalities in Malaysia hospitals; see Ministry of Health Malaysia (2006a)], but the risk of CVDs are expected to be higher in the following decades (Chin & Pengal, 2009; Ng & Chia, 2008). However, these studies only focused on the semi-rural areas in Malaysia but not depicted the overall picture of the burden of CVDs in Malaysia and its risk jeopardizing the Malaysians' health in the country.

Previous studies in Malaysia emphasized more on single CVDRF but few has reported cumulative CVDRFs like Amplavanar *et al.* (2010). Their study depicted horrifying status of Malaysians from whom 87% had at least one of the CVDRFs while more than 60 percent had at least two CVDRFs. This finding has ignited serious attention from Malaysian government to design intervention programmes to tackle future incidents of CVDs in Malaysia.

On the other hand, various other studies in Malaysia has been conducted summarizing that likewise findings from developed nations age has significant effect on hypertension (Rampal *et al.*, 2008), there is significant difference between males and females in prevalence of CVDRFs (Amiri *et al.*, 2014; Cheah *et al.*, 2011), ethnic groups had different prevalence of CVDRFs (Amiri *et al.*, 2014; Rampal *et al.*, 2008; Rampal *et al.*, 2010), and in all ethnicities CVDRFs were inversely associated with SES (Amiri *et al.*, 2014), e.g., ethnicity played a strong role on being obese (Amplavanar *et al.*, 2010), and diabetic (Hong *et al.*, 2004). Indeed, there is significant difference in residential location in Malaysia (i.e., urban or rural) and the prevalence of CVDRFs. For instance, the prevalence of CVDRFs were remarkably high in semi-rural areas of Malaysia (Chin & Pengal, 2009) and also a high CVD risk is expected in future for semi-rural areas in Malaysia which requires further governmental attention for these areas (Chin & Pengal, 2009). In addition, the status of specific risk factors for cardiovascular disease is worse comparing to the rest. For instance, the prevalence of obesity in rural areas had increased drastically over the previous decades in Malaysia (Ismail *et al.*, 2002). Socioeconomically, the health status of Malaysians have seldom been studied previously in a Malaysian representative sample. However, to our best of knowledge there were only two studies conducted in a Malaysian representative sample that only reported education and income and hypertension and diabetes CVDRFs in Malaysia (Rampal *et al.*, 2008; Rampal *et al.*, 2010). They found that education and income were highly and inversely correlated with the prevalence of hypertension and diabetes in Malaysia (Rampal *et al.*, 2008; Rampal *et al.*, 2010)[1].

[1] The search for scientific studies including a Malaysian representative sample and including any of the cardiovascular disease risk factors. This search resulted in three published articles from which one belonged to the authors of this dissertation. Therefore, we did not mention our study in this section.

CHAPTER 3

CARDIOVASCULAR DISEASE RISK FACTORS AND SOCIOECONOMIC BACKGROUND

3.1 Introduction

Scientists have debated that certain behavioral risk factors contributing to cardiovascular diseases (e.g., physical activity and smoking) were significantly associated with current SES, while physiological CVDRFs (e.g., hypercholesterolemia, hyper-tension, obesity, etc.) were influenced by both past and current SES levels (Blane *et al.*, 1996; Metcalf *et al.*, 2007; Rutledge *et al.*, 2003).

The risk of CVD can be increased by behavioral-related risk factors such as hypertension, smoking tobacco, having hypercholesterolemia (state of an elevated blood cholesterol), being physically inactive, being overweight/obese, and excessively consuming alcoholic beverages (Choiniere *et al.*, 2000; Ezeamama *et al.*, 2006; Pocock *et al.*, 1987; Rutledge *et al.*, 2003; Tyroler, 1999).

Data from developed countries illustrated that more than half (about 70 percent) of the premature mortalities caused by CVD can be prevented if risk factors contributing to CVDs were controlled (Choiniere *et al.*, 2000; Wigle *et al.*, 1989).

Studies conducted in developed nations (e.g., Canada, USA, etc.), illustrated significant inverse association between SES and the prevalence of CVDRFs (Choiniere *et al.*, 2000; Lawlor *et al.*, 2005; Nair *et al.*, 1988; Rutledge *et al.*, 2003). However, results from developing countries like Malaysia produced mixed results.

Nonetheless, a strong association between SES and health disparities have been diagnosed in the U.S. (Adler & Newman, 2002). This research has identified that regardless of which component of SES (i.e., education level, income level, and occupational status) is assessed, health status is always powerfully predicted by SES level. That is because higher income level provides capabilities to access health services and facilities accompanied by purchasing power to buy health insurance. In addition, education will equip the individual for a better job opportunity with higher payments as well as professional developments of the individuals. Finally, occupational status also significantly predict the health status of individuals as studies have illustrated that employed individuals were commonly healthier than individuals who were unemployed. This phenomenon is known as 'health worker' effect (Adler & Newman, 2002).

Furthermore, the three main health determinants (i.e., lifestyle and behavior, environment exposure, and healthcare) are affected by SES level of the individual (Adler & Newman, 2002). The behavior and lifestyle, environment exposure and healthcare were respectively responsible for 70, 20, and 10 percent of the premature deaths (Lee & Paxman, 1997).

The residential of lower SES people are commonly in poor communities. Living in poorer communities is accompanied by higher violence rates, more population intensity, and environmental pollution result in poorer health status. In addition, people who have low SES have less ability to seek regular health check-up or attend healthcare facilities. Also, they commonly live uninsured since they lack financial means to buy insurance (Adler *et al.*, 1994; Adler & Newman, 2002). Adler and Newman (2002) endorsed the fact that uninsured individuals will less likely to receive primary and/or preventive healthcare services comparing to insured people.

Nevertheless, the strongest determinants of health that influence SES are the impacts of behavior and lifestyle (Adler & Newman, 2002). Lower SES is not only related to tobacco smoking, physical inactivity, poorer nutrition intakes, all of which influence health status of individuals (Adler & Newman, 2002).

In summary, socioeconomic background and health status are strongly associated with each other. Therefore, if diagnosed accurately and properly, the association of SES level and CVDRF may address health policies to reduce health disparities in the society leading to GDP and economic improvements of the country.

In this chapter, we provided a comprehensive literature review followed by an in detail methodology of how we assessed the risk factors contributing to CVDs as well as age-standardization procedure to obtain age-adjusted prevalence of each CVDRF based on sociodemographic and socioeconomic status of individuals of the Malaysian representative sample. In the end, results were provided and were discussed and compared with the current literature cited in this study.

3.2 Theoretical considerations

Socioeconomic status (SES) is conceptualized as the individual or community’s social standing or class. A combination of education, income, and occupation often measures SES. Examinations of SES often reveal inequities in access to resources, plus issues related to privilege, power, and control (American Psychological Association, 2014a). In other words, SES is an economic and sociological combined total measure of a person's work experience and of an individual's or family's economic and social position in relation to others. The household’s income, earners' education, and occupation are examined when analyzing a family's SES (National Center for Educational Statistics, 2013). Most common categories to describe an individual or a community’s social status are high SES, middle SES, and low SES. Any or all of the three proxies of SES (income, education, and occupation) can be assessed when placing a family or individual into one of these categories. Additionally, low income and little education have shown to be reliable predictors of a range of physical and mental health problems, including respiratory viruses, arthritis, coronary disease, and schizophrenia (Werner *et al.*, 2007).

An examination of SES as a gradient or continuous variable reveals inequities in access to and distribution of resources. SES is relevant to all realms of behavioral and social science, including research, practice, education, and advocacy (American Psychological Association, 2014b). Low SES affects our society as a whole and its correlates (e.g., lower education, poverty, and poor health). Inequities in wealth and quality of life are increasing globally. Despite these challenges, behavioral, and other social science professionals possess the tools necessary to study and identify strategies that could alleviate these disparities at both individual and societal levels. Variance in SES, including gaps in the distribution of wealth, income, and access to resources, affects everyone.

Canadian and United States' data show an inverse relationship between SES, and CVD risk factors of smoking, hypertension, and obesity (Winkleby *et al.*, 1992). However, past findings on Malaysia are mixed (Amiri *et al.*, 2014; Amplavanar *et al.*, 2010; Ismail *et al.*, 2002; Letchuman *et al.*, 2010; Rampal *et al.*, 2010; Zaini, 2000). This study provides current evidence on the relationship between prevalence of CVD risk factors and SES variables in Malaysia (Rasiah *et al.*, 2013). Education in higher socioeconomic families is typically stressed as a more important criterion in the household and local community. In poorer areas, where food and safety are priorities, education can take a backseat.

People from lower socioeconomic positions tend to have a higher prevalence of these risk factors than people from higher socioeconomic positions (Choiniere *et al.*, 2000). Many studies have measured socioeconomic factors and their associations with cardiovascular risk factors across the different income groups, educational level and occupational status.

3.2.1 Income

Wages, salaries, profits, rents, and any flow of earnings received from unemployment or workers compensation, social security, pensions, interests or dividends, royalties, trusts, alimony, or other governmental, public, or family financial assistance form the income level of an individual or household.. Income can be looked at in two terms, relative and absolute. Absolute income, as theorized by economist J. M. Keynes, is the relationship in which as income increases, so will consumption, but not at the same rate. Relative income dictates a person or family's savings and consumption based on the family's income in relation to others. Income is a commonly used measure of SES because it is relatively easy to figure for most individuals (Wisdom Supreme, 2014).

A multilevel analysis of revenue and cardiovascular disease risk factors showed that at low income levels, increased risk factor levels was observed in BMI and hypertension using data from the Behavioral Risk Factor Surveillance System conducted in United States (Diez-Roux *et al.*, 2000). In contrast, a study that examined the distribution of obesity across yearly household income in three rural areas in Yunnan province of China found a positive association (Cai *et al.*, 2013) whereas Eagle et al. found an inverse relationship between obesity and household income among children from Massachusetts, America. In addition, he also found that as household income reduced, the frequency of fried food consumption per day doubled, whereas vegetable consumption and moderate/vigorous exercise decreased (Eagle *et al.*, 2012). At the national level, the NHMS III (2006) showed an inverse relationship between the prevalence of hypercholesterolemia and the level of education achieved and monthly household income among Malaysian adults in the year 2006 (Ministry of Health Malaysia, 2006a). A local study that examined CVD risk factors and socioeconomic variables found mixed associations. Among men, positive relationship was found between income and diabetes, hypertension and hypercholesterolemia whereas among women, a negative association was found with hypertension and hypercholesterolemia although a positive relationship was reported for diabetes (Rasiah *et al.*, 2013).

3.2.2 Education

Often, education levels are used as the most judicious measure among the three SES indicators (Winkleby *et al.*, 1990). For instance, in Israel, lower SES was associated with elevated blood pressure among young adults (Grotto *et al.*, 2007). In Vietnam, hypertension was found to be significantly more prevalent in the low compared with the high education groups (Hoang *et al.*, 2007). A ten-year follow-up study from the United States among women demonstrated that the likelihood of developing hypertension is lower among more educated women (Albert *et al.*, 2006). Another study on cardiovascular risk profile in Indians found that tobacco use and hypertension were significantly more prevalent in low education groups compared to high education groups (Reddy *et al.*, 2007). A similar study also showed that in adolescents, lower parent education is associated with multiple metabolic risks and cumulative risks of higher insulin, higher glucose, greater insulin resistance, higher LDL cholesterol, lower HDL cholesterol, higher waist circumference, and higher body mass index (Goodman *et al.*, 2005; Winkleby *et al.*, 1992).

Education also plays a role in SES and income. Median earnings increase with each level of education. The highest degrees, professional and doctoral degrees, make the highest weekly earnings while those without a high school diploma earn less. Higher levels of education are associated with better economic and psychological outcomes (i.e., more income, more control, and greater social support and networking) (Saegert *et al.*, 2007). Despite dramatic changes, significant gaps remain when minority education attainment is compared to that of Caucasian Americans (King, 2006). African Americans and Latinos are more likely to attend high-poverty schools than Asian Americans and Caucasians (King, 2006).

For acquiring jobs, education plays a major role in skill sets as well as particular qualities that stratify people with higher SES from lower SES.

3.2.3 Occupation

Encompassing both income and educational attainment, occupational prestige reflects the educational attainment required to obtain a job and income levels that vary with different jobs and within ranks of occupations. Additionally, it shows achievement in skills needed for the job. Occupational status measures social position by describing job characteristics, decision-making ability and control, and psychological demands of the job.

Occupations are ranked by the Census (among other organizations), and opinion polls from the general population are surveyed. Some of the most prestigious occupations are physicians and surgeons, lawyers, chemical and biomedical engineers, university professors, and communications analysts. These jobs, considered to be grouped in the high SES classification, provide work that is more challenging and greater control over working conditions but require more ability. The jobs with lower rankings include food preparation workers, counter attendants, bartenders and helpers, dishwashers, janitors, maids and housekeepers, vehicle cleaners, and parking lot attendants. The jobs that are less valued also offer significantly lower wages, and often are more laborious, very hazardous, and provide less autonomy (Liberatos *et al.*, 1988; Saegert *et al.*, 2007; Scott & Leonhardt, 2005).

A study in the southern European countries found that manual occupational classes had higher stroke mortality rates than non-manual occupational classes (Kunst *et al.*, 1998). Rose and Marmot's study of SES and CVD found that the age-adjusted prevalence of angina pectoris was 53% higher for men in the lowest employment grade than those in the top administrative grade (Rose & Marmot, 1981). Investigators from a Health Survey in England conducted in 1995/1997 assessed cotinine levels in children and young adult and found the level of exposure to tobacco smoke to be highest amongst those of lower parental occupational classes (Batty & Leon, 2002). Increased risk of cardiovascular disease that was determined by cigarette smoking, alcohol intake and high systolic blood pressure was found in manual workers in the British Regional Heart Study among men (Shaper *et al.*, 1981). In addition, occupation is the most difficult factor to measure because so many job titles exist, and there are so many competing scales. Many scales rank occupations based on the level of skill involved, from unskilled to skilled manual labor to professional, or use a combined measure using the education level needed and income required.

In sum, the majority of researchers agree that income, education, and occupation together best represent SES. With the definition of SES more clearly defined, it is now important to discuss the effects of SES on individual's health and well-being.

3.2.4 Health

Recently, there has been increasing interest from epidemiologists on the subject of economic inequality and its relation to the health of populations. SES is found to be an important source of health inequity, as there is a very robust positive correlation between SES and health (Adler & Ostrove, 1999; Fiscella *et al.*, 2000; Goode, 1999). This correlation analysis suggests that it is not only the poor who tend to be sick when everyone else is healthy, but there is a continual gradient from the top to the bottom of the socioeconomic ladder, which relates the status to health. This phenomenon is often called the "SES Gradient" (Adler *et al.*, 1994). Lower socioeconomic status has been linked to chronic stress , heart disease, cardiovascular disease, ulcers, diabetes, rheumatoid arthritis, certain types of cancer, and premature aging (Adler & Ostrove, 1999; Clark *et al.*, 2009; Govil *et al.*, 2009; Winkleby *et al.*, 1992; Wu & Rudkin, 2000; Yu *et al.*, 2000).

There is debate regarding the cause of the SES Gradient. A number of researchers found a link between economic status and mortality due to the greater financial resources of the wealthy, but they find little correlation due to social status differences (Leigh *et al.*, 2009). Other researchers such as Richard G. Wilkinson who has found that SES strongly affects health even when controlling for economic resources and access to health care (Wilkinson, 1994, 1999). Most famous for linking social status with health are the Whitehall studies (Marmot, 1993, 1995)—a series of studies conducted on civil servants in London. The studies found that although all civil servants in England have the same access to health care, there was a strong correlation between social status and health. The studies found that this relationship remained strong even when controlling for health-affecting habits such as exercise, smoking, and drinking. Furthermore, it has been noted that no amount of medical attention will help decrease the likelihood of someone getting type two diabetes or rheumatoid arthritis—yet both more common among populations with lower socioeconomic status.

Systemic prejudices against ethnic minorities in the United States create additional barriers in health care that exist regardless of class. In one study, one-fourth of American women of South Asian descent from affluent backgrounds did not have a Pap smear in over 3 years. Those from low socioeconomic status are even more at risk for not having this early detection test yearly (Chaudhry *et al.*, 2003). Socioeconomic status and race/ethnicity have been associated with avoidable procedures, preventable hospitalizations, and untreated disease (Fiscella *et al.*, 2000). Low birth weight, which is related to a number of adverse child health outcomes, has been associated with lower SES and ethnic/minority status (Fiscella *et al.*, 2000). Minority children in high-poverty areas are more likely to be exposed to alcohol and tobacco advertisements and drug distribution (Wallace Jr *et al.*, 1999); they are also more likely to use drugs and exhibit antisocial behaviors (Dubow *et al.*, 1997).

3.2.5 Ethnicity and socioeconomic status

SES, race, and ethnicity are intimately intertwined. Research has shown that race and ethnicity in terms of stratification often determine a person's SES (House & Williams, 2000). Furthermore, SES, race, and ethnicity often segregate communities. These communities commonly share characteristics of developing nations: weak economic development, poor health conditions, and low levels of educational attainment. Low SES has consistently been implicated as a risk factor for many of the problems that plague communities. Seeking protective factors to minimize these risks, researchers have reviewed the literature that highlights the resilience of persons overcoming social challenges associated with a skewed distribution of resources (Corcoran & Nichols-Casebolt, 2004). It is important to understand that continually skewed distributions breed conditions that ultimately affect our entire society. Thus, society benefits from an increased focus on the foundations of socioeconomic inequities and its correlates, such as racial and ethnic discrimination and efforts to reduce the broad gaps in socioeconomic status in the United States and abroad.

Discrimination and marginalization are sometimes barriers for ethnic and racial minorities seeking to escape poverty (Corcoran & Nichols-Casebolt, 2004). African American children are three times more likely to live in poverty than Caucasian children. American Indian/Alaska Native, Hispanic, Pacific Islander, and Native Hawaiian families are more likely than Caucasian and Asian families to live in poverty.

Including SES in our research along with demographic variables, practice, and educational endeavors, we would be able to study the societal barriers experienced by individuals, particularly those of lower SES, and the impact of these barriers on health and well-being. Report participant characteristics related to SES. We are trying to develop models and measures of SES that reflect the social and economic difficulties Malaysians in this period and in the future.

3.3 Methodology

3.3.1 Data source

3.3.1.1 Prospective Urban Rural Epidemiological (PURE) study

The Prospective Urban Rural Epidemiological (PURE) study was a prospective cohort study which established multiple community cohorts in urban and rural areas of 21 low-, middle-, and high-income countries worldwide (Corsi *et al.*, 2013; PURE Investigators, 2007; Teo *et al.*, 2009). It struggled to capture environmental and societal influences on risk factors contributing to CVD across various economy settings around the world (Teo *et al.*, 2009). Using periodic standardized collection of data, the PURE study involved comprehensive data of about 150,000 individuals from the following countries so far: Argentina, Bangladesh, Brazil, Canada, Chile, China, Colombia, India, Iran, Malaysia, Pakistan, Palestine, Philippines, Poland, Saudi Arabia, South Africa, Sweden, Tanzania, Turkey, United Arab Emirates, Zimbabwe (Teo *et al.*, 2009). These countries have been selected from all habitable continents and have been classified under all economy settings (PURE Investigators, 2007).

The PURE study has been conducted in three phases (PURE Investigators, 2007): I) A Vanguard phase which was a 12-month period in which the protocol details were tailored to each selected country, and at least 1,000 subjects were recruited from each country for the pilot study. During this phase, the cross sectional data of about 30,000 individuals were collected; II) Recruitment phase which was a 3-year period during which data of about 120,000 subjects were collected and underwent detailed baseline evaluation. The initial assessment of all countries were published before (Corsi *et al.*, 2013; Teo *et al.*, 2009; Teo *et al.*, 2013; Vorster *et al.*, 2014); III) Follow-up phase which was the additional 8 to 12 years of follow-up of all individuals in every 3-year period to evaluate all variables and clinical events. These follow-ups were designed to assess the following characteristics: data for the INTERHEART risk score, dietary intake, physical activity, non-fasting blood sample, etc.

The aim of the PURE study was to select countries, communities, and individuals with various lifestyles. In doing so, a balance between several economic level countries with various economic and social conditions and policies were selected. In community selections, the feasibility of the centers to follow-up the individuals in the long-term played a significant role. In each country, at least 5-10 urban locations as well as 10-80 rural villages were selected. The overall calculation of the selected communities in each country was approximately 400-500 communities each including about 50-500 individuals. Since the PURE study was conducted in several countries with various economic and location definitions, specific considerations for the definition of urban and rural settings were considered using the suggested definition by National Academy of Sciences Review (Cohen *et al.*, 2003). In addition, PURE considered the definition by each specific country and population density, population employed in agricultural work and distance from major urban centers to select the urban and rural communities (PURE Investigators, 2007).

In the PURE study's protocol (PURE Investigators, 2007), the following justification was provided for the selection of urban and rural communities across all included countries:

> *"Small variations in criteria used to select individual locations are unlikely to matter because in our approach the characteristics of a community are related to the levels of risk factors or CVD rates within a population and then regressed across communities. Further, we do not consider "urban" and "rural" communities as being totally*

distinct, but instead exhibiting a range of characteristics. Urban centers are generally where our collaborating investigators and their institutions are located and represent large and medium sized cities."

The sampling in each country and community depended solely on the 'representativeness' and 'feasibility' of long-term follow-up (PURE Investigators, 2007; Teo *et al.*, 2009). The PURE study's sampling approach was one in which each center recognizes neighborhoods or villages, based study guidelines, but had flexibility to identify a range of heterogeneous community under PURE's broad framework. Once the communities were selected, standardized approaches for household enumeration and individual identifications were considered (Teo *et al.*, 2009).

In urban areas, all eligible households who satisfied the following criteria were selected (PURE Investigators, 2007): "I) households of workers from large companies who usually live in "colonies", or institutions, representing some of the largest employers in that location; II) geographically defined middle class housing areas; and, III) defined slum or shanty town dwellers." These inclusion criteria lead the study to include several community types with various socioeconomic, environmental, and CVD risk factor level within urban areas. In rural locations, villages varying with population sizes were identified with door-to-door enumeration of all households. In all study locations, all households were contacted at least three times. If the household refused to participate in the study, simple demographics, CHD history and risk factors were recorded. This was done to identify the probable selections biases. Once the household accepted to participate, all eligible individuals were enumerated and data were collected. All individuals between 30 to 70 years were invited to participate in the study and written consent were taken from them.

3.3.1.2 Responding to Increasing Cardiovascular Disease Prevalence Study (REDICOVER)

Malaysia has been one of the selected middle-income countries to participate in the PURE study. The principal investigator in Malaysia is Professor Dato' Dr. Khalid Yusoff. He and his team from University of Teknology Mara (UiTM) designed and conducted this study in Malaysia since 2007 struggling to include all the urban and rural locations in Peninsular and Eastern part of Malaysia. Responding to Increasing Cardiovascular Disease Prevalence Study (REDISCOVER) project attempted to select a representative sample of Malaysian adults from both urban and rural areas of Malaysia since 2007. Following the PURE study's protocol (PURE Investigators, 2007; Teo *et al.*, 2009) and employing a voluntary sampling procedure, all eligible households and individuals were recruited in this study in a three-year period between 2007 and 2010. This community-based health survey finally included about 11,959 Malaysian adults (aged ≥ 30 years). Of this number, complete data of income, education, occupation, and CVD risk factors were only available from 7,918 respondents, and hence, the analysis is solely based on this number. Only volunteers who gave a written consent to participate at recruitment into the study were invited to attend community centres in a fasting state where demographic and anthropometric data and blood pressures, as well as, venous blood for glucose and lipid readings were recorded. The community centres were located in Selangor (5), Kuala Lumpur (3) and Negeri Sembilan (2), and in the EPM states of Pahang (4) and Kelantan (4), and the EM state of Sabah (1). Whereas WPM is constituted by the most urbanized states in Malaysia, EPM and EM are constituted by the least urbanized provinces in Malaysia (Department of Statistics Malaysia, 2013b). Increasing significant participation in the community survey, the REDISCOVER team pledged to monitor their CVD risk factors over the period 2007-2016. It is for these reasons the ethnic breakdown of the sample of 75.3% Malays, 6.4% Chinese, 2.4% Indians and 15.9% others (includes non-

Malay natives and other Malaysians not classified as Malays, Chinese or Indians) differed from the ethnic breakdown of the 2010 national population of, 55.1% Malays, 24.6% Chinese, 7.3% Indians and 13.0% others (Department of Statistics Malaysia, 2013b). Nevertheless, the data set approximates the ethnic breakdown of the states included in the study as Malays dominate the ethnic populations of Kelantan and Pahang. Given that the survey involves health screening during the study, and the large size of the sample, we believe the sample is sufficiently robust for meaningful interpretation of the results. In doing so, we followed the same sampling procedure used by Yusuf *et al.* (2011).

3.3.2 Study variables

3.3.2.1 Cardiovascular disease risk factors

The CVD risk factors classified as the followings (Choiniere *et al.*, 2000; Klein *et al.*, 1997):

3.3.2.2 Hypertension

The elevated blood pressure was considered as hypertension if Systolic and/or Diastolic Blood Pressure equaled or above 140/90 mmHg or if any antihypertensive medications were used.

3.3.2.3 Diabetes Mellitus

To be diabetic defined as if the Random Blood Sugar (RBS) equaled or above 11.0 mmol/L and/or were under diabetes treatment (Letchuman *et al.*, 2010). In addition, high risk of diabetes was classified if the RBS levels were between 5.6 and 11.0 mmol/L.

3.3.2.4 Hypercholesterolemia

Those who had Total Cholesterol (TC) ≥5.2 mmol/L and/or were using cholesterol-lowering drugs were categorized as hypercholesterolemic.

3.3.2.5 Overweight/Obesity

To qualify as obese, the Asian classifications of BMI (kg/m^2) of over 25 $\frac{kg}{m^2}$ was used (Ko *et al.*, 1999; WHO Expert Consultation, 2004). However, there have been debates on consideration of 27.5 up to 30 $\frac{kg}{m^2}$ as overweight/obese for Asians (Ko *et al.*, 1999; Pan *et al.*, 2004; Shiwaku *et al.*, 2004; WHO Expert Consultation, 2004; Wildman *et al.*, 2004), but we chose to classify 25 $\frac{kg}{m^2}$ and above (i.e. where public health interventions must take effect) as overweight/obesity (i.e. obesity includes high-risk overweight, pre-obese and obese types I, II, and III) according to WHO Expert Consultation (2004).

3.3.2.6 Smoking

Smokers were adults who smoked at least a cigarette per day (Huxley & Woodward, 2011).

3.3.2.7 Cumulative cardiovascular disease risk factors

Having at least one of the above CVD risk factors was considered as the outcome of the logistic regression model. The cumulative CVD risk factors 1 included hypertension, diabetes, and smoking (i.e., CCVDRF 1). The cumulative CVD risk factors 2 included obesity and hypercholesterolemia (i.e., CCVDRF 2). We classified cumulative 1 and 2 risk factors based on the best statistical results.

3.3.3 Demographic variables

3.3.3.1 Age (in years)

We included only respondents who at the time of data collection above 30 years old. Subsequently, the age classifications were 30’s (between 30 and 39 years old), 40’s (between 40 and 49 years old), 50’s (between 50 and 59 years old), 60’s (between 60 and 69 years old), and 70 ≤ (i.e., above 70 years old). However, the logistic models were controlled for continuous values of age.

3.3.3.2 Gender

Likewise other studies, we classified the gender variable into men (males) and women (females).

3.3.3.3 Ethnic/race group

Ethnically, the population distribution of Malaysia divides into Malays (67.4%), Chinese (24.6%), Indians (7.3%), and other ethnic/race groups (0.7%) (Department of Statistics Malaysia, 2013b). Hence, we classified the ethnic/race variable into Malays, Indians, and Chinese or others minor ethnic groups.

3.3.3.4 Marital status

Finally, the marital status was categorized as single, married, widowed/widower, and divorced sub-groups (Department of Statistics Malaysia, 2013a).

3.3.3.5 Region

The Western Peninsular Malaysia (WPM) states are the more urbanized than Eastern Peninsular Malaysia (EPM) and East Malaysia (EM) where the cost of living was lower in the former than the latter.

3.3.4 Socioeconomic status (SES)

3.3.4.1 Education level

Continuous years of formal education was classified into the education variable. Therefore, we categorized the education variable as no education (zero years of formal education), primary (between 1 and 5 years of formal education), secondary (between 6 to 12 years of formal education), technical (i.e., if the respondent's formal education was in technical areas) and university education (i.e., more than 13 years of education and/or any university degrees).

3.3.4.2 Income level

It is most difficult to obtain salaries from respondents around the world. However, the majority of our respondents were willing to provide adequate information for this variable. Income levels were classified as low, middle and high according to the individual's annual income of ≤MYR10,000, >MYR10,000-MYR50,000, and >MYR50,000 per annum. These income values were obtained using the average of expenditures and costs in both urban and rural areas and considering the other studies conducted in Malaysian contexts before (Amiri *et al.*, 2014; Rampal *et al.*, 2008; Rasiah *et al.*, 2013).The income level was adjusted for the inflation rate between 2007 to 2010 (Economic Planning Unit Malaysia, 2013).

3.3.4.3 Occupational status

Finally, the elementary occupations, the house maker, skilled professionals, professionals, and others occupations were the categories of occupational status (Department of Statistics Malaysia, 2013a; The HLS-EU Consortium, 2012).

3.3.5 Age Standardization

Firstly, the sample was descriptively analyzed. Then, age-standardized prevalence of each risk factors were tabulated against demographic and socioeconomic variables. The prevalence rates were age-adjusted using 2010 standard Malaysian population. Standard deviation was employed to derive the distribution of the variables. The number of observations of each CVD risk factors varies because of missing responses.

To age standardize the prevalence rates and standard error we followed the procedure below. First, we used *svyset* command to define the survey design variables. This is due to the fact that SVYSET is needed before using the SVY series of commands. The format of this command that we used was:

svyset [w= std_wgt], strata(age_cat) vce(linearized)

or,

svyset PUREIDCOMPLETE, vce(linearized) singleunit(missing)

Where standard weight was defined by std_wgt; stratification variable was age_cat; and, method for calculating variance was set as default by linearized (Taylor linearization).

In the second step, the initial step to calculate the age-adjusted prevalence rate of hypertension, we used the age standardizing proportions from 2010 Malaysian census, and subsequently applied them to the populations under comparison (see Klein and Schoenborn (2001); NHANES (2013)). A spreadsheet with the year 2010 Malaysian population structure by age is in table below. The proportions are calculated by dividing the age-specific Census population (P) by the total Census population number (T). The standardizing proportions (P/T) should sum to 1 (see Table 3.1)

Table 3.1: Population and standard weight of Malaysians by age in year 2010

Age classification	Population 2010	Standard weight 2010
30's	4,136,500	0.3382
40's	3,405,800	0.2785
50's	2,436,800	0.1992
60's	1,361,500	0.1113
≥ 70	887,100	0.0725
TOTAL	12,227,700	1.000

Source: Department of Statistics Malaysia (2013).

Finally, for generating the age-adjusted proportions we used the following commands (examples):

svy, subpop(if elig==1): mean hpt, stdize(age_cat) stdweight(std_wgt)

svy, subpop(if elig==1): mean hpt, stdize(age_cat) stdweight(std_wgt) over(ethnicity)

The Stata command, *svy: mean*, is used to generate age-adjusted proportions and standard errors. Using *svy:mean* is not a mistake - a proportion is the mean of a dichotomous variable.

The general form of the command is just like the mean command from descriptive statistics but uses the *stdize* and *stdweight* options.

```
svy, subpop(condition):  mean depvar, stdize(agevar) stdweight(ageweightvar)
```

3.4 Results

3.4.1 Sample characteristics

The demographic and socioeconomic characteristics of the sample are illustrated in Table 3.2. The majority of the respondents were in their 40's (33.0%), females (55.5%), Malays (75.3%), and married (90.1%). Rural residents (56.5%) and WPM (46.6%) had the highest contributions to our sample population. Socioeconomically, the respondents had middle-income level (44.0%), secondary education level (38.1%) and house makers (35.6%).

Table 3.2: Characteristics of the sample

Variables	Categories	Number	%
Age	30's	833	10.5
	40's	2,611	33.0
	50's	2,586	32.7
	60's	1,529	19.3
	≥70	357	4.5
Gender	Male	3,526	44.5
	Female	4,392	55.5
Ethnicity	Malay	5,963	75.3
	Chinese	505	6.4
	Indian	189	2.4
	Others	1,261	15.9
Marital Status	Single	174	2.2
	Married	7,133	90.1
	Divorced	166	2.1
	Others	445	5.6
Location	Urban	3,444	43.5
	Rural	4,474	56.5
Region	WPM	3,687	46.6
	EPM	2,785	35.2
	EM	1,446	18.3
Income Level	Low	3,375	42.6
	Middle	3,481	44.0
	High	1,062	13.4
Education Level	None	1,127	14.2
	Primary	2,275	28.7
	Secondary	3,018	38.1
	Technical	158	2.0
	University	1,340	16.9
Occupation Status	Elementary	1,820	23.0
	Homemaker	2,817	35.6
	Skilled professionals	1,710	21.6
	Professionals	1,192	15.1
	Others	379	4.8

3.4.2 Total sample size in variable breakdowns

Sample sizes by gender, age, ethnicity, location, and region breakdowns by men and women are presented in Figure 3.1. This diagram represents the whole population breakdown of the sample by different socio-demographic and location as well as the regions of the study.

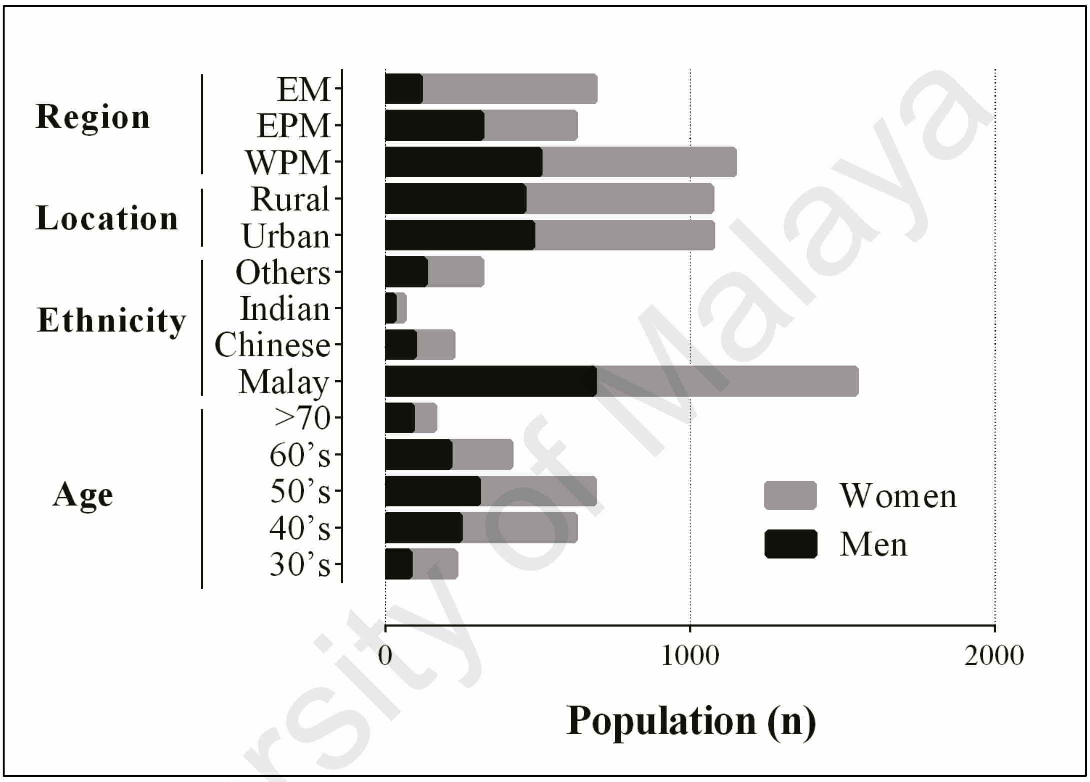

Figure 3.1: Number of respondents

3.4.3 Population size in each cardiovascular disease risk factors

Figure 3.2 shows the number of respondents in each CVDRF. The most populous risk factor in both men and women is hypercholesterolemia, whereas the least populated is obesity in men and smoking in women. The number of hypercholesterolemic or smoking men suppress the normal cholesterol and non-smoking men. In addition, in women the number of hypercholesterolemic patients were more than double the number of women who did not suffer from this CVDRF.

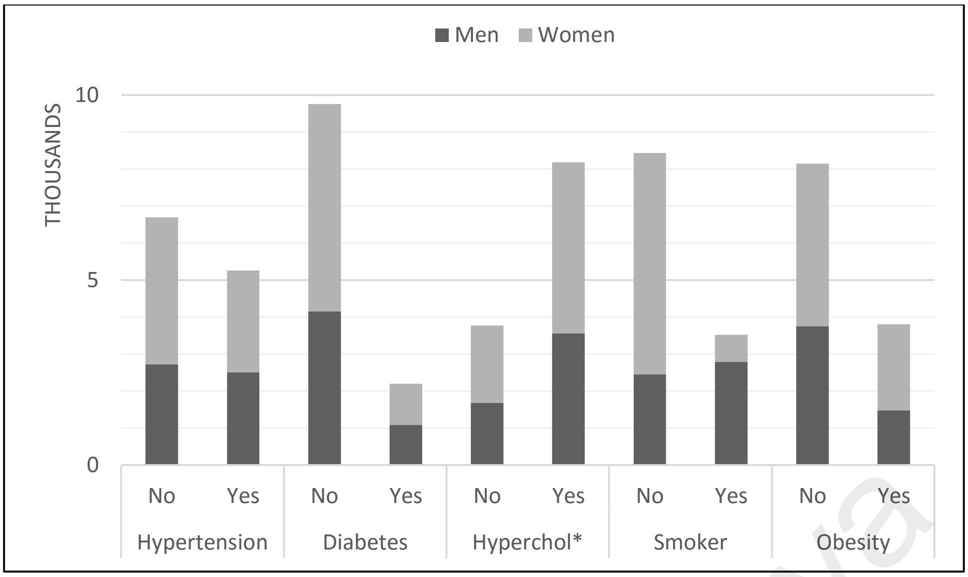

Figure 3.2: Number of respondents in cardiovascular disease risk factors

Note: * Hypercholesterolemia.
Hypertension: Mean SBP (Systolic Blood Pressure) ≥ 140 mm Hg or Mean DBP (Diastolic Blood Pressure) ≥ 90 mm Hg or using medication; **Diabetes:** Mean plasma glucose ≥ 126 mg/dL or 7.0 mmol/Lit; **Hypercholesterolemia:** Mean Plasma cholesterol ≥ 5.2 mmol/Lit; **Smoker status:** Smokes at least one cigarette per day; **Obesity/overweight:** BMI (Body Mass Index) ≥ 25 kg/m^2

3.4.4 Population size by education levels

In Figure 3.3, Figure 3.4, Figure 3.5, and Figure 3.6 we depicted the education level categories population of men and women in each socio-demographic and location variables as well as the regions of the study.

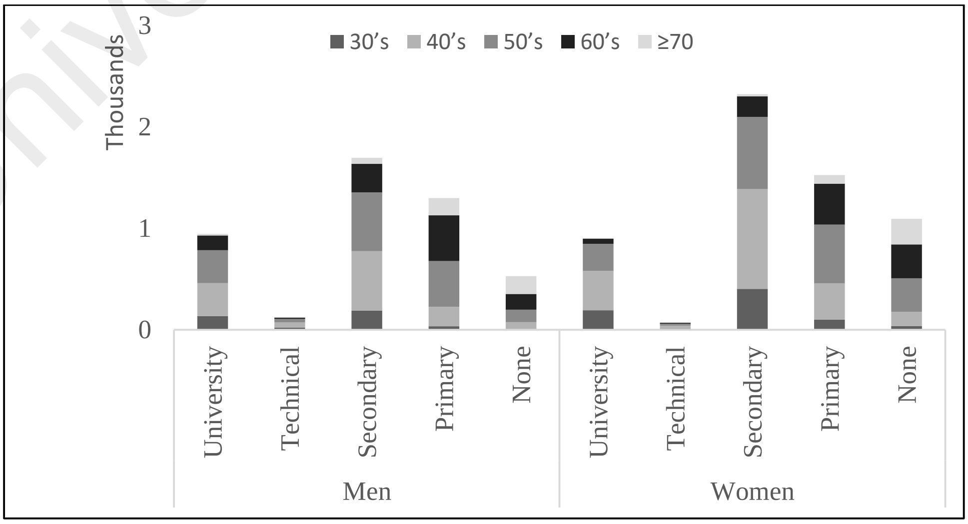

Figure 3.3: Number of respondents by age and education

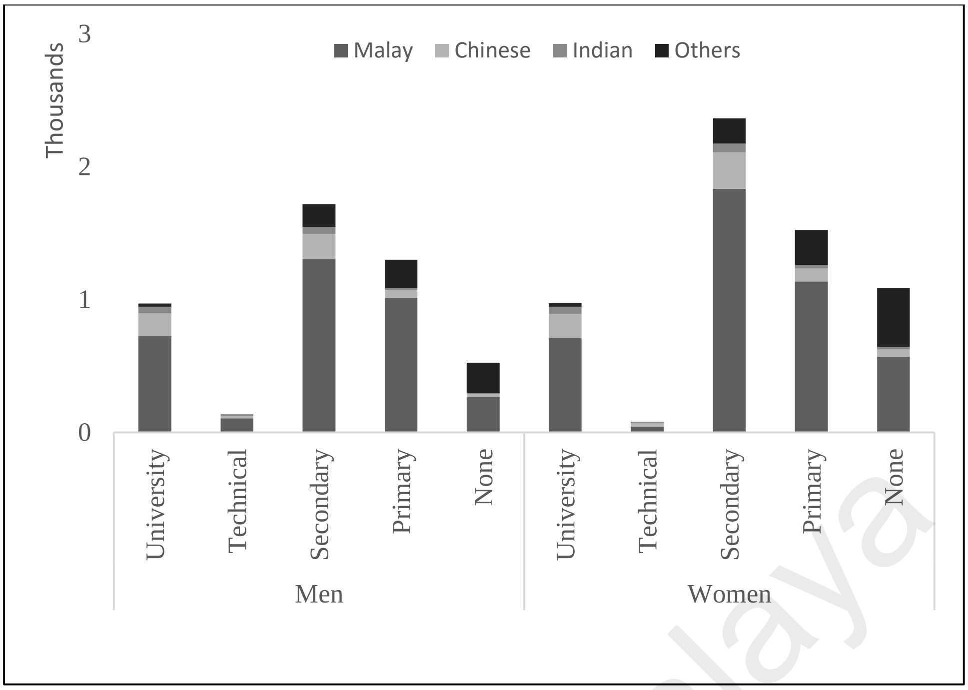

Figure 3.4: Number of respondents by ethnicity and education

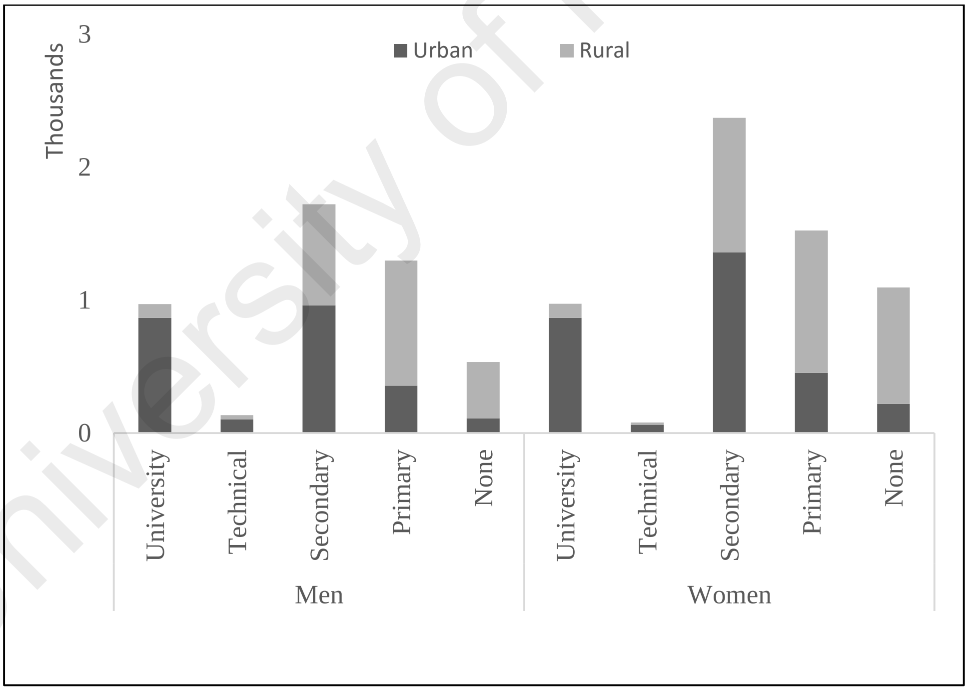

Figure 3.5: Number of respondents by location and education

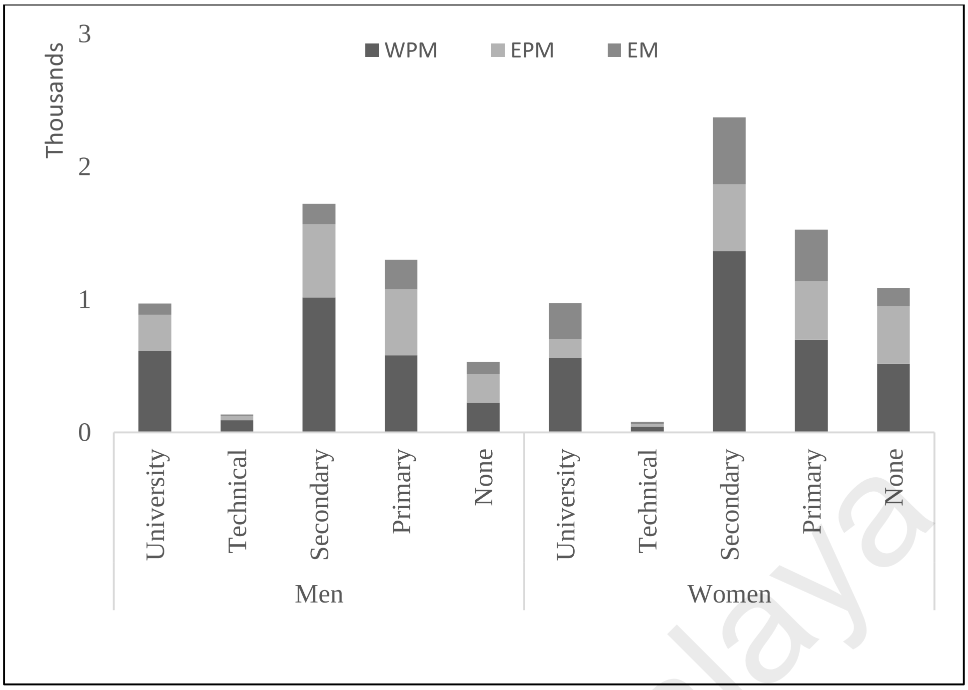

Figure 3.6: Number of respondents by region and education

3.4.5 Population size by income levels

Sample sizes by age, ethnicity, location and region breakdown are presented in Figure 3.7, Figure 3.8, Figure 3.9, and Figure 3.10.

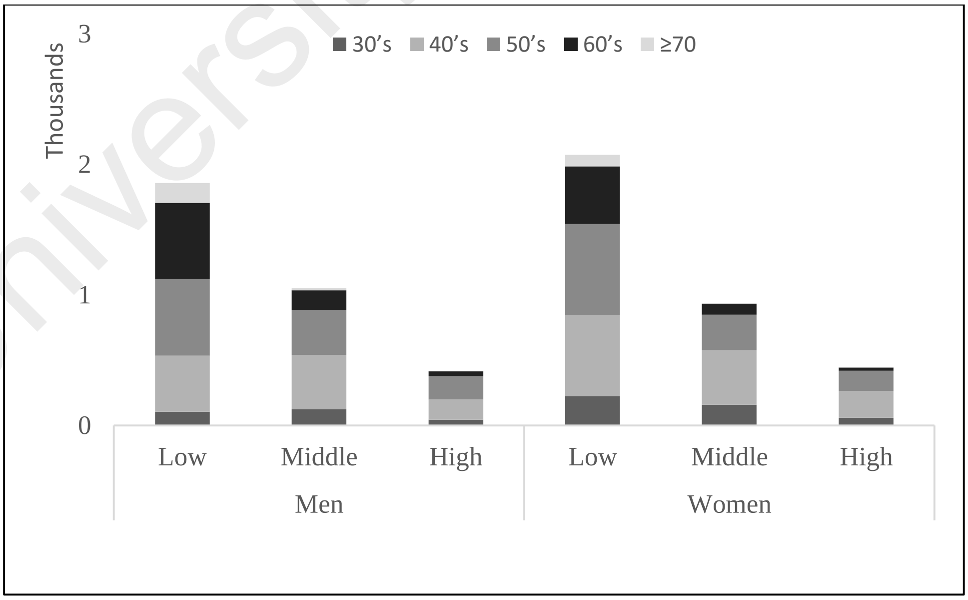

Figure 3.7: Number of respondents by age and income

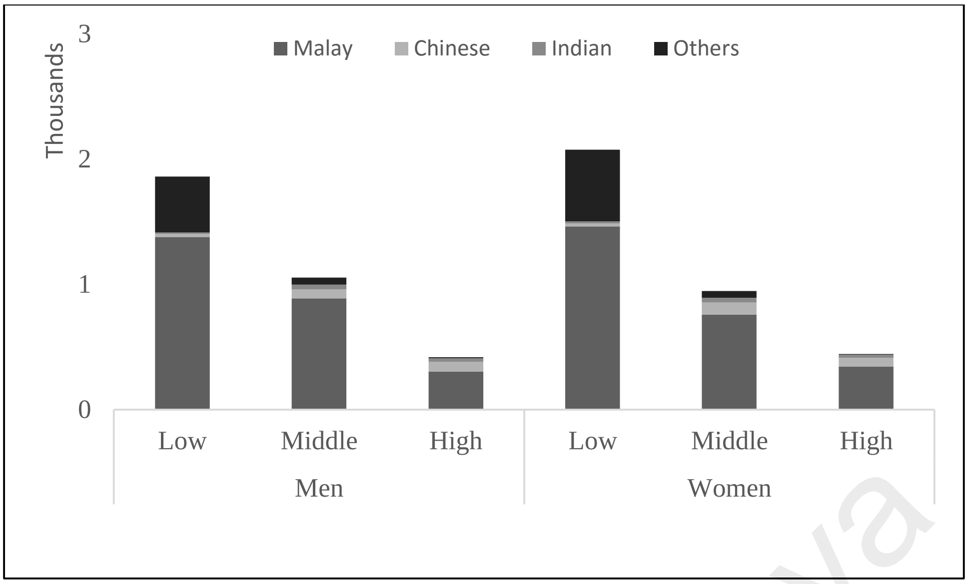

Figure 3.8: Number of respondents by ethnic and income

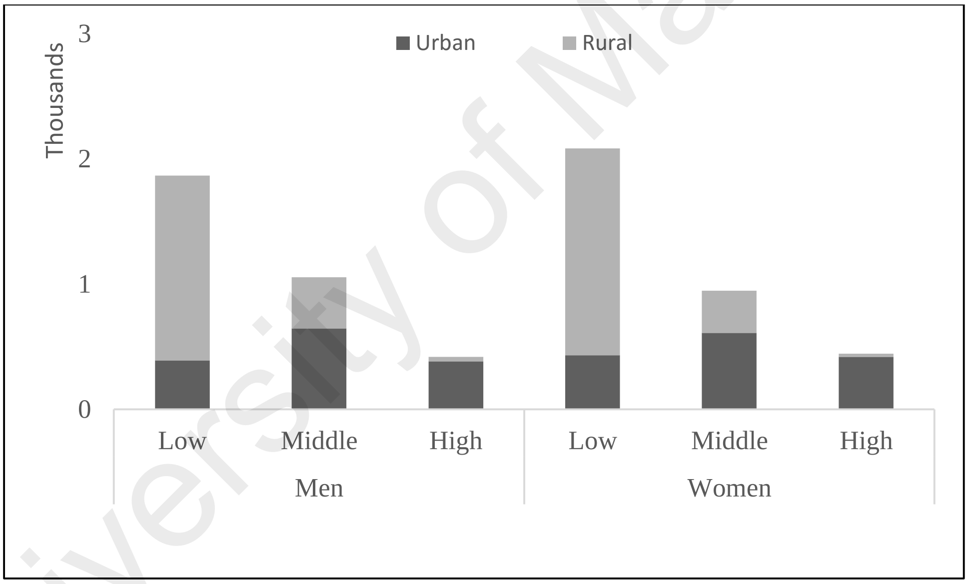

Figure 3.9: Number of respondents by location and income

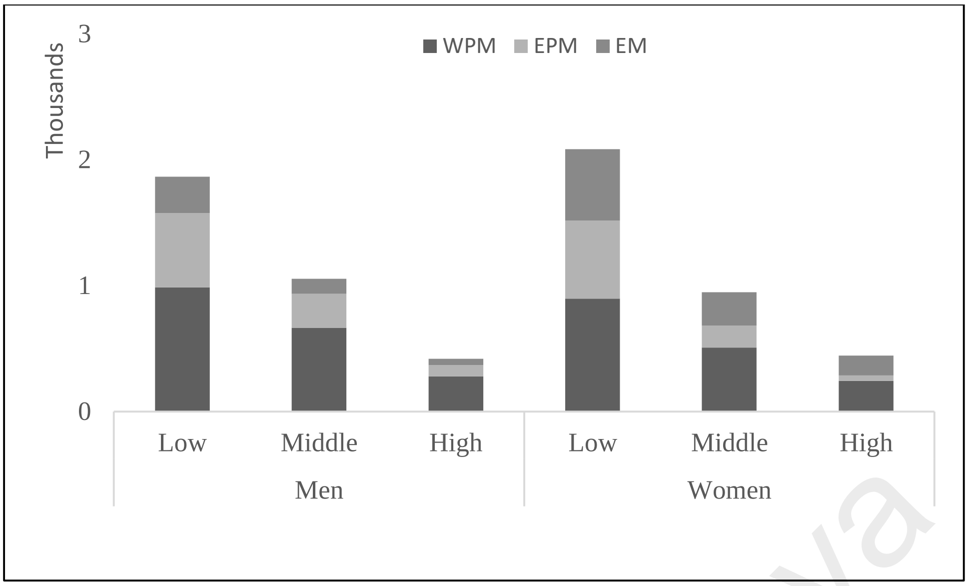

Figure 3.10: Number of respondents by region and income

3.4.6 Socioeconomic factors and cardiovascular disease risk factors

3.4.6.1 Age-adjusted prevalence of smoking and education levels

There was no relationship between smoking and education (see Figure 3.11, Figure 3.12, Figure 3.13, and Figure 3.14). However, the prevalence of smoking in men was significantly higher than women in all education, ethnic and location categories. The maximum prevalence of smoking was found among men with technical education in the age group of 30's (83%, SE 8.1). Ethnically, Malay men consistently showed a higher prevalence of smoking in all education groups; the technically educated exhibited the highest (45%, SE 4.6).

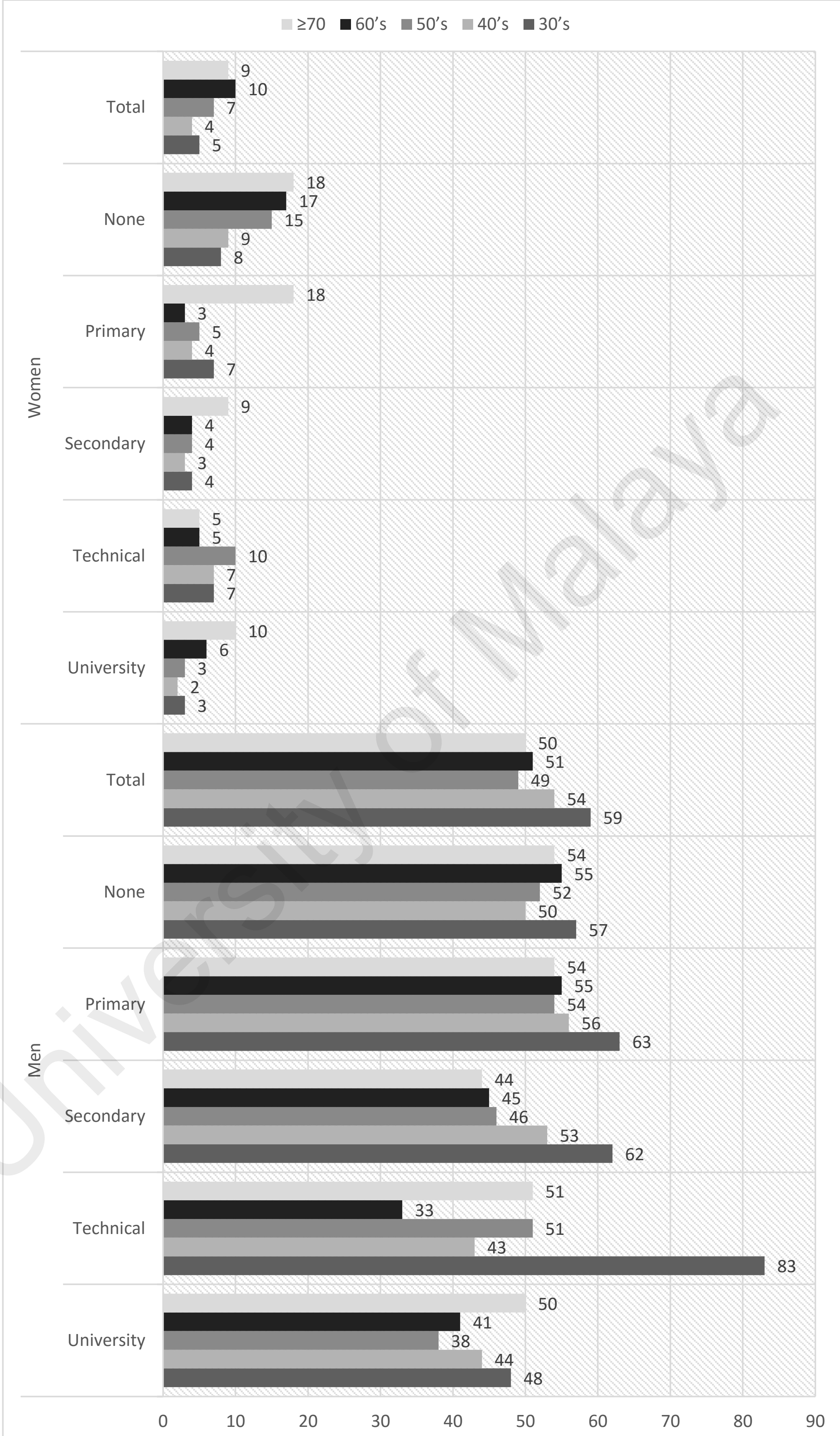

Figure 3.11: Prevalence of smoking in education levels by age

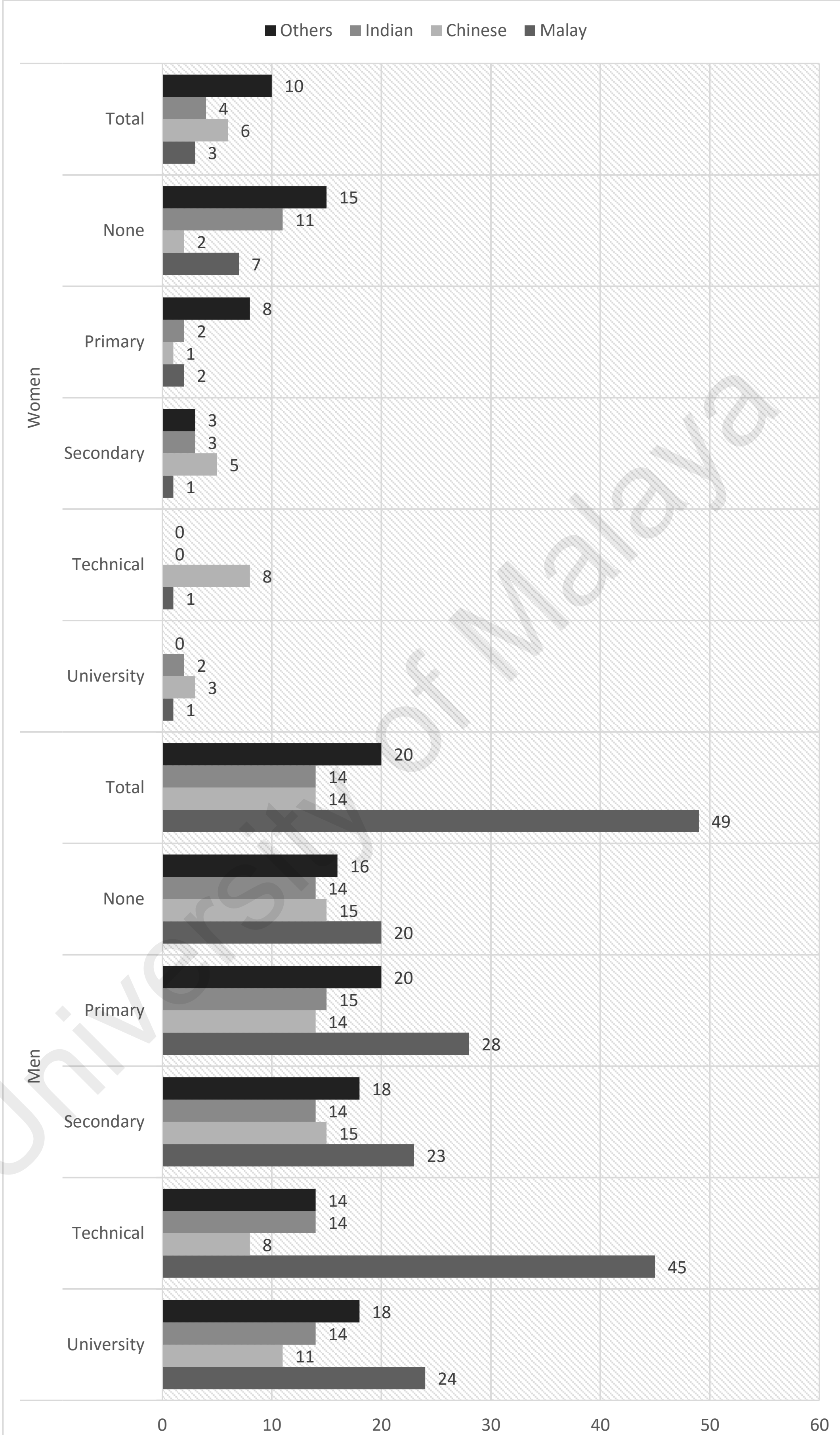

Figure 3.12: Prevalence of smoking in education levels by ethnicity

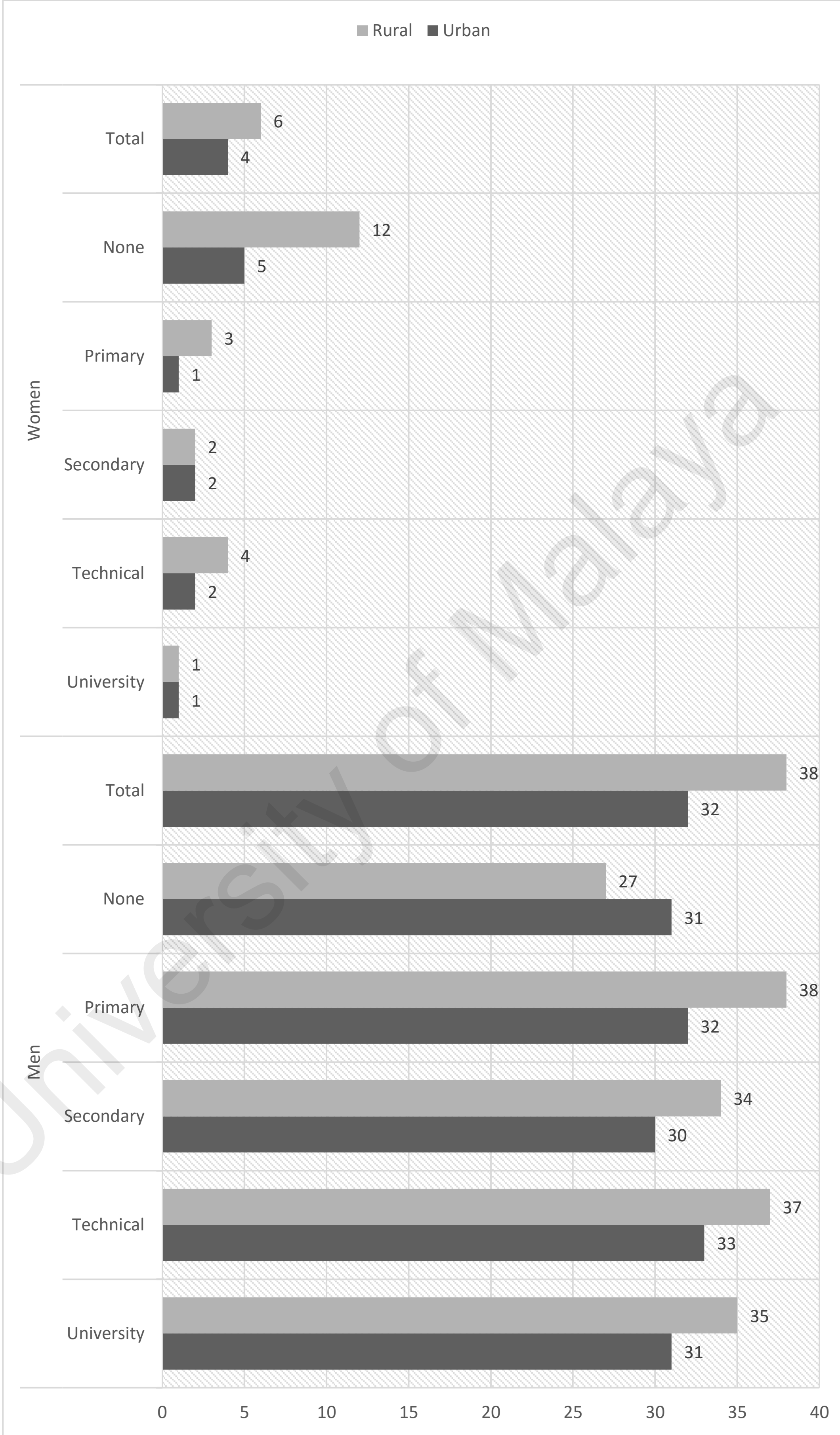

Figure 3.13: Prevalence of smoking in education levels by location

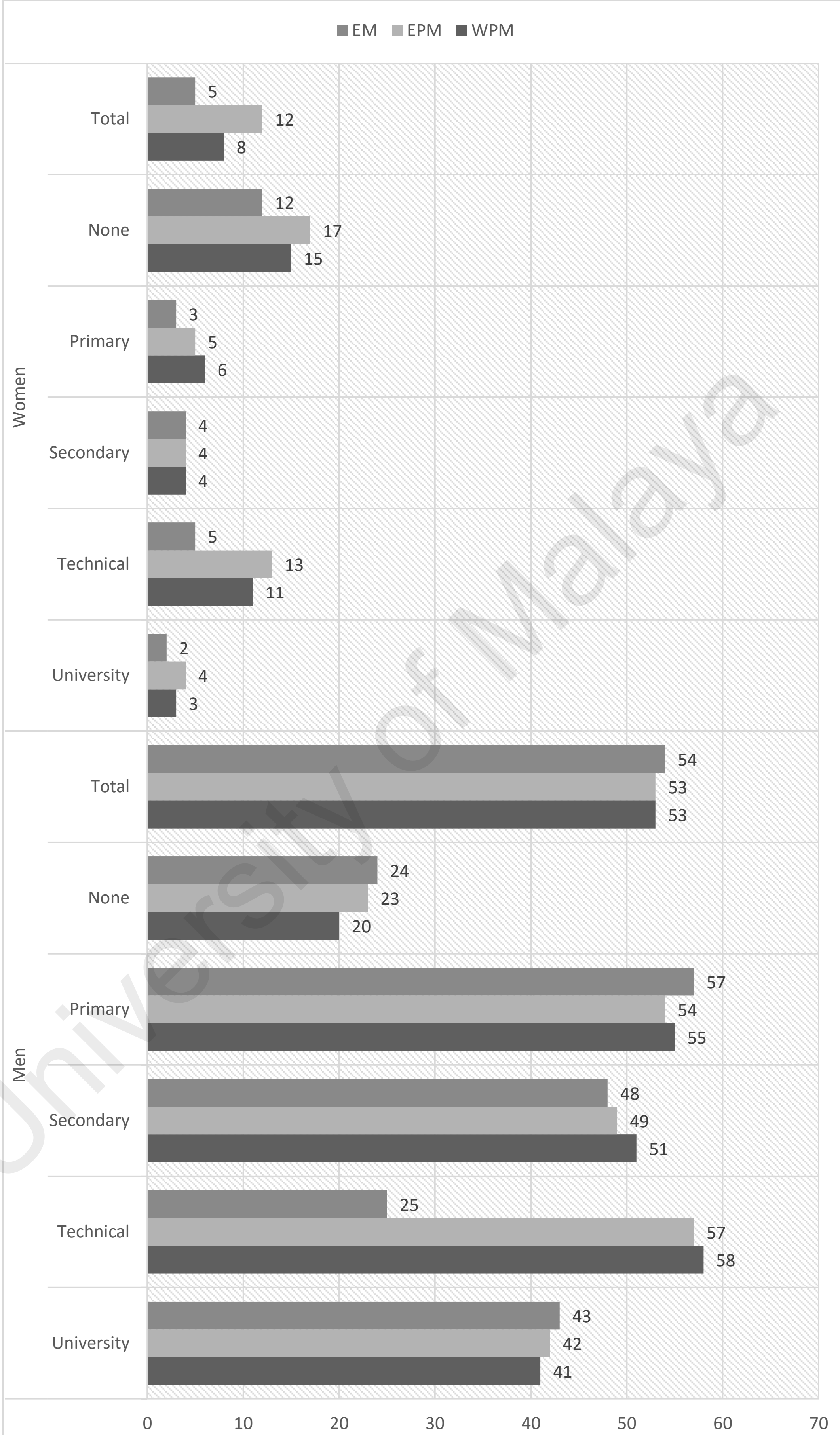

Figure 3.14: Prevalence of smoking in education levels by region

3.4.6.2 Age-adjusted prevalence of hypertension and education levels

Hypertension had no systematic association with education (see Figure 3.15, Figure 3.16, Figure 3.17, and Figure 3.18). Ethnically, apart from differences among primary educated women, there were no other rural-urban differences in the prevalence of hypertension. The prevalence of hypertension was highest in other ethnic groups-among women with technical education (46%, SE 2.5) followed by Indian women with no education (44%, SE 11.9), technical (39%, SE 3.5) and primary (32%, SE 10.2) education. Urban women with primary education (42%, SE 2.3) followed by urban (35%, SE 3.4) and rural (35%, SE 1.7) women with no education showed the highest prevalence of hypertension.

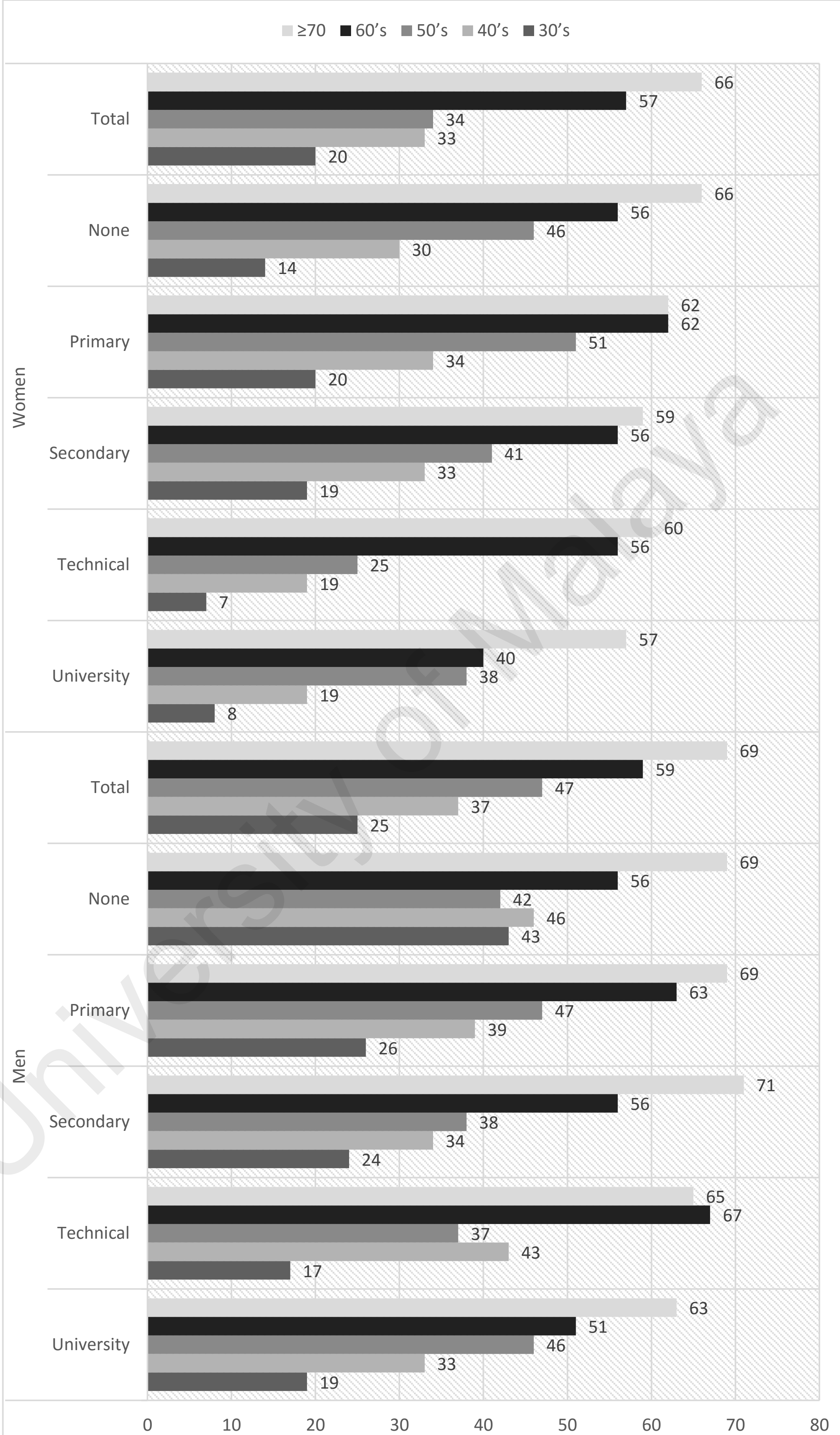

Figure 3.15: Prevalence of hypertension in education levels by age

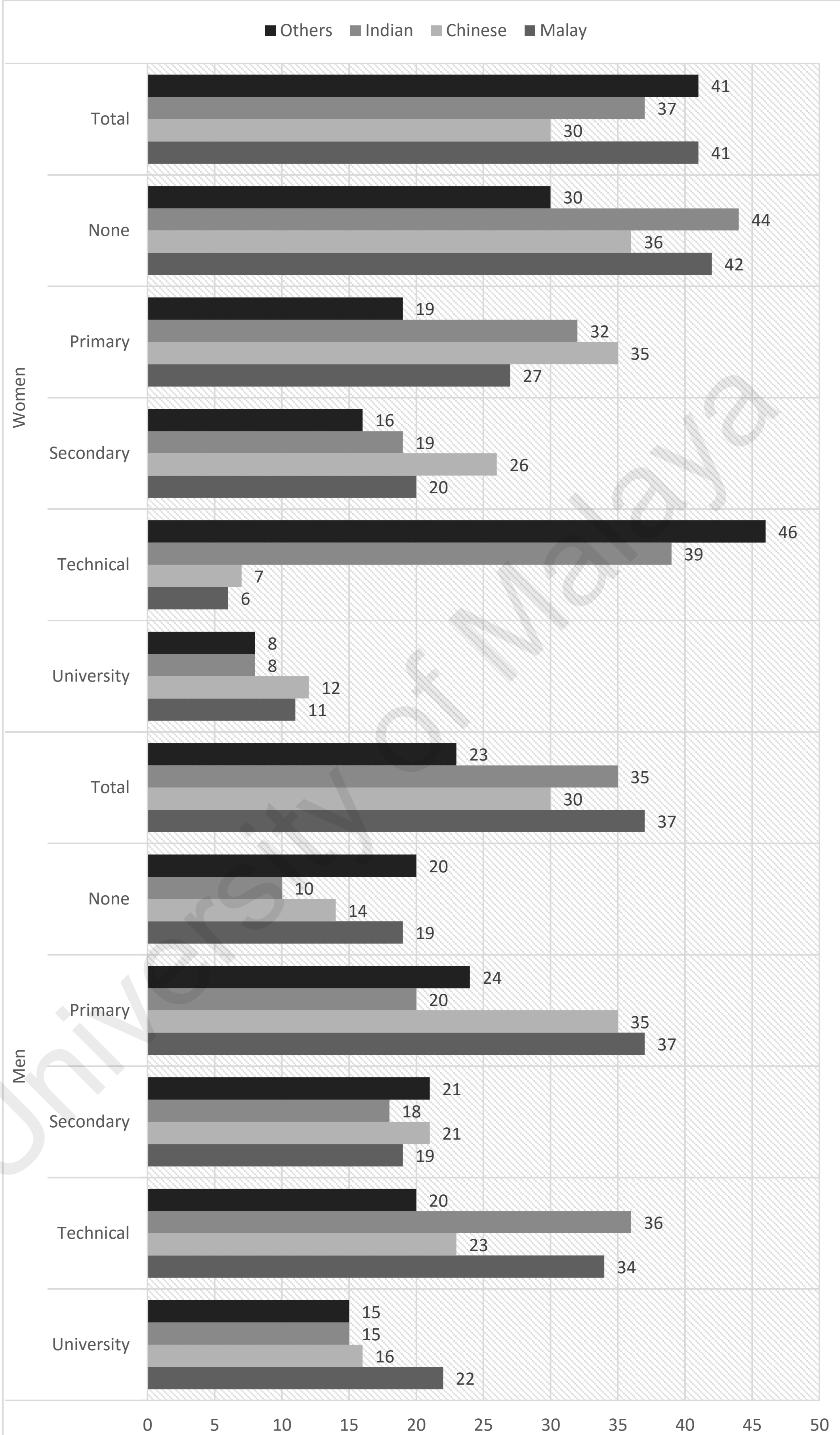

Figure 3.16: Prevalence of hypertension in education levels by ethnicity

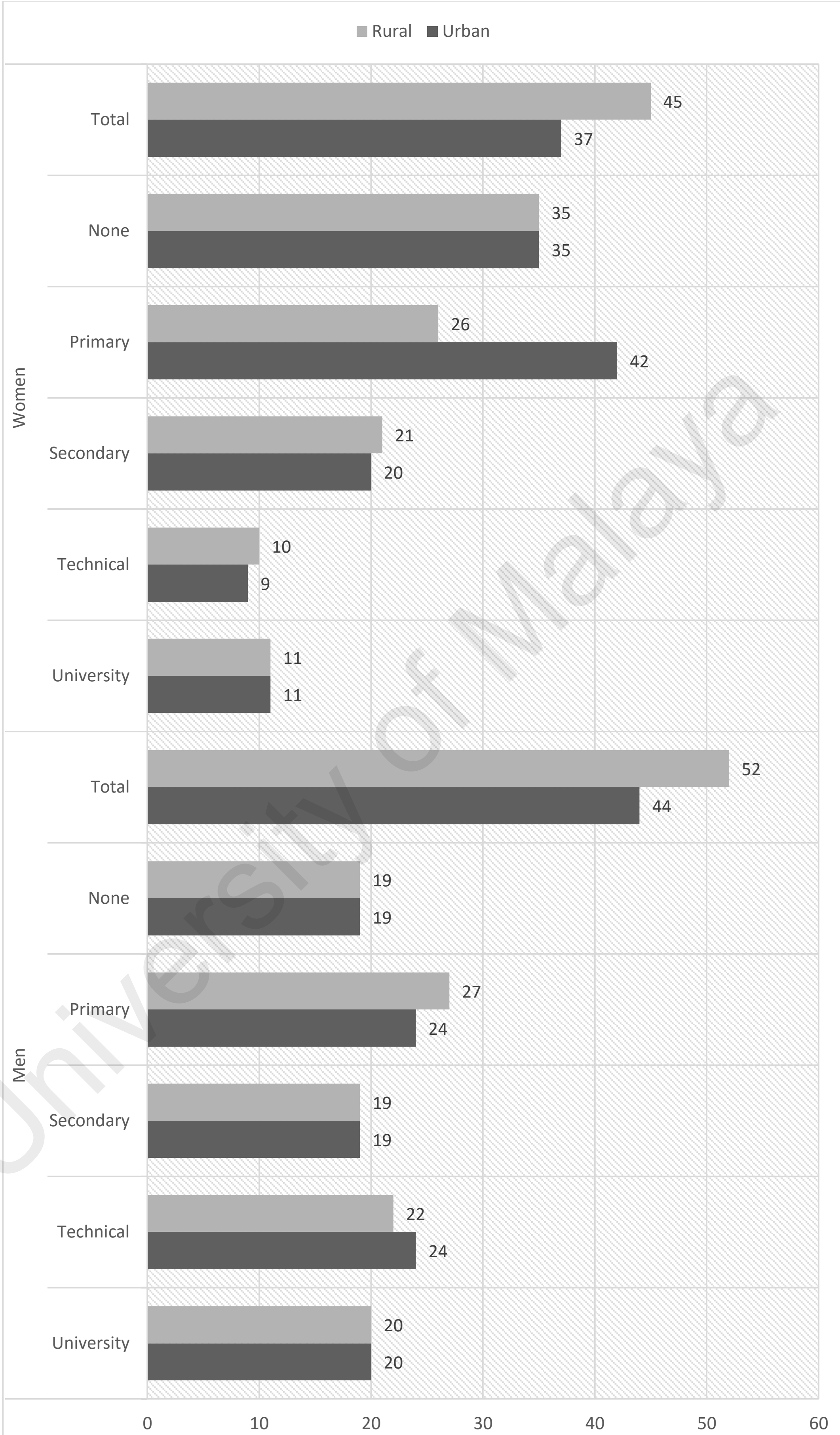

Figure 3.17: Prevalence of hypertension in education levels by location

Men from EM had higher prevalence of hypertension than WPM and EPM among the university, technical and secondary educated, while men with primary or no education from EPM had a higher prevalence of hypertension than WPM and EM. Women with technical, secondary, primary and no education in EPM had the highest prevalence of hypertension. Women from WPM and EM had the highest prevalence of hypertension among the university educated.

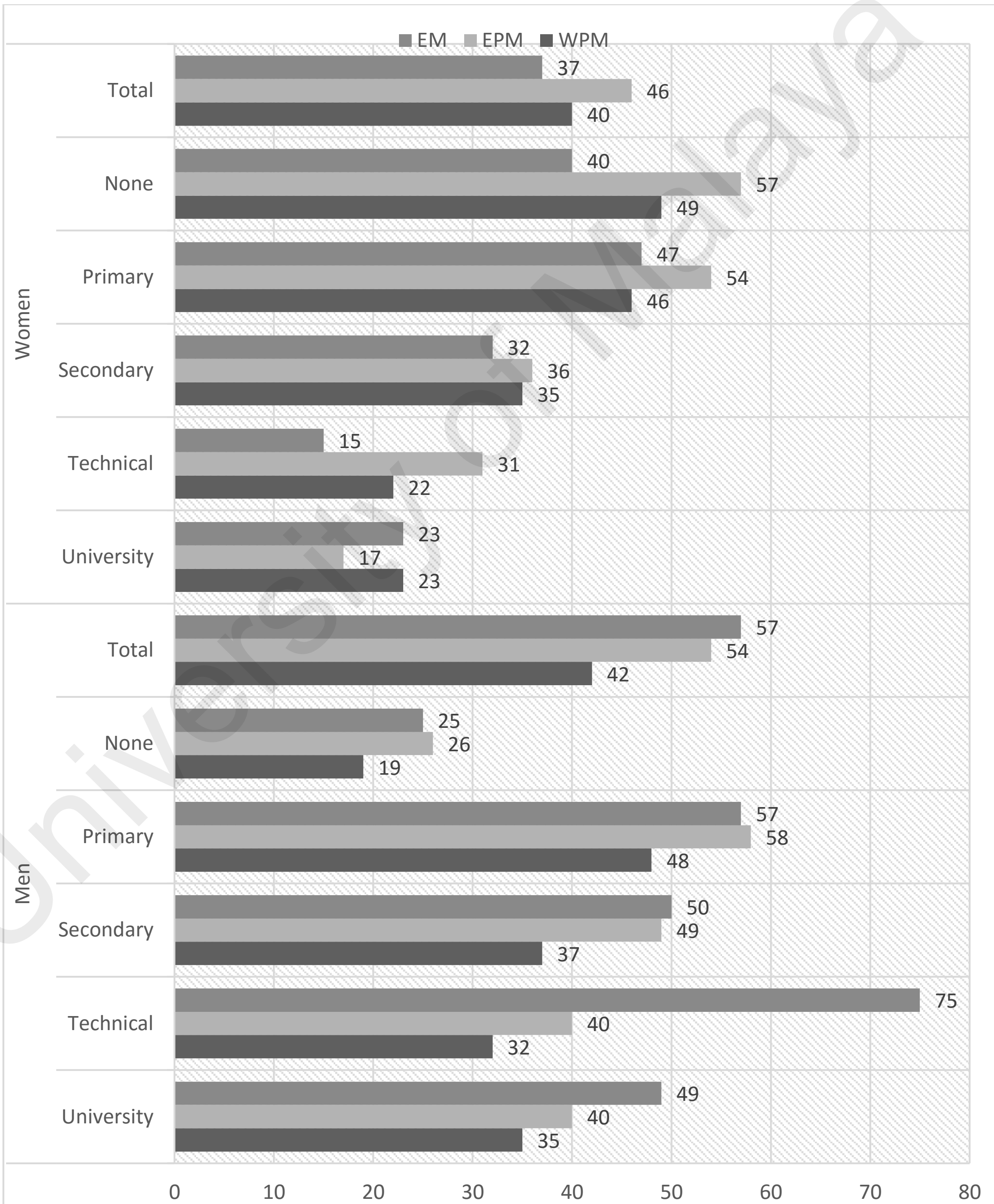

Figure 3.18: Prevalence of hypertension in education levels by region

3.4.6.3 Age-adjusted prevalence of diabetes and education levels

There was no apparent association between the prevalence of diabetes and education (see Figure 3.19, Figure 3.20, Figure 3.21, and Figure 3.22). However, the prevalence of diabetes was highest among Indian women with no education (20%, SE 1.4) followed by Indian women with primary education (18%, SE 1.2), and Indian men with technical (26%, SE 1.8), primary (16%, SE 13.0), and secondary (15%, SE 6.7) education. EPM had the highest prevalence of diabetes among men and women in all education categories.

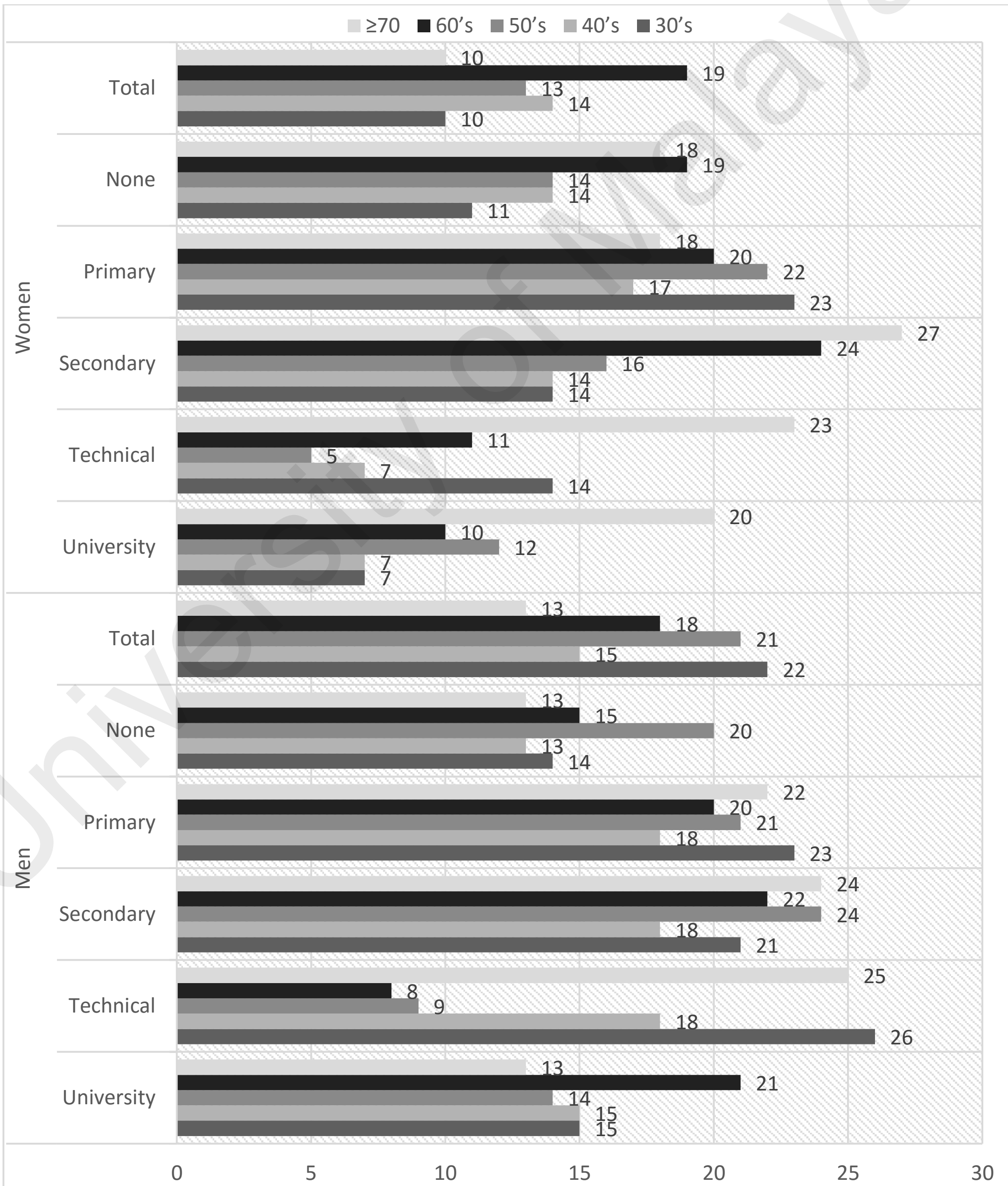

Figure 3.19: Prevalence of diabetes in education levels by age

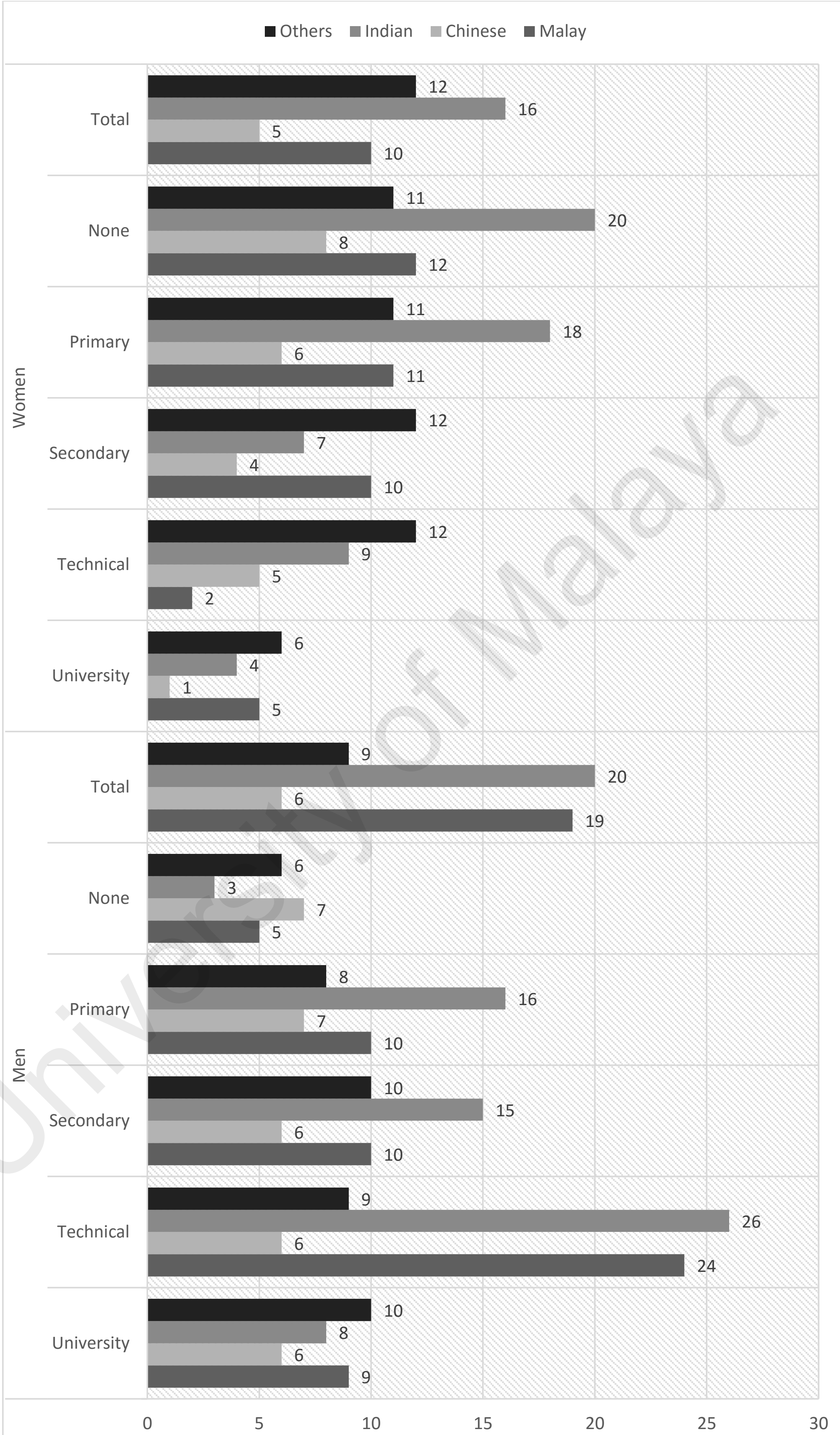

Figure 3.20: Prevalence of diabetes in education levels by ethnicity

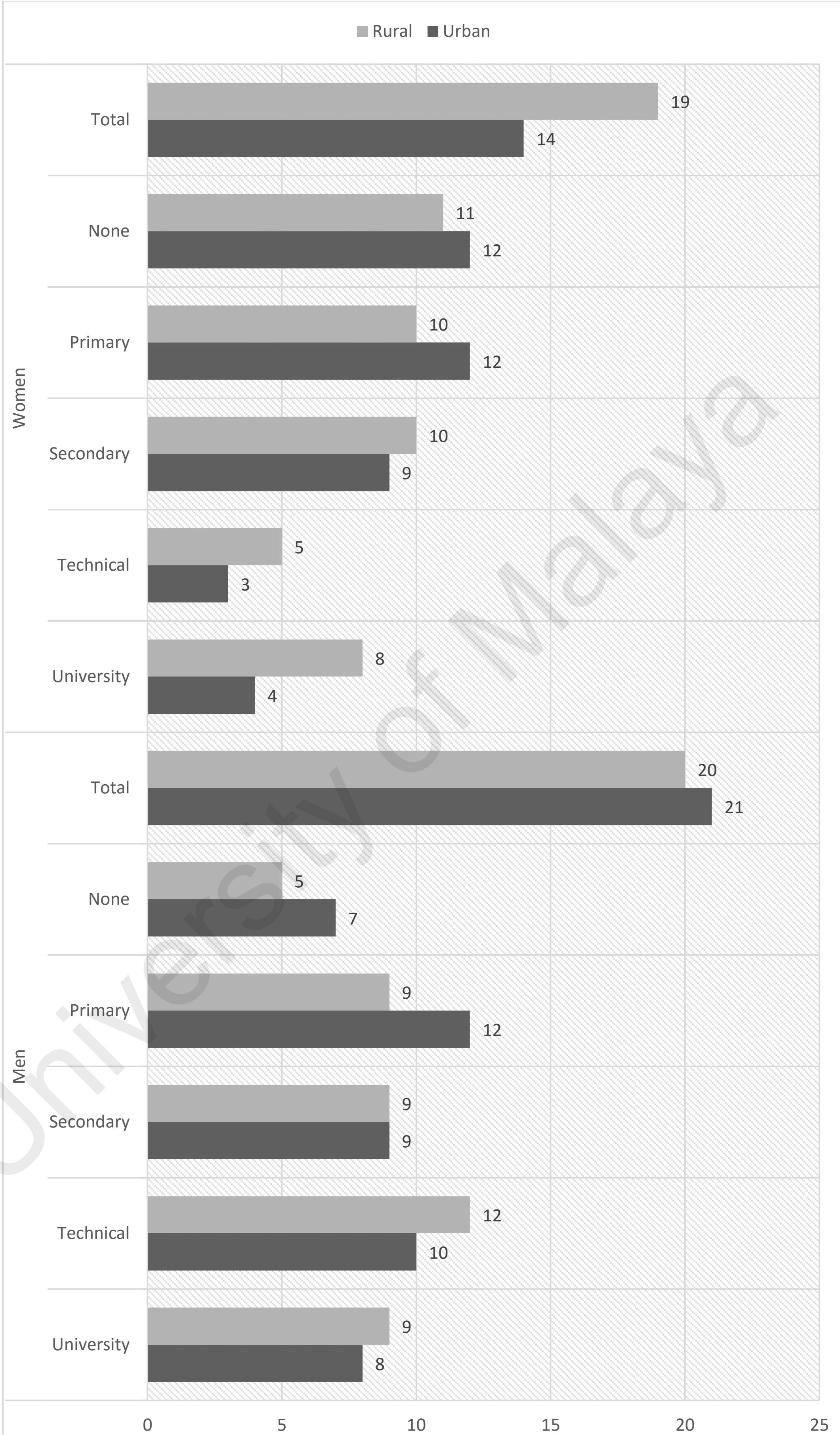

Figure 3.21: Prevalence of diabetes in education levels by location

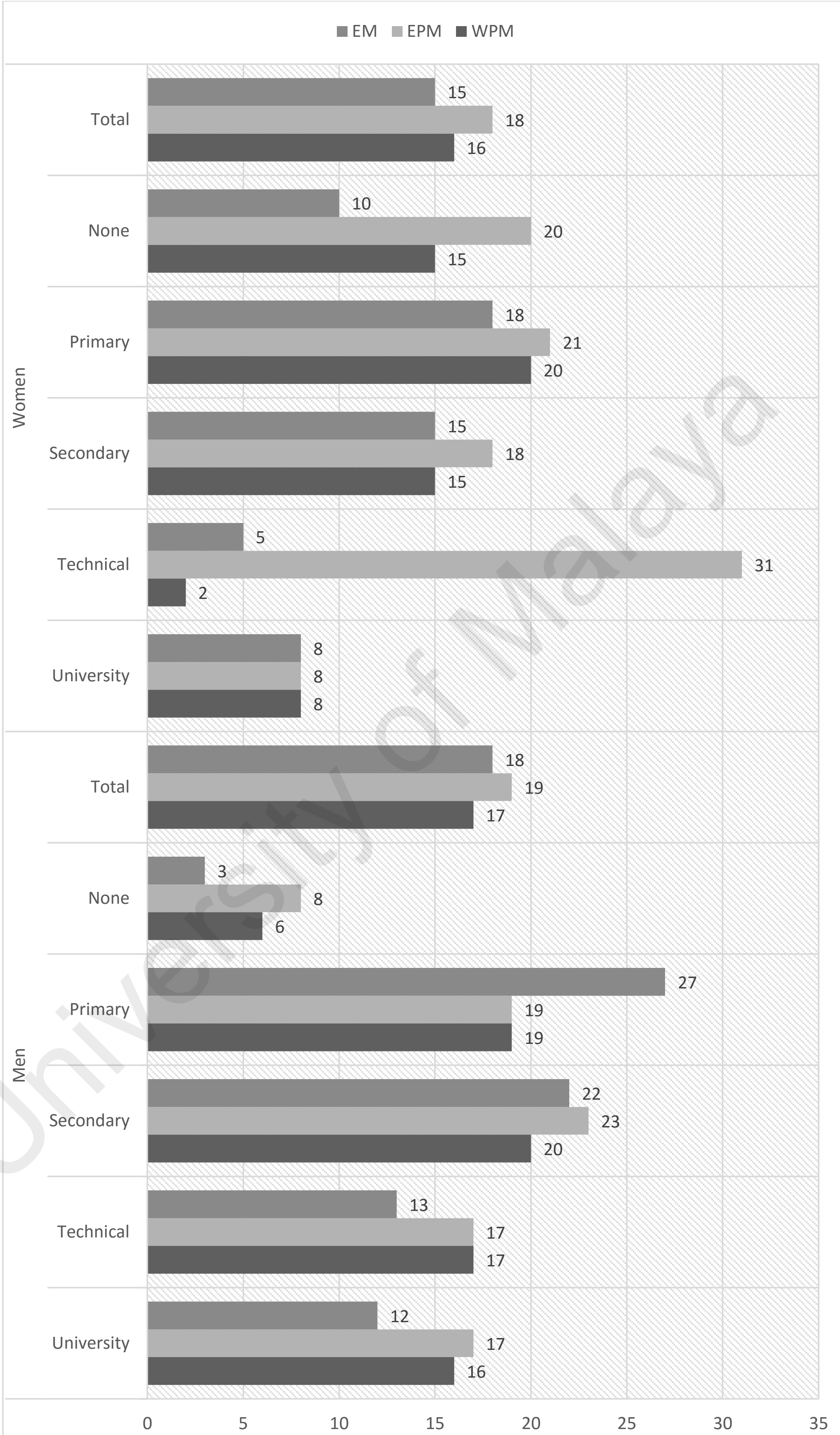

Figure 3.22: Prevalence of diabetes in education levels by region

3.4.6.4 Age-adjusted prevalence of hypercholesterolemia and education levels

There was no clear relationship between hypercholesterolemia and education and gender (see Figure 3.23, Figure 3.24, Figure 3.25, and Figure 3.26). However, Malay men in all categories had the highest prevalence of hypercholesterolemia with the highest in the technical education group (69%, SE 4.5). Women with no education had the highest prevalence of hypercholesterolemia in all ethnic groups. Malay women (55%, SE 1.7) had highest hypercholesterolemia followed by Indian women (51%, SE 10.6). Urban women had higher hypercholesterolemia than rural women in all education categories. The maximum prevalence of hypercholesterolemia was recorded by urban women with no education (52%, SE 2.8), and in men among technically educated (41%, SE 4.7).

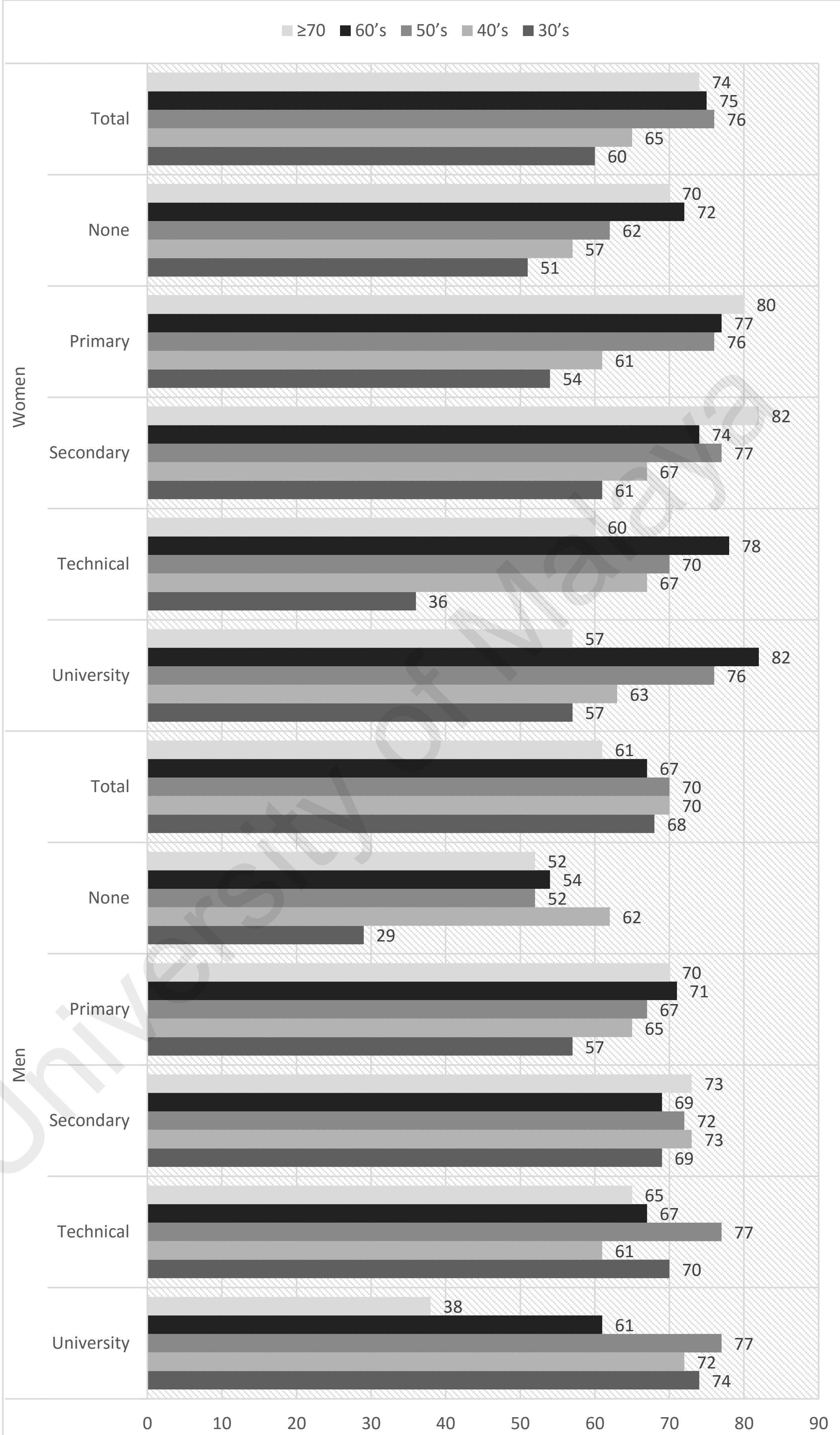

Figure 3.23: Prevalence of hypercholesterolemia in education levels by age

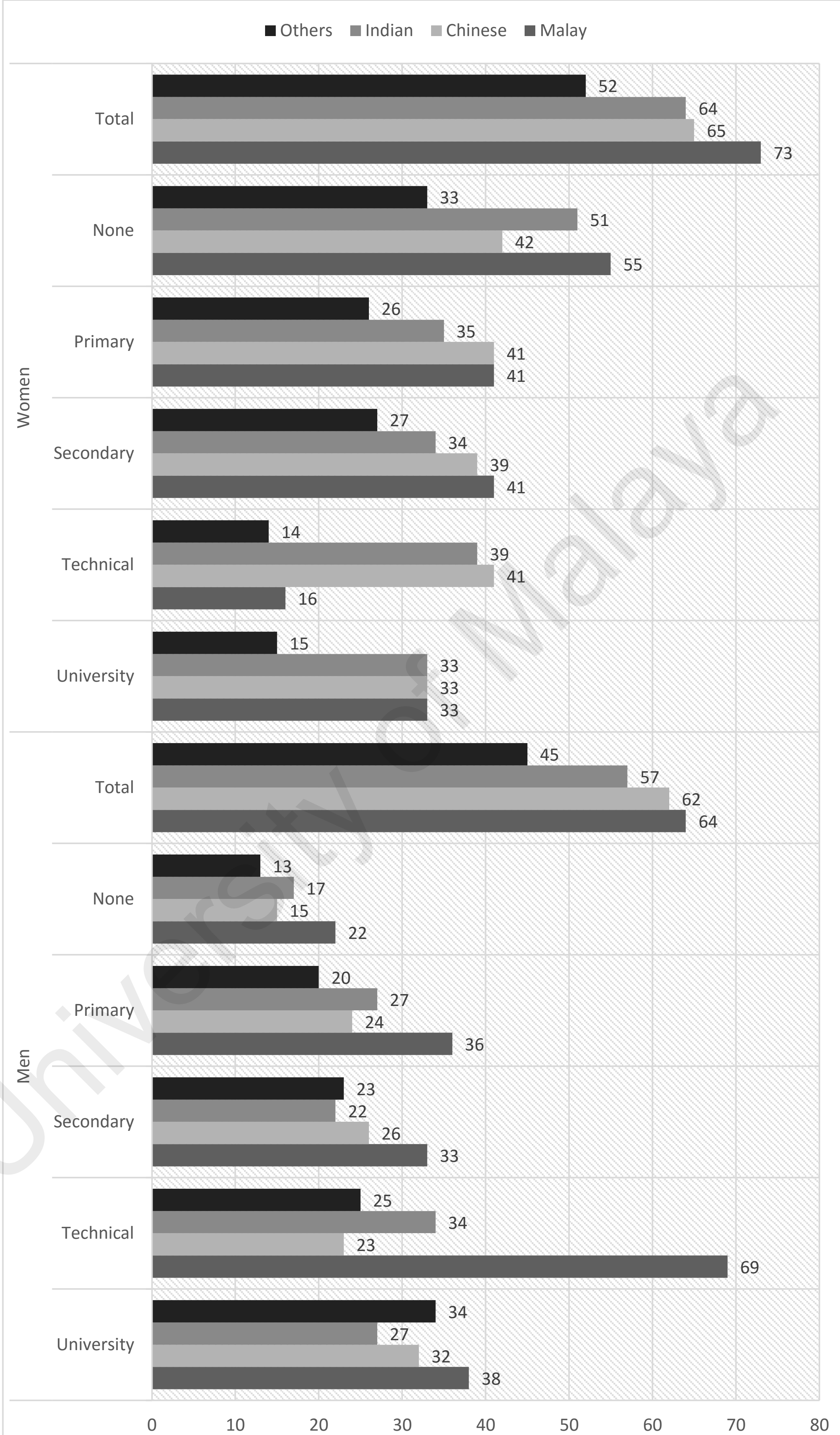

Figure 3.24: Prevalence of hypercholesterolemia in education levels by ethnicity

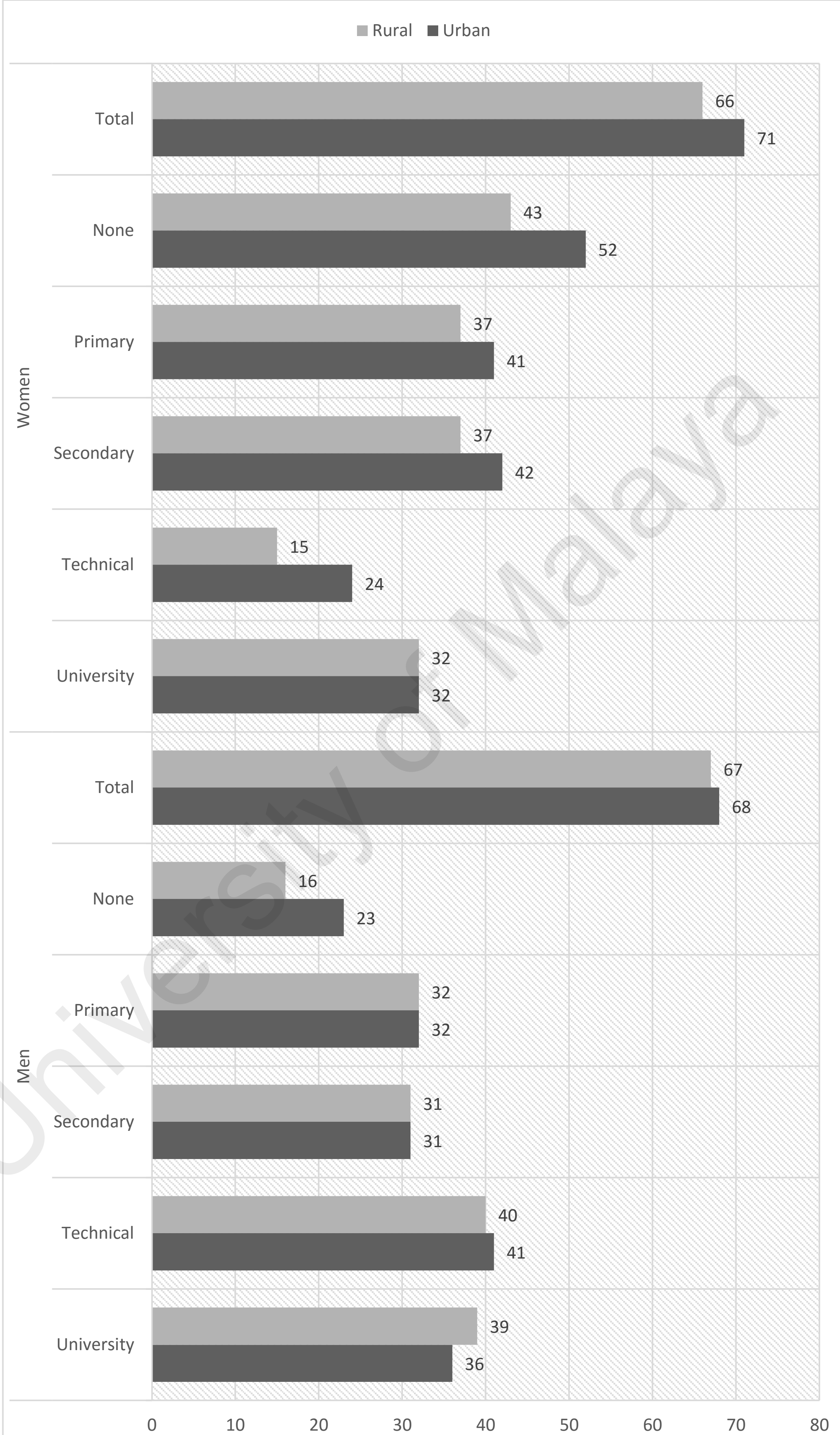

Figure 3.25: Prevalence of hypercholesterolemia in education levels by location

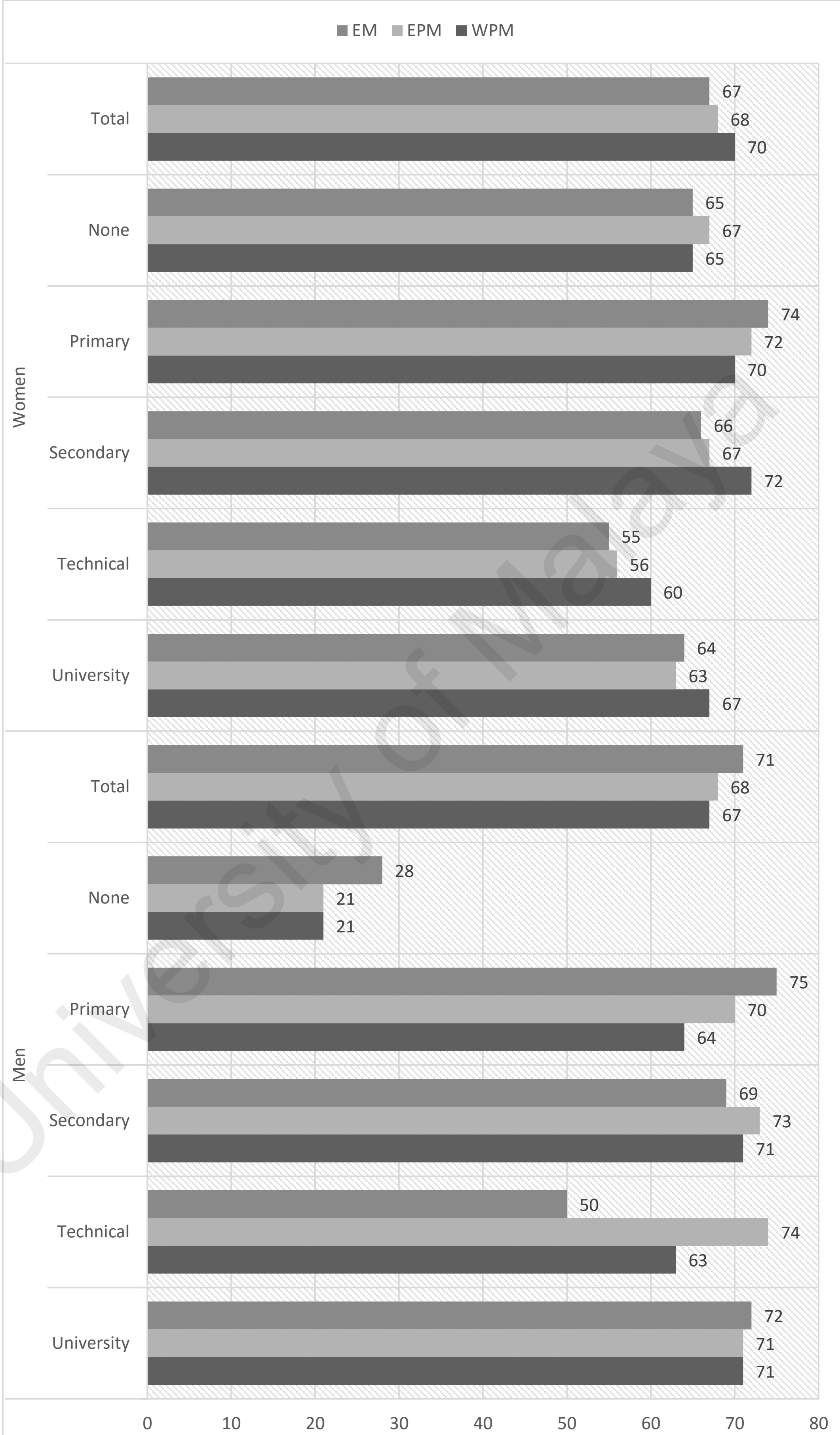

Figure 3.26: Prevalence of hypercholesterolemia in education levels by region

3.4.6.5 Age-adjusted prevalence of overweight/obesity and education levels

Except for the primary educated, Malays had the highest prevalence of obesity in men (see Figure 3.27, Figure 3.28, Figure 3.29, and Figure 3.30). Indians had the highest prevalence of obesity among men with primary education. Among women, except for the university and secondary educated, Indians had the highest prevalence of obesity. Malays had the highest prevalence of obesity among university and secondary educated women. Urban men with secondary, primary and no education showed a higher prevalence of obesity than rural men. Except for the technically educated, urban women showed a higher prevalence of obesity than rural women.

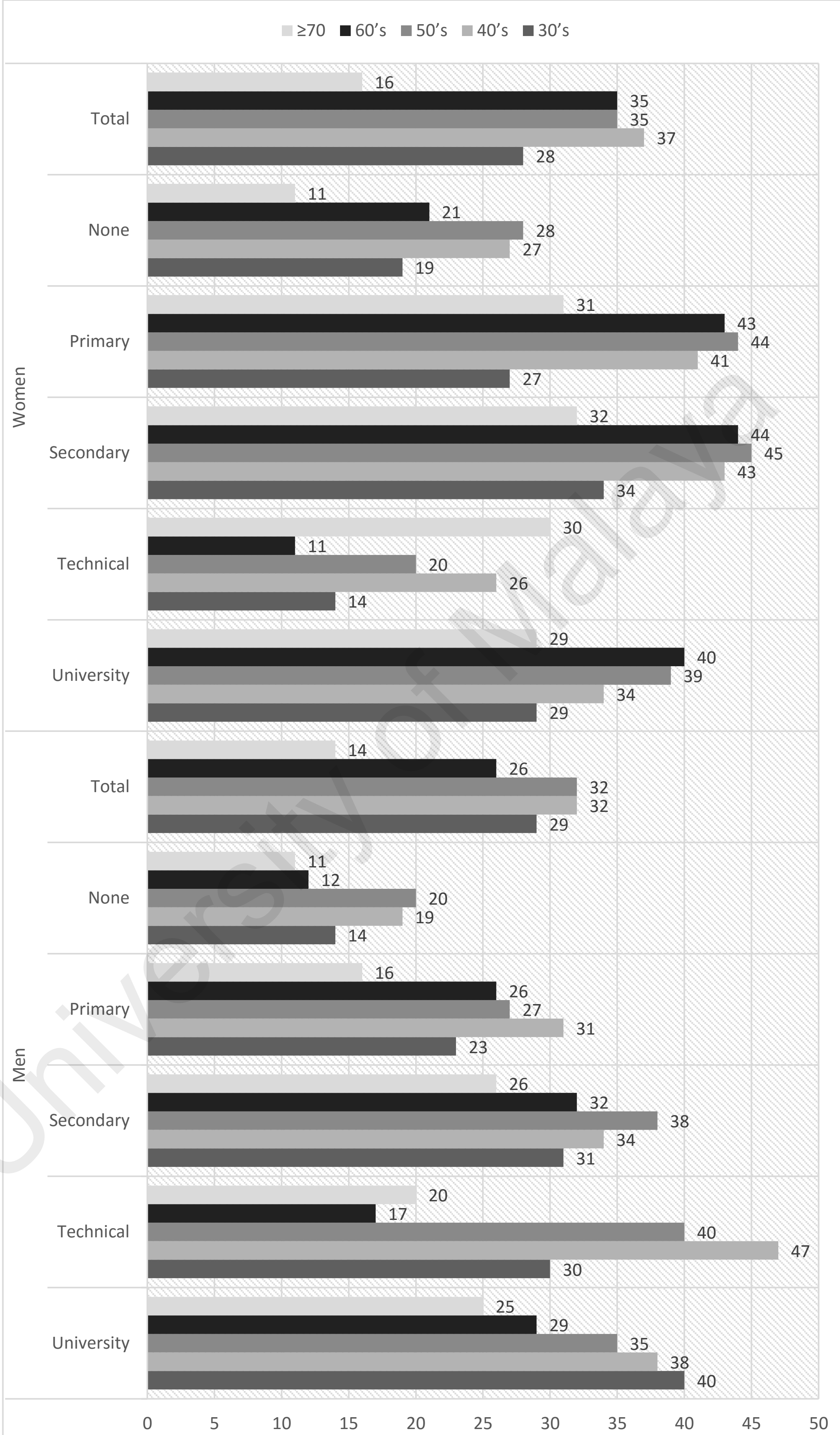

Figure 3.27: Prevalence of overweight/obesity in education levels by age

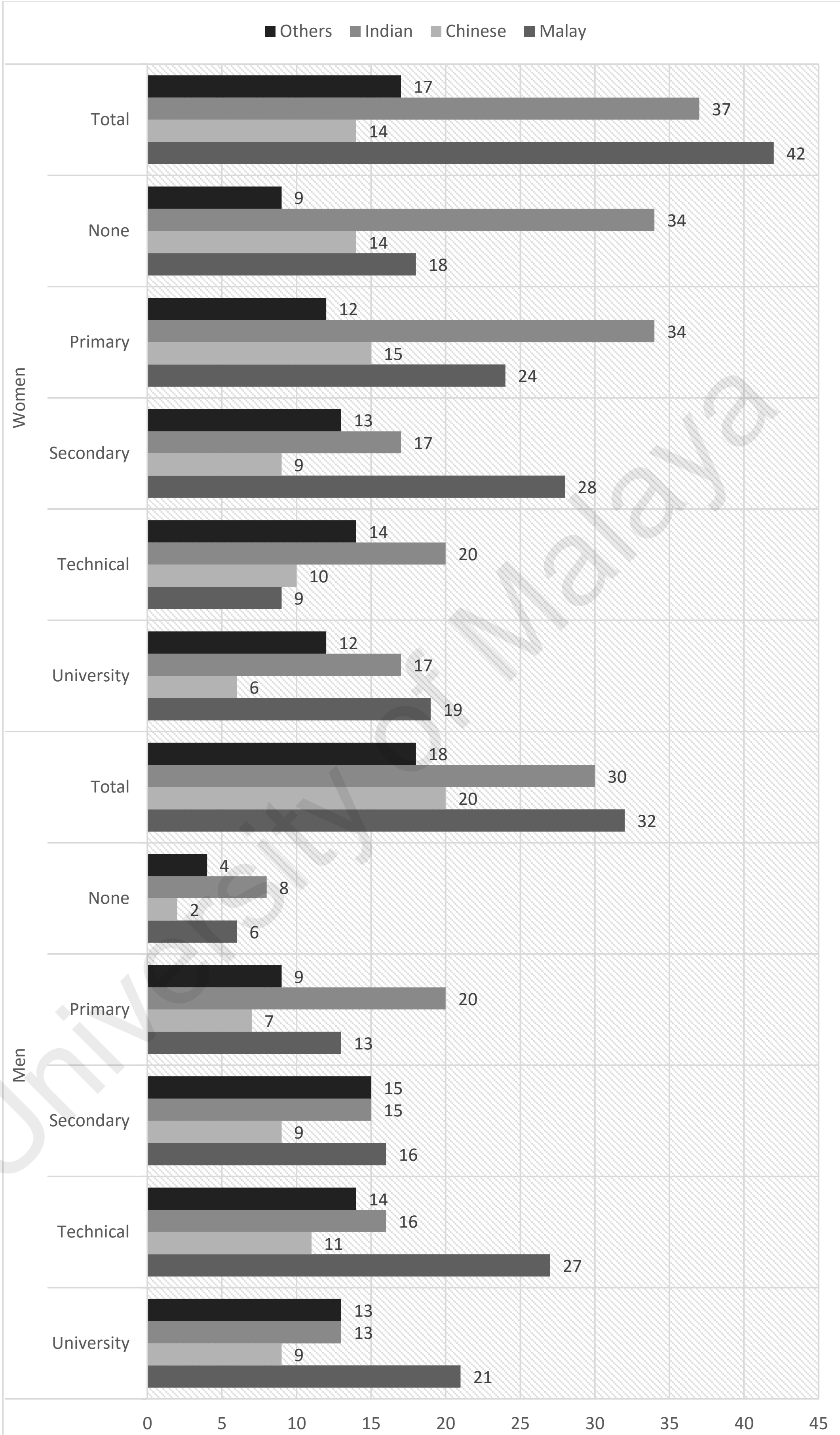

Figure 3.28: Prevalence of overweight/obesity in education levels by ethnicity

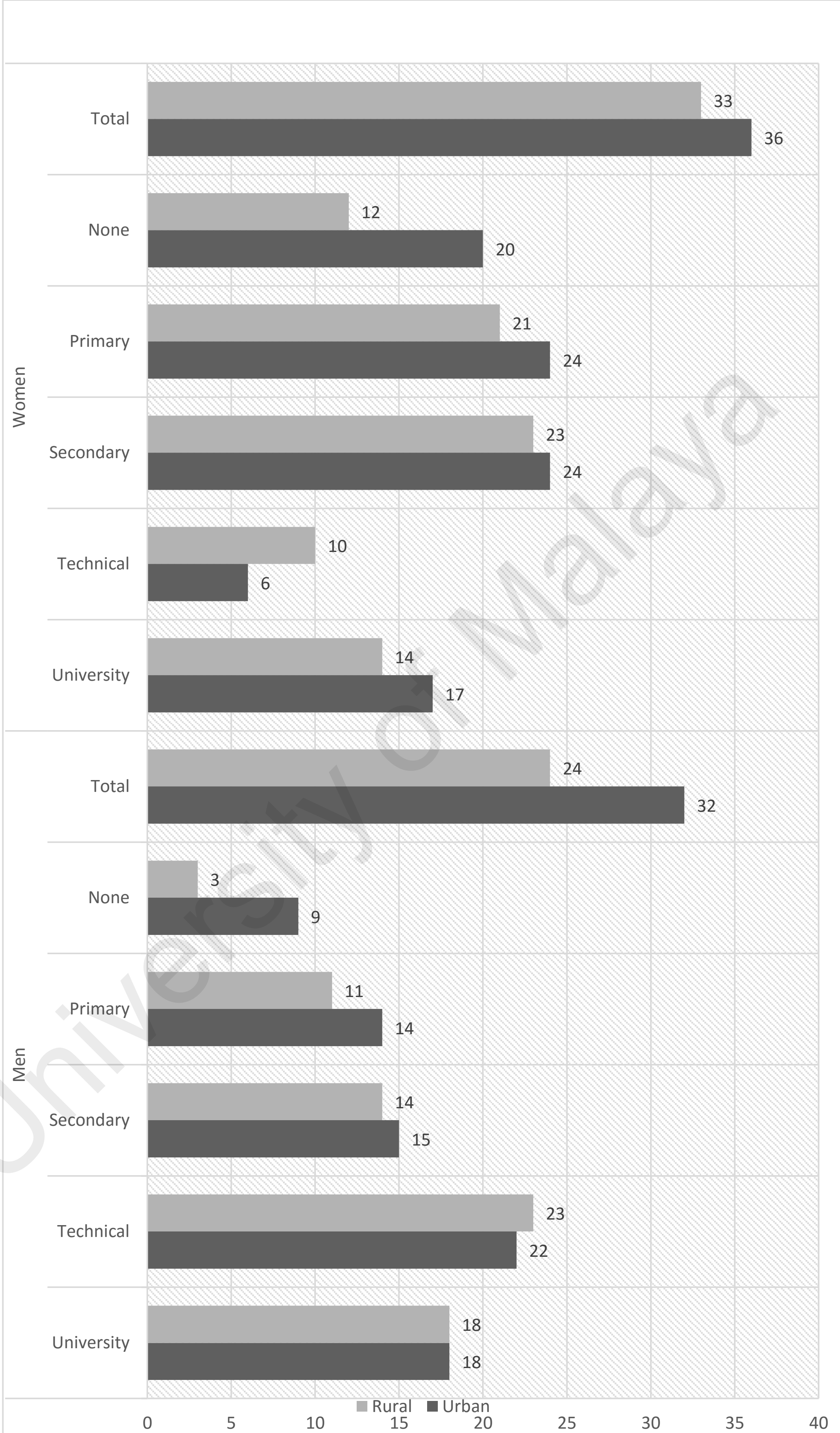

Figure 3.29: Prevalence of overweight/obesity in education levels by location

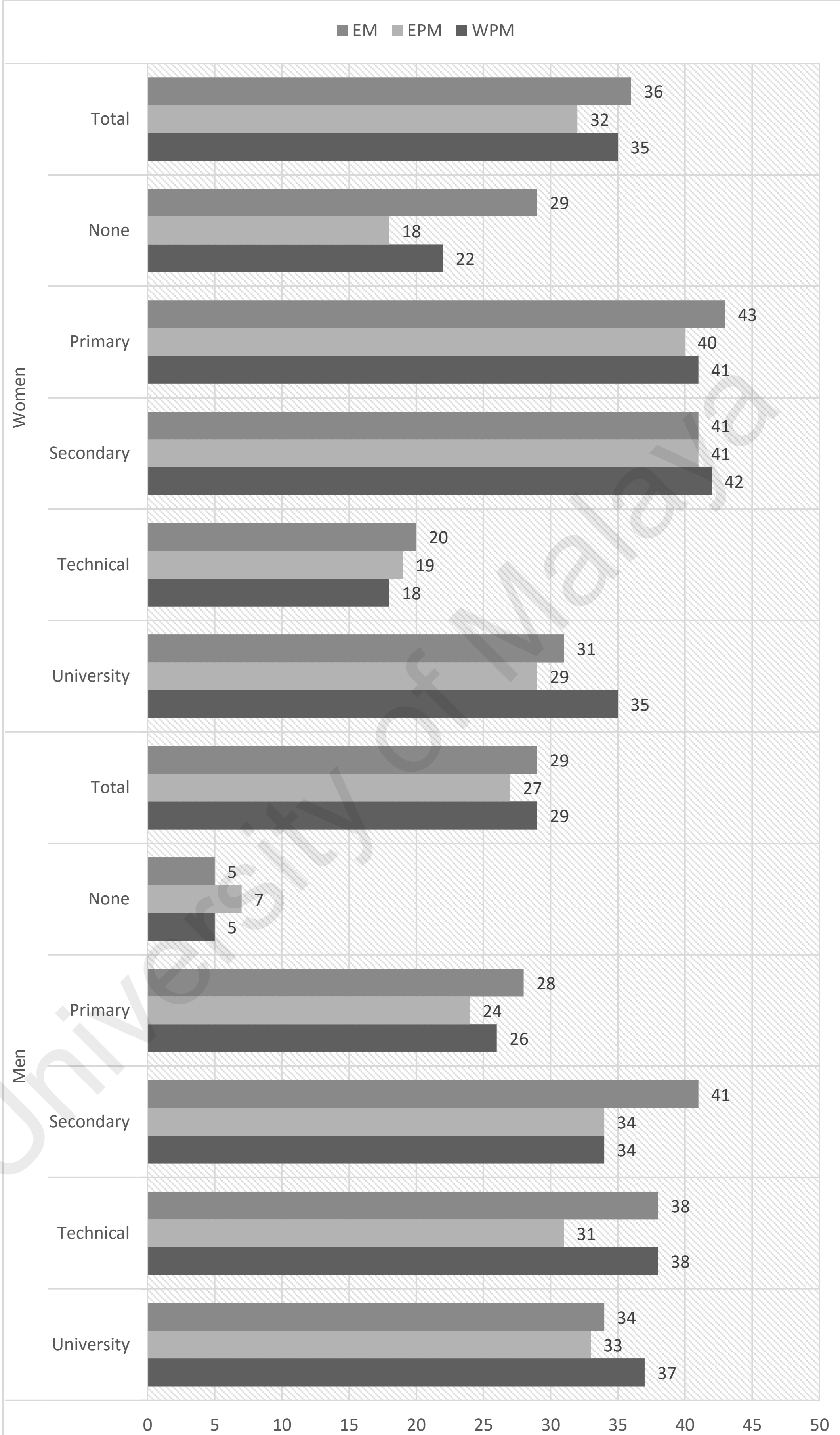

Figure 3.30: Prevalence of overweight/obesity in education levels by region

3.4.6.6 Cardiovascular disease risk factors and education levels

To sum up, the prevalence of CVD risk factors by education varied considerably. In all education levels, the prevalence of hypertension is higher in men than women (see Figure 3.31). In both sexes, it is highest among those without education (men 60%, SE 2.2; women 56%, SE 1.5) followed by primary education (men 58%, SE 1.4; women 53%, SE 1.3). The prevalence of diabetes in women was lower than men. Men had a higher prevalence of diabetes than women among the university, technical and secondary educated. The prevalence was similar among those with primary education, while those with no education showed the highest prevalence. Men showed a higher prevalence of hypercholesterolemia than women among the university and technical educated. Whereas the prevalence in men and women was the same among the secondary educated, women showed a higher prevalence among the primary and non-educated. In men, the prevalence of hypercholesterolemia was highest among the secondary educated (71%, SE 1.1) and lowest among the uneducated (53%, SE 2.2).The prevalence of smoking was highest among men with primary or no education. The prevalence of obesity in men was highest among secondary (34%, SE 1.1), technical (34%, SE 4.2) and university educated (34%, SE 1.5). It was lowest among men with no education followed by primary education. The prevalence of obesity in women was highest among the secondary educated (42%, SE 1.1) followed by the primary educated (35%, SE 1.5).

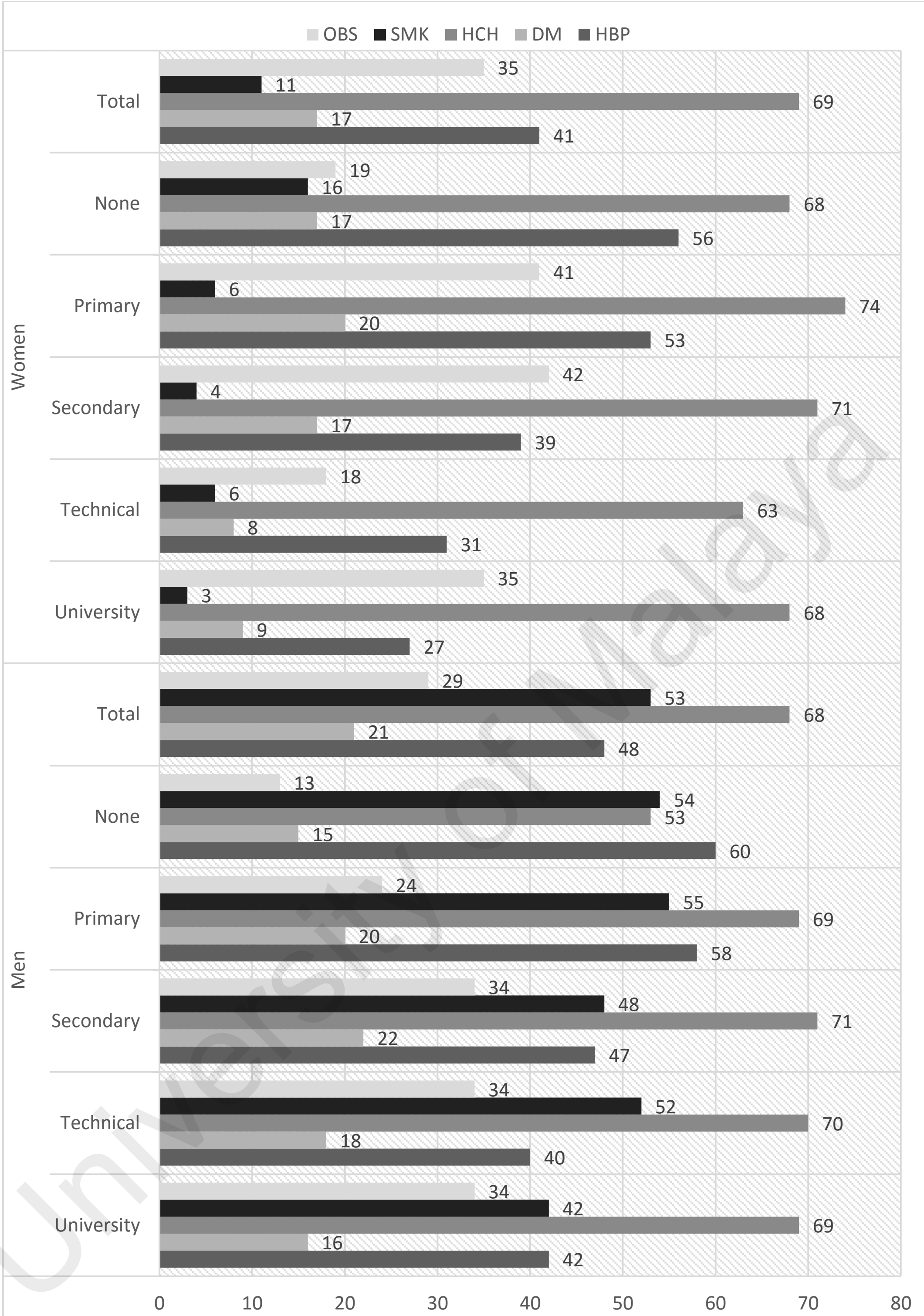

Figure 3.31: Prevalence of cardiovascular disease risk factors by education levels

Note: High Blood Pressure (HBP): Mean SBP (Systolic Blood Pressure) ≥ 140 mm Hg or Mean DBP (Diastolic Blood Pressure) ≥ 90 mm Hg or using medication; Diabetes Mellitus (DM): Mean plasma glucose ≥ 126 mg/dL or 7.0 mmol/Lit; Hypercholesterolemia (HCH): Mean Plasma cholesterol ≥ 5.2 mmol/Lit; Smoking (SMK): Smokes at least one cigarette per day; Overweight/obesity (OBS): BMI ≥27.5 kg/m^2

3.4.6.7 Age-adjusted prevalence of smoking and income levels

Men smoked more than women in all income, age, ethnic and rural-urban categories (see Table 3.3 and Table 3.4). The relationship between smoking and income was negative in the age groups of 30's, 40's and 60's among men, and 30's and 50's among women. Malays had the highest prevalence of smoking among men. The relationship between tobacco use and income in men was negative among Malays, Chinese, and others. In women, the prevalence of smoking was highest among other ethnic groups in the low income (15%, SE 1.5) and high income (10%, SE 1.3), and Chinese among middle-income earners (12%, SE 3.3). More rural men smoked than urban men in all income categories. Except among low-income rural women (9%, SE 0.7) who smoked more than urban women (7%, SE 0.8), the prevalence of smoking among middle and high-income women was similar. There was no regional association between smoking and income. However, EM had the highest prevalence of smoking among men among the low (43%, 7.1) and high (56%, SE 2.9) income. EPM had the highest prevalence of smoking in women among the low (14%, SE 5.3) income.

Table 3.3: Prevalence of smoking by income level in men

Age/Ethnicity/ Location/Region	Men			
	Low	**Middle**	**High**	**Total**
30's	60 (4.8)	57 (4.4)	53 (7.5)	59 (2.3)
40's	57 (2.4)	49 (2.5)	41 (4.0)	54 (1.4)
50's	43 (2.1)	46 (2.7)	84 (3.6)	49 (1.2)
60's	52 (2.1)	49 (4.1)	38 (8.1)	51 (1.5)
≥70	56 (4.0)	35 (11.9)	45 (2.1)	50 (2.1)
Malay	58 (1.3)	51 (1.7)	48 (2.9)	49 (0.8)
Chinese	42 (9.9)	31 (5.6)	10 (4.6)	14 (2.1)
Indian	11 (1.5)	34 (7.8)	29 (8.7)	14 (3.9)
Others	43 (2.3)	40 (6.6)	13 (1.2)	20 (1.8)
Urban	37 (2.5)	37 (2.0)	30 (2.5)	32 (1.0)
Rural	40 (1.3)	38 (2.5)	39 (8.4)	38 (1.0)
WPM	41 (2.9)	49 (1.9)	53 (1.6)	53 (0.9)
EPM	40 (5.2)	48 (3.1)	54 (2.1)	53 (1.2)
EM	43 (7.1)	49 (4.6)	56 (2.9)	54 (2.0)

Table 3.4: Prevalence of smoking by income level in women

Age/Ethnicity/ Location/Region	Women			
	Low	**Middle**	**High**	**Total**
30's	6 (1.6)	4 (1.6)	2 (1.7)	5 (1.1)
40's	5 (0.9)	3 (0.9)	5 (1.6)	4 (0.6)
50's	9 (1.0)	3 (1.1)	2 (1.1)	7 (0.7)
60's	10 (1.4)	2 (1.7)	16 (7.5)	10 (0.9)
≥70	14 (3.7)	1 (2.1)	2 (1.7)	9 (2.0)
Malay	5 (2.8)	2 (2.7)	4 (3.8)	3 (0.4)
Chinese	4 (8.1)	12 (3.3)	6 (2.9)	6 (1.1)
Indian	2 (2.8)	3 (2.7)	4 (3.8)	4 (2.6)
Others	15 (1.5)	6 (3.1)	10 (1.3)	10 (1.3)
Urban	7 (0.8)	3 (0.7)	4 (1.0)	4 (0.5)
Rural	9 (0.7)	3 (1.0)	4 (3.8)	6 (0.6)
WPM	4 (1.3)	3 (.8)	8 (.9)	8 (0.5)
EPM	14 (5.3)	3 (1.4)	8 (1.1)	12 (0.8)
EM	2 (1.1)	4 (1.2)	6 (1.0)	5 (0.7)

3.4.6.8 Age-adjusted prevalence of hypertension and income levels

The relationship between hypertension and income was inverse in the age categories of 40's and ≥70 years, but direct in 50's (see Table 3.5 and Table 3.6). The association was clear among women and was inverse in all but the income category of ≥70 years. There was no clear association between hypertension and income ethnically. However, low-income Indian women (70%, SE 12.0) and men (56%, SE 1.7) showed the highest prevalence of hypertension. Men (53%, SE 6.7) and women (41%, SE 6.7) in others category showed the highest prevalence of hypertension among the middle income. Among the high-income, Malay men (38%, SE 2.8) and other women (40%, SE 9.9) showed the highest prevalence of hypertension. Rural men and women showed a higher prevalence of hypertension than urban men and women in all income categories. The association between hypertension and revenue was inverse with urban and rural men, and urban women. Whereas EPM showed the highest prevalence of hypertension among women in all income categories, EPM showed the highest prevalence of hypertension among low-income men. EM had the highest prevalence of hypertension among middle and high-income men.

Table 3.5: Prevalence of hypertension by income level in men

Age/Ethnicity/ Location/Region	Men			
	Low	Middle	High	Total
30’s	20 (3.9)	27 (4.0)	18 (5.8)	25 (2.1)
40’s	38 (2.3)	33 (2.3)	33 (3.8)	37 (1.3)
50’s	39 (2.1)	45 (2.7)	50 (3.7)	47 (1.2)
60’s	60 (2.0)	64 (3.9)	57 (8.3)	59 (1.5)
≥70	68 (3.8)	88 (8.1)	89 (2.0)	69 (2.0)
Malay	45 (1.3)	37 (1.6)	38 (2.8)	37 (0.8)
Chinese	50 (10.0)	43 (6.0)	27 (5.5)	30 (2.2)
Indian	56 (1.7)	32 (7.6)	32 (9.0)	35 (3.8)
Others	51 (2.4)	53 (6.7)	13 (1.2)	23 (1.8)
Urban	48 (2.5)	39 (1.9)	39 (2.5)	44 (1.0)
Rural	49 (1.3)	46 (2.5)	44 (8.4)	52 (1.0)
WPM	36 (2.9)	37 (1.9)	44 (1.6)	42 (0.9)
EPM	47 (5.3)	46 (3.0)	55 (2.1)	54 (1.2)
EM	43 (7.1)	54 (4.6)	57 (2.9)	57 (2.0)

Table 3.6: Prevalence of hypertension by income level in women

Age/Ethnicity/ Location/Region	Women			
	Low	Middle	High	Total
30’s	20 (2.7)	16 (2.9)	8 (3.7)	20 (1.4)
40’s	35 (1.9)	27 (2.2)	22 (2.9)	33 (1.0)
50’s	57 (1.9)	44 (3.0)	32 (3.8)	34 (1.1)
60’s	57 (2.4)	57 (5.4)	56 (10.1)	57 (1.5)
≥70	66 (5.1)	71 (1.8)	76 (2.3)	66 (2.3)
Malay	44 (1.4)	33 (8.0)	26 (7.9)	41 (0.7)
Chinese	43 (10.6)	22 (4.2)	26 (5.4)	30 (1.8)
Indian	70 (12.0)	35 (8.0)	19 (7.9)	37 (3.5)
Others	40 (2.0)	41 (6.7)	40 (2.4)	41 (1.5)
Urban	39 (2.3)	29 (1.8)	25 (2.1)	37 (0.8)
Rural	44 (1.2)	40 (2.7)	42 (9.9)	45 (0.9)
WPM	24 (2.7)	30 (2.0)	40 (1.6)	40 (0.8)
EPM	28 (6.9)	41 (3.7)	49 (2.0)	46 (1.2)
EM	27 (3.6)	32 (2.9)	42 (2.1)	37 (1.3)

3.4.6.9 Age-adjusted prevalence of diabetes and income levels

There was an apparent association between diabetes and income by gender (see Table 3.7 and Table 3.8). However, the relationship between diabetes and income was negative among men in the age category of ≥70, and among women 40’s, 50’s and ≥70. The relationship between diabetes and income was positive among men in the age class of 50’s and 60’s.

Table 3.7: Prevalence of diabetes by income level in men

Age/Ethnicity/ Location/Region	Men			
	Low	Middle	High	Total
30's	11 (3.1)	23 (3.8)	13 (5.1)	22 (1.9)
40's	14 (1.7)	18 (1.9)	16 (3.0)	15 (1.1)
50's	13 (1.5)	20 (2.1)	38 (2.8)	21 (1.0)
60's	17 (1.6)	18 (3.1)	19 (6.5)	18 (1.2)
≥70	13(2.8)	12 (8.1)	11 (1.8)	13 (1.8)
Malay	16 (1.0)	20 (1.3)	17 (2.1)	19 (0.7)
Chinese	12 (6.4)	5 (3.4)	18 (4.4)	6 (1.5)
Indian	11 (1.1)	29 (7.5)	11 (6.0)	20 (3.6)
Others	7 (1.5)	18 (5.1)	12 (1.5)	9 (1.5)
Urban	20 (2.0)	21 (1.6)	18 (1.8)	21 (0.8)
Rural	14 (0.9)	17 (1.8)	25 (7.3)	20 (0.8)
WPM	15 (2.1)	19 (1.5)	15 (1.1)	17 (0.8)
EPM	17 (4.0)	21 (2.5)	13 (1.4)	19 (1.0)
EM	22 (6.0)	17 (3.4)	19 (2.3)	18 (1.6)

There was no clear association between ethnicity and diabetes in all income groups. However, within ethnic origin, Malay men (16%, SE 1.0) and Indian women (18%, SE 9.0) had the highest prevalence of diabetes among the low income. Indian men (29%, SE 7.5) and other women (17%, SE 5.1) had the highest prevalence of diabetes among the middle income. Chinese men (18%, SE 4.4) and other women (20%, SE 2.0) had the highest prevalence of diabetes among the high income. The relationship between the prevalence of diabetes and income was direct among rural men.

Table 3.8: Prevalence of diabetes by income level in women

Age/Ethnicity/ Location/Region	Women			
	Low	Middle	High	Total
30's	8 (1.8)	11 (2.5)	7 (3.3)	10 (1.3)
40's	14 (1.4)	8 (1.3)	6 (1.6)	14 (0.8)
50's	20 (1.4)	15 (2.2)	10 (2.5)	13 (0.8)
60's	16 (1.8)	14 (3.8)	20 (8.2)	19 (1.2)
≥70	15 (3.8)	8 (1.9)	1 (1.9)	10 (1.9)
Malay	16 (9.5)	11 (5.7)	8 (6.4)	10 (0.5)
Chinese	4 (4.3)	4 (2.0)	6 (2.9)	5 (1.0)
Indian	18 (9.0)	14 (5.7)	12 (6.4)	16 (2.7)
Others	11 (1.3)	17 (5.1)	20 (2.0)	12 (1.3)
Urban	18 (1.8)	9 (1.2)	8 (1.3)	14 (0.6)
Rural	14 (0.9)	15 (1.9)	15 (7.2)	19 (0.7)
WPM	7 (1.6)	9 (1.3)	14 (1.2)	16 (0.6)
EPM	14 (5.3)	14 (2.6)	19 (1.4)	18 (1.0)
EM	9 (2.3)	13 (2.1)	19 (1.5)	15 (0.9)

The relationship between prevalence of diabetes and income was inverse in rural women but direct in urban women. Whereas EPM generally showed highest prevalence between low (14%, SE 5.3) and middle (14%, SE 2.6) income women, it had the highest prevalence among middle-income men (21%, SE 2.5).

3.4.6.10 Age-adjusted prevalence of hypercholesterolemia and income levels

The prevalence of hypercholesterolemia increased with income in the age categories of 30's, 50's, 60's and ≥70 years among men and ≥70 (inverse) among women (see Table 3.9 and Table 3.10). Hypercholesterolemia increased with age among middle-income women. However, Indian men (78%, SE 1.4) and women (82%, SE 10.0) showed the highest prevalence of hypercholesterolemia among the low income. Malay men (67%, SE 1.4) and women (63%, SE 8.0) showed the highest prevalence of hypercholesterolemia among the middle income. Other men (88%, SE 1.8) and Malay women (67%, SE 9.7) showed the highest prevalence of hypercholesterolemia among the high income. There was a strong association between hypercholesterolemia and income among rural (direct) and urban (inverse) men.

Table 3.9: Prevalence of hypercholesterolemia by income level in men

Age/Ethnicity/ Location/Region	**Men**			
	Low	**Middle**	**High**	**Total**
30's	49 (4.9)	75 (3.9)	76 (6.5)	68 (2.2)
40's	66 (2.3)	75 (2.1)	73 (3.6)	70 (1.2)
50's	54 (2.0)	75 (2.3)	86 (3.2)	70 (1.1)
60's	66 (2.0)	67 (3.8)	73 (7.4)	67 (1.4)
≥70	61 (4.0)	76 (1.6)	80 (2.1)	61 (2.1)
Malay	63 (1.2)	67 (1.4)	66 (2.4)	64 (0.7)
Chinese	54 (1.0)	64 (5.8)	68 (5.3)	62 (2.1)
Indian	78 (1.4)	58 (8.1)	61 (9.4)	57 (3.9)
Others	37 (2.3)	56 (6.6)	88 (1.8)	45 (1.8)
Urban	76 (2.2)	74 (1.7)	73 (2.3)	68 (1.0)
Rural	61 (1.3)	74 (2.2)	81 (6.5)	67 (0.9)
WPM	73 (2.7)	74 (1.7)	62 (1.5)	67 (0.9)
EPM	77 (4.5)	76 (2.6)	65 (2.0)	68 (1.1)
EM	73 (6.4)	69 (4.2)	71 (2.7)	71 (1.8)

Table 3.10: Prevalence of hypercholesterolemia by income level in women

Age/Ethnicity/ Location/Region	Women			
	Low	Middle	High	Total
30's	53 (3.3)	60 (3.9)	51 (6.6)	60 (1.7)
40's	61 (2.0)	69 (2.3)	62 (3.4)	65 (1.0)
50's	87 (1.7)	76 (2.6)	76 (3.5)	76 (1.0)
60's	73 (2.1)	81 (4.3)	68 (9.5)	75 (1.3)
≥70	70 (4.9)	86 (2.1)	88 (2.0)	74 (2.1)
Malay	75 (9.5)	73 (8.0)	67 (9.7)	73 (0.6)
Chinese	65 (1.2)	63 (4.9)	66 (5.8)	65 (1.8)
Indian	82 (10.0)	65 (3.1)	62 (9.7)	64 (3.5)
Others	46 (2.1)	46 (6.8)	20 (2.0)	52 (1.5)
Urban	75 (2.1)	72 (1.8)	54 (2.3)	71 (0.8)
Rural	65 (1.2)	67 (2.6)	62 (9.7)	66 (0.8)
WPM	63 (3.1)	71 (2.0)	67 (1.6)	70 (0.8)
EPM	51 (7.7)	71 (3.4)	67 (1.9)	68 (1.1)
EM	74 (3.5)	69 (2.9)	66 (2.0)	67 (1.2)

3.4.6.11 Age-adjusted prevalence of overweight/obesity and income levels

The relationship between obesity and income was positive among men in the age categories of 50's and ≥70 (see Table 3.11 and Table 3.12). The relationship between obesity and income among women was positive in the age category of ≥70, and inverse in 50's. Ethnically, Chinese men (27%, SE 8.9) had the highest prevalence of obesity among the low income, while Malay men had the highest prevalence of obesity among the middle (40%, SE 1.6) and high income (43%, SE 2.8).

Table 3.11: Prevalence of overweight/obesity by income level in men

Age/Ethnicity/ Location/Region	Men			
	Low	Middle	High	Total
30's	28 (4.4)	34 (4.2)	29 (6.8)	29 (2.1)
40's	24 (2.1)	42 (2.4)	37 (3.9)	32 (1.3)
50's	24 (1.9)	40 (2.6)	91 (3.7)	32 (1.2)
60's	22 (1.7)	37 (4.0)	30 (7.6)	26 (1.3)
≥70	14 (2.8)	18 (9.5)	33 (3.3)	14 (1.5)
Malay	26 (1.2)	40 (1.6)	43 (2.8)	27 (0.8)
Chinese	27 (8.9)	29 (5.4)	19 (4.5)	20 (1.8)
Indian	22 (1.4)	34 (7.8)	21 (7.9)	30 (3.7)
Others	17 (1.8)	37 (6.4)	38 (1.9)	18 (1.4)
Urban	32 (2.4)	39 (1.9)	38 (2.5)	32 (0.8)
Rural	22 (1.1)	39 (2.4)	31 (7.8)	24 (0.9)
WPM	37 (2.9)	38 (1.9)	23 (1.3)	29 (0.9)
EPM	39 (5.2)	42 (3.0)	23 (1.7)	27 (1.0)
EM	35 (6.9)	39 (4.2)	29 (2.7)	29 (1.8)

Malay women had the highest prevalence of obesity in all income groups. The prevalence of obesity rose with income among Malay and other men, while it declined among Chinese women. Urban men showed a higher prevalence of obesity than rural men in all income categories. Whereas urban women showed a higher prevalence of obesity than rural women among the low- and middle-income, it was the reverse among the high income.

Table 3.12: Prevalence of overweight/obesity by income level in women

Age/Ethnicity/ Location/Region	Women			
	Low	Middle	High	Total
30's	27 (3.0)	32 (3.7)	27 (5.8)	28 (1.5)
40's	39 (2.0)	43 (2.4)	33 (3.3)	37 (1.1)
50's	45 (1.8)	43 (3.0)	31 (3.7)	35 (1.1)
60's	33 (2.2)	42 (5.4)	36 (9.8)	35 (1.4)
≥70	15 (3.8)	29 (1.8)	31 (2.0)	16 (1.7)
Malay	42 (9.5)	36 (8.0)	37 (9.2)	42 (0.7)
Chinese	13 (7.2)	12 (3.3)	9 (3.5)	14 (1.3)
Indian	18 (10.0)	35 (8.0)	31 (9.2)	37 (3.5)
Others	18 (1.6)	26 (6.0)	20 (1.2)	17 (1.2)
Urban	45 (2.4)	42 (2.0)	31 (2.3)	36 (0.8)
Rural	32 (1.1)	39 (2.7)	42 (9.9)	33 (0.8)
WPM	32 (3.0)	42 (2.2)	36 (1.6)	35 (0.8)
EPM	40 (7.5)	39 (3.7)	31 (1.8)	32 (1.1)
EM	29 (3.6)	40 (3.0)	37 (2.0)	36 (1.3)

3.4.6.12 Cardiovascular disease risk factors and income levels

To sum up, there was a positive relationship between diabetes, hypercholesterolemia and overweight or obesity, and income in men. However, the relationship between hypertension, diabetes and hypercholesterolemia, and income in women was negative (see Table 3.13).

Among men and women, the highest prevalence of CVDRF in income categories was hypercholesterolemia by 68 and 69 percent respectively. However, in men the next most prevalent CVDRFs were smoking (53%) and hypertension (48%), whereas in women hypertension (41%) and overweight/obesity (35%) were the next prevalent risk factors (see Table 3.13).

Table 3.13: Prevalence of cardiovascular disease risk factors by income level

	Income level	HBP*	DM¶	HCHOδ	SMKθ	OBSψ
Men	Low	52 (1.2)	15 (0.8)	62 (1.1)	51 (1.2)	21 (1.0)
	Middle	47 (1.5)	19 (1.2)	73 (1.4)	48 (1.5)	38 (1.5)
	High	58 (2.4)	22 (1.8)	78 (2.2)	55 (2.4)	49 (2.5)
	Total	48 (0.7)	21 (0.6)	68 (0.6)	53 (0.7)	29 (0.6)
Women	Low	51 (1.1)	16 (0.8)	73 (1.0)	9 (0.6)	35 (1.1)
	Middle	37 (1.5)	11 (1.0)	73 (1.5)	3 (0.6)	41 (1.7)
	High	29 (2.1)	9 (1.3)	68 (2.3)	5 (1.0)	32 (2.2)
	Total	41 (0.6)	17 (0.5)	69 (0.6)	11 (0.4)	35 (0.5)

Note: * Hypertension (HBP): Mean SBP (Systolic Blood Pressure) ≥ 140 mm Hg or Mean DBP (Diastolic Blood Pressure) ≥ 90 mm Hg or using medication; ¶ Diabetes Mellitus (DM): Mean plasma glucose ≥ 126 mg/dL or 7.0 mmol/Lit; δ Hypercholesterolemia (HCHO): Mean Plasma cholesterol ≥ 5.2 mmol/Lit; θ Smoking (SMK): Smokes at least one cigarette per day; ψ Overweight/Obesity (OBS): BMI ≥25 kg/m^2

3.5 Discussion

The association between risk factors contributing to cardiovascular disease and education level and income categories was clear with smoking status and hypertension, which was in line with studies from developed nations such as Canada (Choiniere *et al.*, 2000; Nair *et al.*, 1988), the United States (Winkleby *et al.*, 1992), England (Huff & Gray, 2001), as well as with a previous study conducted in Malaysia by Rampal *et al.* (2008). A previous report on the status of non-communicable diseases in the world also provided statistics which further endorse our study's findings (WHO, 2010b).

Substantially higher prevalence of smoking was found among men compared to women in all SES levels, which is consistent with the findings from Malaysia (Amiri *et al.*, 2014; Amplavanar *et al.*, 2010; Cheah & Naidu, 2012; Tan *et al.*, 2009; WHO, 2010b, p. 42) and developed countries (Choiniere *et al.*, 2000; Winkleby *et al.*, 1992).

We found the highest smoking prevalence in all education groups among Malay men that is in line with previous findings from Malaysia (Rampal *et al.*, 2008). In addition, in all income groups more men smoked than women in all age categories, ethnic/race groups, and all residential locations. Except respondents in their 50's and 70 and above, the relationship between income and smoking was inverse in men, which indicates that people in higher SES categories may be more aware of the disadvantages of tobacco smoking (Cheah & Naidu, 2012; Tan *et al.*, 2009)

We diagnosed a direct association between ageing and hypertension in all education groups in Malaysian women, but in Malaysian men, it was positive among university, secondary, and primary educated respondents. These findings were in line with results from a previous study conducted in Malaysia by Rampal *et al.* (2008). In addition, in both genders the highest prevalence of hypertension risk factor was among respondents without education level followed by primary educated, which is in corroboration with previous findings in Malaysia (Rampal *et al.*, 2008; WHO, 2010b, p. 42).

The association of age and hypertension was also increasing in both men and women in all income groups (Amiri *et al.*, 2014). Although a past study in Malaysia found an inverse association between hypertension status and education level (Rampal *et al.*, 2008), we found no association between them, which nonetheless is consistent with some studies from other countries (Tomiak & Gentleman, 1992). Past studies on Malaysians used different age intervals, however we found the relationship between hypertension and income by gender to be negative in the age categories of 40's but was positive in 50's and 70 year old and above.

In addition, diabetes was inversely associated with education and income levels demonstrating that the risk factor can be reduced by improving socioeconomic status (Choiniere *et al.*, 2000; Winkleby *et al.*, 1992). WHO (2010b, p. 43) showed that in

Malaysia the relationship between diabetes and education level was inverse among women, while in men the association of diabetes and income level was inverse, but the middle income women and medium level educated men had lowest prevalence of diabetes rates.

However, our results indicate no apparent association between diabetes and education, while our study shows a positive association between diabetes and income level in age groups of 50's, 60's, and a negative association in age group of 70 year old and above.

Past findings on the association of hypercholesterolemia and education in both genders varied significantly (Choiniere *et al.*, 2000; Nair *et al.*, 1988; Winkleby *et al.*, 1992). However, we found no clear relationship between hypercholesterolemia and education in both genders the developing country of Malaysia. Having classified respondents into their ethnic/race groups, we diagnosed that among Malay, Chinese, and Indian women the association of hypercholesterolemia and education was negative, but it was positive among Chinese and others ethnic groups for men. These findings were in line with previous findings from Singapore and Malaysia (Cutter *et al.*, 2001; Liew *et al.*, 1997).

Moreover, in a past study in Malaysia, where any significant association between hypercholesterolemia and income level was indistinguishable (WHO, 2010b, p. 43), our findings show that the prevalence of hypercholesterolemia is increasing with income in the age groups of 30's, 50's, 60's, and 70 years and above among women.

Our finding about an inverse association between education level and overweight/obese was in line with previous literature (Chee *et al.*, 2004; Ismail & Vickneswary, 1999; Sidik & Rampal, 2009; Tan *et al.*, 2012). Except primary educated respondents, Malays had the highest prevalence of being overweight/obese among men (Cutter *et al.*, 2001; Sidik & Rampal, 2009). In addition, the relationship between being overweight and income was positive among men in age category of 70 and above, which does not support some of the findings in Malaysia (Chee *et al.*, 2004; Sidik & Rampal, 2009; Tan *et al.*, 2012).

The likelihood of obesity increased with income in men but decreased in women. Malay men showed the highest prevalence of hypercholesterolemia, while Malay women had the highest prevalence of obesity in all income categories, demonstrating the need to review the diet of Malays. The prevalence of diabetes in EPM was higher than WPM and EM in all education levels, and among men and women, which confirms that residents from EPM must reduce their consumption of sugar. Rural respondents smoked more than urban respondents in all education and income categories demonstrating that awareness creation programs must be targeted at rural areas.

To sum up, there was a positive relationship between being overweight/obese, diabetic, and hypercholesterolemic and income categories in men. These findings do not support pas findings in Malaysia where diabetes and income was inversely related, while the middle income level had the highest hypercholesterolemia prevalence (WHO, 2010b, pp. 42-43). In women, the association between hypercholesterolemia and hypertension and income was inverse which is consistent with past studies in developing and developed nations (Choiniere *et al.*, 2000; Nair *et al.*, 1988; Tomiak & Gentleman, 1992; WHO, 2010b; Winkleby *et al.*, 1992). However, there was no clear association between the remaining CVD risk factors, and education and income.

CHAPTER 4

ROLE OF SOCIOECONOMIC STATUS IN PREDICTION OF CARDIOVASCULAR DISEASE RISK

4.1 Introduction

When Robert Beaglehole, a pioneer in researching cardiovascular disease in developing countries, was writing his highly cited paper '*Cardiovascular disease in developing countries'* (Beaglehole, 1992), he wrote the current prevalence statistics for mortality as follows:

> *"Cardiovascular diseases account for about one quarter of all deaths worldwide. In developed countries about half of all deaths are due to cardiovascular disease (principally coronary heart disease and stroke), and the epidemic is being at least partially prevented in some of these. In developing countries, the proportion of deaths due to cardiovascular disease is estimated to be about 15%, but with wide variations. The total number of deaths due to cardiovascular disease, however, is thought to be at least as great as in developed countries as about 80% of all deaths occur in developing countries."*

However reviewing the most recent statistics of CVD-related deaths from WHO (2010a), it can be easily distinguished that all statistics of deaths have been increased dramatically. For instance, statistics show that nearly two-third (i.e., 36 million deaths out of 57 million deaths) of the overall deaths occurred in developing and less developed countries around the world. In addition, CVD-related deaths alone were accounted for 48 percent of all NCD related deaths making it the number one killer worldwide. The figure for low- and middle-income countries (LMCs) was over 80 percent for CVD and diabetes combined. However, people who were under 70 years of age suffered the largest amount of deaths due to CVD (39%) and diabetes (4%). Older people indeed suffer more from NCDs especially CVD and diabetes. That is why population ageing, population growth and improved longevity in developing countries contribute to the higher prevalence and incidents of CVD, diabetes, and overall to NCDs.

WHO (2010a) has estimated that as people age, the annual NCD deaths worldwide will reach 52 million by 2030. Specifically, CVD related deaths will increase by 6 million and cancer will increase by 4 million. However, "in LMCs the NCDs will be responsible for three times as many disability adjusted life years (DALYs) and nearly five times as many deaths as communicable diseases, maternal, perinatal, and nutritional conditions combined in the next two decades." (WHO, 2008, 2010a)

Nonetheless, it is predicted that these figures will be even worse in the following two decades (WHO, 2010a). The prediction of NCD related deaths by 2030 is that firstly it is going to be the first cause of deaths in developing countries accounting for nearly 75% of all deaths. Therefore, in light of the aforementioned concerns it is vital to predict the future risk of diseases especially CVDs.

The objective measures of SES (i.e., education level, income level, and occupational status) association with the cardiovascular disease risk has studied in developed context (Fiscella & Holt, 2008; Fiscella *et al.*, 2009). To our best of knowledge, however, no previous research analyzed the relationship of the sociodemographic, geographic location, and SES and the CVD risk in developing countries. Therefore, we try to fill this gap in this chapter.

In this chapter, a literature review regarding the cardiovascular risk prediction models have been presented. Then, the methodologies that were used to estimate the ten-year CVD risk and to diagnose the possible sociodemographic, geographic location, and SES associates were discussed. Finally, results obtained from the analysis were presented and discussed accordingly.

4.2 Theoretical considerations

Cardiovascular diseases have been ranked the leading cause of deaths and disabilities in developed nations as well as in developing countries (Yusuf *et al.*, 2014). Many risk factors are responsible for CVDs, naming the most important ones: high blood pressure, diabetes mellitus, dyslipidaemia or high blood cholesterol. However, social status (also known as socioeconomic position, socioeconomic status [SES], and social class) have been shown to be an important role player in forming CVDs (Fiscella *et al.*, 2000; Fiscella *et al.*, 2009). People from different SES levels tend to experience cardiovascular (CV) health differently. For instance, individuals who are from lower SES levels have more than just one risk factors contributing to CVD that results in a multiplicative effect on emergence of CVDs like myocardial infarction (MI) or stroke (Chia, 2011).

In recent decades as the CVD related mortality and morbidity rates have increased drastically, researchers as well as health policy makers urgently have tried to estimate the CVD risk in different populations so that they know that all of modestly elevated risk factors need to be treated with lifestyle modifications, non-pharmacological or pharmacological therapies, and/or socioeconomic interventions (Chia, 2011).

As a matter of fact, estimation of future risk of coronary heart disease or cardiovascular disease (CHD/CVD) based on current known risk factors as well as social class in crucial. Because, it indicates the individuals get benefitted from the interventions or preventive policies. This will enlighten the aims to save more lives and assist the more socially and economically deprived/disadvantaged people living in the societies (Chia, 2011). Having said that, this diagnosis will address the risk-benefit ratio and in the meantime recognizes those at higher risk of CVD to be immediately intervened. In addition, this process prevents turning a healthy individual to an 'ill' person just his/her exposure to a single mild CVDRF (Chia, 2011).

Nevertheless, of important reasons for estimation of CVDR is that it can tailor policies by government so that they can calibrate the intensity and direction of the preventive interventions, and even if none existed create one. The followings are the intervention types which have been proven to tackle some of the CVD contributing risk factors: dietary advice, promotions and education on physical activity, pharmacological (i.e., drug) intervention on people at higher risk of CVD and in lower SES levels (Chia, 2011).

A previous study showed that considering age, gender, hypertension and smoking status, being diabetic/non-diabetic alone can predict 85% of the risk for CHD (Yusuf *et al.*, 2004a). In addition, history of premature heart disease as well is proven to increase risk by 50%. However, this risk factor is not included in any of the CHD/CVD risk estimation models (Chia, 2011). Nonetheless, many important novel CVDRFs such as obesity/metabolic syndrome, physical inactivity, arterial fibrillation, left ventricular hypertrophy, pulse rate, as well as social deprivation and SES level have been proven to have caused CVDs (Chia, 2011).

The important question here is that what should be taken into account for risk estimation of CHD/CVD? Replying to this question, I have reviewed the most internationally well-known risk scoring algorithms such as Framingham Risk Scoring (FRS) model for CHD (Wilson *et al.*, 1998), Framingham General CVDR profile prediction (D'Agostino *et al.*, 2008), QRISK I and QRISK II (Hippisley-Cox *et al.*, 2007; Hippisley-Cox *et al.*, 2008), and PROCAM (Assmann *et al.*, 2002). Indeed, other risk scoring methods exist, but they are out of the scope of this study.

In the following section, we reviewed the literature regarding the commonly used and widely validate risk scoring algorithms from across the globe.

4.2.1 Framingham risk scoring model

The Framingham Risk Scoring (FRS) algorithm is a highly internationally well-known and validated model including predictions of both fatal and non-fatal (i.e., mortality and morbidity) coronary heart events (Wilson *et al.*, 1998). In 2008, the original FRS was modified by D'Agostino *et al.* (2008) including not only cardiac events, but also stroke both fatal and non-fatal.

National Heart Institute (which is now known as the National Heart Lung and Blood Institute) founded the Framingham study in 1948 (D'Agostino *et al.*, 2001). The city of Framingham is located in Massachusetts USA where people are known to be stable and the rate of migration to be very low. Therefore, this population has been considered for the study sample in order to identify the common factors contributing to CVD by following its development in long-term.

This algorithm includes coronary heart diseases or cerebrovascular incidents. However, the participants must be free from CHD/CVD. The first study sample in 1948 was enrolled. Since then medical history of participants, various physical examinations and medical tests were conducted every couple of years. The Offspring Cohort was conducted in 1975 of the second generation of the original participants of the FRS. This sample comprised of 5,124 adult offsprings. In 2002, the third generation who were the third generation of the original participants were enrolled to study the history and the genetic factors of CVD (Chia, 2011).

This study was conducted in United States of America to address the increasing mortalities and morbidity rates from CVD which became and epidemic in the country. By the time, very little was known about the causal effects of different risk factors to heart diseases and stroke. This study provided so much information which is available to the public as well as to the researchers. Now, we have so much information about the risk factors contributing to CHD/CVD because of this study. The original cohort of this study has the following characteristics: 1. Total number of participants were 5,345 (46.5% men); 2. The participants were aged 30 to 74 years; 3. The data was collected between 1971 and 1974; 4. The follow up was for 12 years; 5. Participants who has CHD were excluded from the study; 6. All the clinical history of CHD were reviewed; 7. Two independent researchers validated the CHD events in the participants.

This scoring method included age, gender, SBP, HDL-C, TC, and diabetes status. The outcome of this study was presented in charts which predicted CHD, including fata and non-fatal MI as well as angina and coronary insufficiencies (Wilson *et al.*, 1998). Separate charts were developed for TC as well as for LDL-C. In addition, scoring charts were developed for men and women separately.

Alike many other studies, this study has limitations. First, the small number of participants and then the predominance of the white population and the small number of events (383 in men and 227 in women). The exclusion of family history of CHD and BMI, and not considering the treatment for hypertension were other weaknesses of this study. However, this study has its strengths as well. It was one the first pioneer studies considering a prospective nature which was conducted at a single centre and a similar study protocol throughout the follow-ups. Moreover, the frequency of two years examination as well as the validation and adjudication of events by specialists were among strengths of this study. However, the greatest strength of FRS was that it was 1971 and 1986 which was contemporary to the fact that the majority of patients were not on any medication for hypertension. This is due to the fact that until 1980 there was no calcium channel blocker, until 1981 there was no lovastatin, and until 1987 there was no statin drugs (Chia, 2011). However, since 32.6% of the FRS participants had hypertension only 6.8% were on treatment. Therefore, it is ignorable that the majority of respondents were not on any active treatment. This active treatment could lower the risk level. So, it could deteriorate the risk scoring prediction level, which could result in altering the intervention indications for policy making management.

Recent risk estimation algorithms, like QRISK, considered patients who were on treatment as well. Thus, comparing FRS to these risk prediction models identifies a natural over-prediction of risk in patients who are already on treatment.

Despite all these limitations, the FRS has been validated in various populations around the world. For instance, in U.S. (D'Agostino *et al.*, 2001), Australia (Zomer *et al.*, 2011), China (Liu *et al.*, 2004b), European countries (Empana *et al.*, 2003), as well as in several other countries including Malaysia (Chia *et al.*, 2015; Chia *et al.*, 2012; Ng & Chia, 2008).

Yet, considering all these limitations it has been found that this model performs well in populations with similar CHD/CVD rates such as Caucasians, African-Americans, and Koreans (Chia, 2011). However, this risk scoring model has been suggested that it overestimates risk in contemporary Northern Europeans by 50% (Menotti *et al.*, 2000), as well as in British men (Brindle *et al.*, 2003), and Chinese population (Liu *et al.*, 2004b).

Nevertheless, a recent FRS algorithm was developed to include several CVD risk profiles to be used in primary care by D'Agostino *et al.* (2008). It used the same methodology but included the data from 1968 to 1987, including the data for the Offspring Cohort. The number of participants, therefore, was over 8000. This algorithm also counted for treated or untreated blood pressure. This model is also validation in various populations (Majed *et al.*, 2013; Zomer *et al.*, 2011).

4.2.2 Prospective cardiovascular Munster (PROCAM score)

This scoring (also referred as Munster score) was developed in the city of Munster, Germany. The data of about twenty thousand people aged from 16 to 65 years old from the year 1975 to 1985 was collected. The original score, however, was developed on 5,389 men from the population. In total, 325 CHD events which was even fewer than those among FRS was diagnosed.

Likewise FRS, this scoring method only included CHD mortality and morbidity. As women were not included in this scoring algorithm, it was been suggested that the score for women must be multiplied by a factor of 1.2 for that of men (Assmann *et al.*, 2002).

However, this scoring method had its own advantage as it included the history of CHD and triglyceride in the scoring. This scoring method has been recently by including the MI and stroke to increase its accuracy (Assmann *et al.*, 2007).

4.2.3 QRISK I and QRISK II

QRISK I was developed in UK (Hippisley-Cox *et al.*, 2007). The total number participants in this risk estimation model was about 1.3 million people whose data were collected from 1997 to 2007. Patients were aged 35 to 74 years and were free of CVD as well as diabetes. This study was validated using more than six hundred thousand participants. In this model, age, gender, smoking status, blood pressure, total and HDL cholesterol, family history of CHD in first degree relatives, area of deprivation, and treatments with anti-hypertensive agents, and BMI were also included. This scoring model predicts both fatal and non-fatal CVD, i.e., MI, stroke, CHD, and transient ischemic attacks (Hippisley-Cox *et al.*, 2007).

Using various scoring methods has illustrated that FRS over-predicts the risk by 35% while QRISK only over-estimates by only 0.4% (Chia, 2011). However, the QRISK also under-predicts risk among 12% of the cohort sample. The limitations of QRISK were that about 75% of the sample had one or more missing values which were arbitrarily calculated and imputed in the data. This questions the robustness of the model for estimation of the results. In addition, only about 30% of the participants had their serum cholesterol levels measured, and only after 2003 the HDL measurements became available. Another limitations of this model were as follows: 1) The events were not diagnosed by doctors; 2) Participants were included in the sample at different times; 3) Not all sample participants were followed up; 4) Comparing to FRS, the median follow up was relatively short; 5) Only about 23% of the patients had been followed up for ten years; 6) This scoring method has not been validated in any population except for British.

The QRISK II (Hippisley-Cox *et al.*, 2008) was the next generation of QRISK I. It followed the same protocol as QRISK I. It included England and Wales, and a population of 2.3 million individuals aged 35 to 74 were collected during 1993 to 2008. This study was also not been validated in other countries than Britain.

4.2.4 Desirable risk estimation method in Malaysia

It is more desirable to have a risk scoring model for each population. However as this practice is very costly and time consuming, it is reasonable to use the current known studies from other countries which is already validated or calibrated in the target population (Chia, 2011).

As this study's population is a representative population from urban and rural areas of Malaysia, I used FRS to estimate the cardiovascular risk as this scoring method has been shown to be reliable in Malaysia (Chia *et al.*, 2015; Chia *et al.*, 2012; Ng & Chia, 2008). These studies have validated the FRS algorithm in a Malaysian sample providing a reliable tool for primary care practices and public health researchers in Malaysia to use it with confidence. Therefore, in this study I will use this scoring method to evaluate the risk of cardiovascular disease.

In addition, the Asia Pacific Cohort Studies Collaboration showed that the calibrated FRS model predicts the CVD risk with similar precision in Asian populations comparing to tools developed from local cohorts (Asia Pacific Cohort Studies Collaboration *et al.*, 2007). Therefore, while a local CVD risk estimation algorithm is not available it is worthy to use this risk scoring method for local patients to have a good prediction of the patients' future status of cardiovascular health (Chia, 2011). In conclusion, it is important to use a model that one is more familiar with and to use it correctly and in the right context and population. In addition, not using any of the risk estimation models may result in overlooking low risk patient and therefore intervention opportunities to prevent future incidents of CHD/CVD.

To our knowledge, the ten-year CVD risk has never been predicted in a nationally representative population of Malaysia and even in South East Asia region. In order to fill this information gap, we predicted the ten-year CVD risk profile of Malaysians with respect to different demographic and socioeconomic variables as well as regional and location indicators.

4.2.5 Socioeconomic status and cardiovascular risk

Reducing health disparities has already been triggered in developed nations (Fiscella *et al.*, 2000; Fiscella *et al.*, 2009). Much of the disparities in life expectancies, which has been increasing with the level of social class, is attributable to mortalities due to CVDs and CHDs among lower SES individuals (Fiscella *et al.*, 2009). Several factors contribute to CHD/CVD related mortalities. For instance, early life environment/community and material disadvantage (Claussen *et al.*, 2003), behavioural or social risk factors contributing to CHD/CVD (Lynch *et al.*, 1996), access to healthcare facilities (Federman *et al.*, 2001), and especially underestimation of CHD/CVD risk among people with lower SES level (Fiscella & Tancredi, 2008). Thus, it is extremely crucial to address the SES importance in CHD/CVD risk.

Many of the internationally well-known risk estimation algorithms do not account for social class which may broadens the SES related health disparities (Fiscella & Tancredi, 2008). If the cardiovascular risk is properly estimated, the lower SES people will enjoy the targeted interventional studies such as increased statin use for cholesterol reduction and aspirin use for CHD/CVD prevention (Fiscella & Tancredi, 2008; Fiscella *et al.*, 2009). This act will ultimately reduce the health disparities among the poor and lower SES people.

Apart from the generally well-known risk factors contributing to CHD/CVD (i.e., age, gender, smoking, diabetes mellitus, high blood pressure), socioeconomic level also is inversely associated with risk of CHD/CVD (Fiscella & Franks, 2004). This social class disadvantage contributes separately to the health of individuals (Fiscella & Franks, 2004). Low educational attainment's contribution to risk of CHD is almost incomparable to that of high cholesterol level (Fiscella & Franks, 2004). These results suggest that risk scoring models such as FRS underestimates the risk for people with lower socioeconomic positions (Fiscella *et al.*, 2009).

The underlying association between social class gradient and CVD is complicated but several biomedical, psychosocial, and behavioural risk factors certainly mediate this relationship (Fiscella *et al.*, 2009). A previous study (Shishehbor *et al.*, 2006) showed that certain physiological malfunctions (e.g., impaired functional exercise capacity and abnormal heart rate recovery) are associated with low SES that account for major proportion of the relationship between lower SES and increase mortalities. In addition, evidence endorses the link between chronic psychosocial stress with low SES level that exacerbates the events of CHD/CVD and atherosclerosis (Marmot *et al.*, 1997). More importantly, lower SES people tend to have more behavioural risk factors such as smoking tobacco and alcohol drinking (Cheah *et al.*, 2011; Fiscella & Tancredi, 2008).

However, the magnitude of each social class level and risk of cardiovascular disease in developing world has never been studies. Having had no evidence to tackle risk of CHD/CVD among lower SES individuals would cause greater barriers for interventions or therapeutic, lifestyle education or lifestyle prescription, behavioural education among deprived people. Therefore, decreasing health disparities among lower SES people seem impossible if the SES and CVD/CHD risk association remain undiagnosed.

To address this gap in developing countries, I firstly evaluated the general risk of CHD/CVD among a Malaysian representative population. Then, by classifying individuals based on their educational attainment, income level, and occupational status I will try to diagnose higher risk of CVD/CHD among the more deprive individuals in this study's sample.

4.3 Methodology

4.3.1 Prediction of risk

There are two types of sex-specific multivariable risk prediction models. The first model is known as classic Framingham Risk Scoring (FRS) model by using laboratory based CVD risk predictors (Wilson *et al.*, 1998). Wilson *et al.* (1998) presented a simplified prediction model incorporating blood pressure (BP), total cholesterol (TC) or low density lipoprotein cholesterol (LDL-C) categories proposed by the JNC-V and NCEP ATP II (Grundy *et al.*, 1993; Joint National Committee, 1993). Their algorithm (model) has been highly validated internationally in the U.S. (D'Agostino *et al.*, 2001), Spain (Buitrago *et al.*, 2011; Marrugat *et al.*, 2014), Australia (Zomer *et al.*, 2011), and China (Liu *et al.*, 2004a) as well as in Malaysia (Chia *et al.*, 2015; Chia *et al.*, 2012).

4.3.2 Procedure

4.3.2.1 Variables

The FRS model uses BP (mm Hg), TC (mmol/l) or LDL-C (mmol/l) to evaluate the risk of the cardiovascular disease in ten years. In this model, treatment for high BP (hypertension) and therapy for high blood cholesterol (hypercholesterolemia) were not included. However in a modified prediction model, D'Agostino *et al.* (2008) incorporated treatments for high BP and diabetes. Yet this algorithm needs further validations in Asia and especially in Malaysia.

4.3.2.2 Risk estimation

To illustrate the method, several definitions were taken into consideration. Smokers were persons who smoked regularly during the past year. The body mass index was calculated as weight (kg) over squared height (m^2). The average of two BP measurements in a sitting position and a 5-min interval were considered for the analysis. Categorization for the hypertension risk factor was according to JNC-V classification (Joint National Committee, 1993). The categorization were as follows:

- Optimal: SBP <120 mm Hg and DBP <80 mm Hg
- Normal BP: SBP 120-129 mm Hg and DBP 80-84 mm Hg
- High normal BP: SBP 130-139 mm Hg and DBP 85-89 mm Hg
- Stage I hypertension: SBP 140-159 mm Hg and DBP 90-99 mm Hg
- Stage II-IV hypertension: SBP ≥160 mm Hg and DBP ≥100 mm Hg

Note here that when SBP or DBP falls in a different category, the higher category was considered. The person was diabetic if he was under treatment or if the blood glucose exceeded 150 mg/dl. The considered cutoffs for TC, LDL-C, and HDL-C were: TC (<200, 200-239, 240-279, ≥280 mg/dl), LDL-C (<130, 130-159, ≥160 mg/dl), and HDL-C (<35, 35-59, ≥60 mg/dl). This risk estimation model followed subjects for a 12-year period and the development of the following diseases were noted: angina pectoris, recognized and unrecognized myocardial infarction, coronary insufficiencies, and the deaths due to coronary heart diseases.

4.3.2.3 Statistical methods

To estimate the risk of coronary heart disease, age-adjusted linear or logistic regressions were used to evaluate the existence of trends across BP, TC, LDL-C classifications (Neter *et al.*, 1996). Furthermore, Wilson *et al.* (1998) incorporated the age-adjusted Cox-proportional hazards models and subsequent C-statistics to identify the associations existed between variables and outcomes. Using the results from the aforementioned regressions provided separate gender specific scoring sheet (see Appendix 1A and Appendix 1B).

4.3.2.4 Calculation of the risk

Using the gender separated charts (Appendix 1A for men and Appendix 1B for women), the points for age, LDL-C or TC, HDL-C, BP, diabetes, and smoking status must be summed up. Then, based on the calculated points the ten-year risk can be obtained using Step 8 of the Appendix 1. The risk was classified as low (≤6 %), moderate (7 to 20 %), and high (>20 %) (D'Agostino *et al.*, 2008).

4.3.3 Statistical methods to assess the predicted risk

We calculated the mean and median of the predicted ten-year risk of CVD based on all sociodemographic, residential location and region, and socioeconomic variables. Since the assessed ten-year risk was not normally distributed, we employed non-parametric tests such as Kruskal-Wallis K (i.e. ANOVA equivalent for non-normally distributed data) to evaluate whether there is significant difference between categorical variables and continuous outcomes ($p < 0.05$). All statistical analyzes were done by Stata v11.2 (Stata Corp., USA).

4.4 Results

4.4.1 Predicted cardiovascular disease risk by sociodemographic variables

The mean (SD) of the ten-year CVD risk profile are illustrated in Figure 4.1. The CVD risk increased by age; males had more risk comparing to females; Malays had the highest ten-year risk comparing to other ethnic groups. The other marital status and married individuals were at peak of CVD risk profiles.

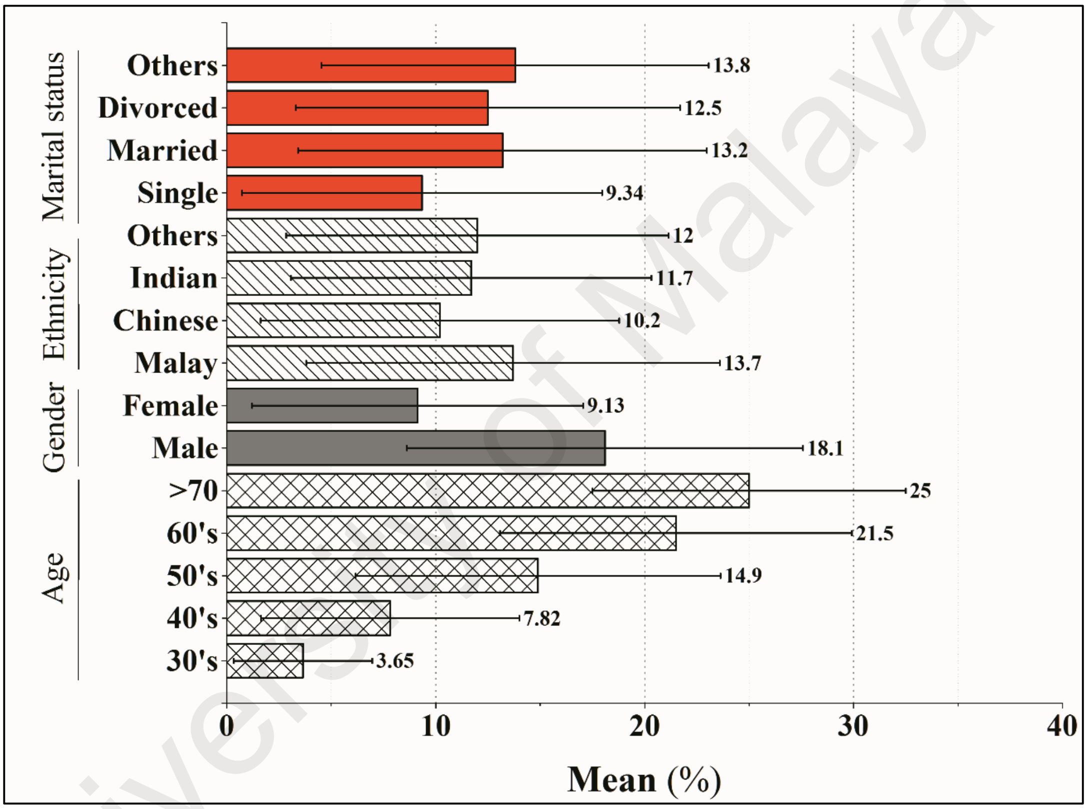

Figure 4.1: Average of cardiovascular disease risk by demographic variables

4.4.2 Predicted cardiovascular disease risk by location and region

Figure 4.2 shows the mean of cardiovascular disease risk by residential area and region. It is obvious that rural areas have greater average of the predicted risk comparing to the urban areas, while regionally the EPM region has the highest predicted CVD risk comparing to the WPM and EM.

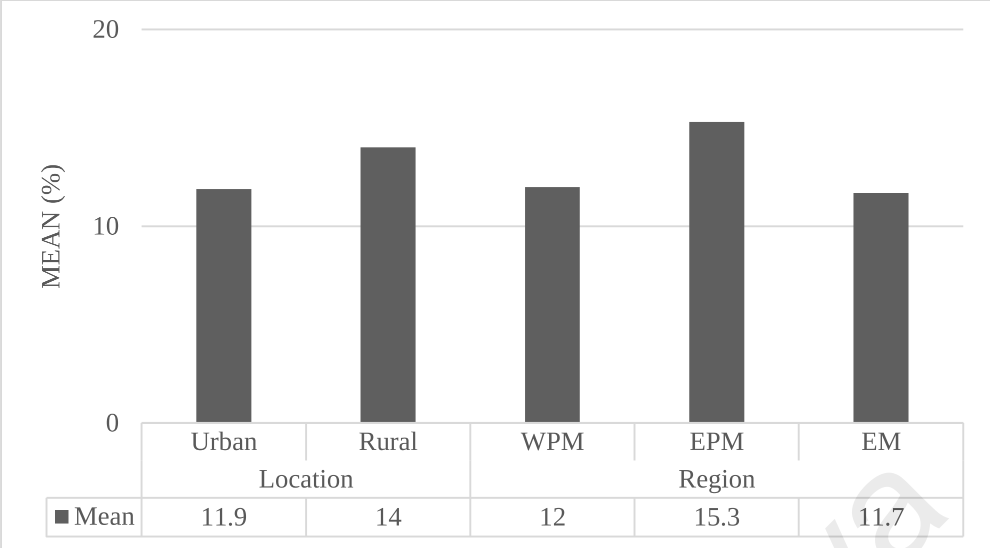

Figure 4.2: Cardiovascular disease risk average by location and region

4.4.3 Predicted cardiovascular disease risk by socioeconomic status

There is an inverse association between the predicted cardiovascular risk and income level (see Figure 4.3). The low income respondents have the highest level of the predicted cardiovascular risk (14.6%) followed by middle income participants (12.5%) and high income individuals (10.3%).

Although there was no vivid trend of the predicted cardiovascular disease risk and the education level, it is obvious that respondents with lower educational levels (i.e., uneducated and primary educated respondents) have higher average of the predicted risk comparing to participants who had higher educational levels (i.e., secondary, technical and university educated respondents).

Among occupations, respondents who have elementary education levels have the highest level of cardiovascular disease risk (16.6%), while individuals who have a professional level occupation have the lowest predicted risk (10.2%). Note here that skilled professionals (14.0%) had the second highest level of the predicted cardiovascular disease risk, whereas homemakers have the second lowest rank among all occupational statuses (11.6%).

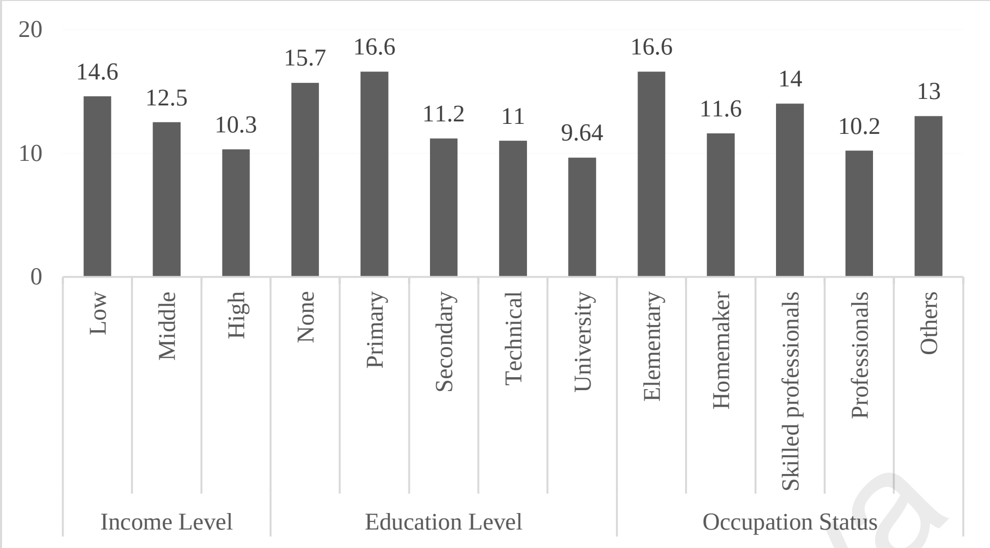

Figure 4.3: Cardiovascular disease risk average by socioeconomic status

4.4.4 Predicted cardiovascular disease median by sociodemographic variables

To further elaborate skewed data of the cardiovascular risk, we incorporated the median (Interquartile range: IQR — 25th to 75th percentile) in Table 4.1. Results indicate that there is a direct association between median of the predicted cardiovascular risk and age. Respondents in lower age categories have lower median of the predicted cardiovascular disease risk, while respondents in higher age categories have higher median of cardiovascular disease risk. In addition, while males (Median: 18.4; IQR: 20) have higher median of risk comparing to females (6.6; 8.4), Malays (11.2; 16.3) have the greatest median of the ten-year cardiovascular disease risk. In marital status variable, respondents who are single have the least predicted risk (5.3; 9.9), whereas respondents in others marital status have the highest 10-year CVD risk (11.7; 15.2).

Table 4.1: Cardiovascular disease risk median by demographic variables

Variables	Categories	Median	IQR[2]	KW[3]	Prob.
Age	30's	2.8	3.2	3567.2	<0.001
	40's	5.6	6.7		
	50's	13.2	14.3		
	60's	24.8	16.3		
	≥70	30	8.5		
Gender	Male	18.4	20	1758.1	<0.001
	Female	6.3	8.4		
Ethnicity	Malay	11.2	16.3	80.8	<0.001
	Chinese	7.3	12.3		
	Indian	10	11.1		
	Others	9.4	13.9		
Marital Status	Single	5.3	9.9	37.1	<0.001
	Married	10	16.8		
	Divorced	10	14		
	Others	11.7	15.2		

4.4.5 Predicted cardiovascular disease median by location and region

In Table 4.2, the cardiovascular disease risk median by residential location and region is presented. The respondents residing in rural areas (11.2; 16.3) have greater median risk of cardiovascular disease comparing to respondents who are dwelling in urban areas (8.6; 13.9). Whereas WPM (8.6; 14.5) and EM (8.6; 11.1) have an equal median of the predicted cardiovascular disease risk, the EPM (13.2; 19.0) have the highest median of CVD risk among all regional breakdowns.

Table 4.2: Cardiovascular disease risk median by location and region

Variables	Categories	Median	IQR[2]	KW[3]	Prob.
Location	Urban	8.6	13.9	91.5	<0.001
	Rural	11.2	16.3		
Region	WPM	8.6	14.5	222.6	<0.001
	EPM	13.2	19		
	EM	8.6	11.1		

4.4.6 Predicted cardiovascular disease median by socioeconomic status

Table 4.3 illustrates the median of cardiovascular disease by SES variables. Respondent who have lower SES have greater median of CVD risk. For instance, low income respondents have the greatest risk (11.7; 19.5), whereas high income respondents have the lowest level of the 10-year risk (7.3; 11.7).

Although there is no apparent trend in educational level and median of cardiovascular disease risk, but respondents in lower educational levels (i.e., uneducated and primary educational levels) have higher medians of cardiovascular disease risk in a decade from now. In addition, while the university educated individuals have the lowest CVD risk (6.7; 9.9), the primary education respondents have the highest CVD risk (15.6; 21.2).

Among occupational status categories, the professional respondents have the least risk (7.3; 12.3), whereas individuals who have elementary occupations have the highest level of CVD risk in ten years (15.6; 20.6).

Table 4.3: Cardiovascular disease risk median by socioeconomic status

Variables	**Categories**	**Median**	**IQR²**	**KW³**	**Prob.**
Income Level	Low	11.7	19.5	184.8	<0.001
	Middle	9.4	14		
	High	7.3	11.7		
Education Level	None	13.7	17.5	699.6	<0.001
	Primary	15.6	21.2		
	Secondary	7.9	11.7		
	Technical	9.4	11.1		
	University	6.7	9.9		
Occupation Status	Elementary	15.6	20.6	435.8	<0.001
	Homemaker	8.6	14.6		
	Skilled professionals	11.2	16.3		
	Professionals	7.3	12.3		
	Others	10	17.1		

In summary, the lower levels of income and education level had the highest average and median of 10-year CVD risk in Malaysia. Finally, the elementary occupations had the highest level of the predicted CVD risk in our population of Malaysians.

4.5 Discussion

We predicted the burden of ten-year risk of CVD among Malaysian citizens and identified the demographic and socioeconomic trends of it. Our results generally tallied with previous findings where older respondents and males were at higher risk of CVD in the next decade (Lyngbaek *et al.*, 2013; O'Donnell & Elosua, 2008). However, in our study we found a contradictory outcome of predicted CVD risk in different marital statuses. In a previous study, the singles and widows had the highest CVD risk while based on descriptive results we found married respondents had highest median of predicted CVD risk (Maselko *et al.*, 2009). It would be due to cultural variation that never married adults or divorce in South East Asian region lived with the family and secured social and emotional protection compared to western societies.

Our findings of the predicted risk of CVD contradicts with findings of the INTERHEART study, which included 52 countries, concluding that the prevalence and risk of CVDs in urban areas are higher (Yusuf *et al.*, 2004a). We found a higher risk of CVD in rural areas comparing to the urban areas. However, our scoring results were lower comparing to a study conducted in semi-rural areas, i.e., our study showed 18.1% and 9.1% for men and women respectively while they illustrated 55.8% and 15.1% for men and women respectively (Chin & Pengal, 2009). That study in semirural areas included a higher percentage of elderly respondents and the mean age of study participants was 65.4 (SD 8.0) years. The average age of our study participants was 51.9 (SD 9.9) years which shows a significantly younger population comparing to the reported statistics in semi-rural areas of Malaysia. The gap between mean ages explained why CVD risk predicted in our study was lower than the previous study.

In addition, our study illustrated that elementary occupations, which seek no significant education, played a significant role in protection of CVD (Gregory *et al.*, 2007; Winkleby *et al.*, 1992). Individuals with elementary occupations had a higher risk of CVD compared to the rest of occupation types. Generally, paid-employees (e.g. skilled professionals and professionals) are occupied full-time position and have secured regular income either in private or governmental sectors. Hence, occupational status is a significant determinant of CVD risk in Malaysia, too and it was approved in several previous studies (Gregory *et* *al.*, 2007; Kivimaki *et al.*, 2002; Kivimaki *et al.*, 2012; Macleod *et al.*, 2005; Winkleby *et al.*, 1992). Therefore, investing in educating individuals, creating more job opportunities, securing a stable income or increasing the income level of the economically disadvantaged population are highly recommended. These particular efforts may decrease the CVD risk and enhance the health condition among low-income individuals (Cornaz *et al.*, 2009; Rasiah *et al.*, 2013; Schulz *et al.*, 2008).

The CVD risk prediction models, which we used to predict the ten-year CVD risk, have the following advantages over the other methods. Firstly, it is a more advanced scoring method compared to the previous Framingham scoring model (Conroy *et al.*, 2003; Wilson *et al.*, 1998). Secondly, unlike the SCORE method (which only predicts CVD risk based fatal CVD events) (Conroy *et al.*, 2003), FRS considers both fatal and non-fatal events of CVD. Thirdly, SCORE considers the high risk of CVD as >5% whereas it is >20% in FRS, which indicates a more logical classification. Fourthly, FRS scoring have been widely validated in Asia (Asia Pacific Cohort Studies Collaboration *et al.*, 2007; Liu *et al.*, 2004a; Ng & Chia, 2008; Suka *et al.*, 2002) and worldwide before (Brindle *et al.*, 2003; D'Agostino *et al.*, 2001; Marrugat *et al.*, 2007; Marrugat *et al.*, 2014). Besides, the FRS is the only risk prediction model which has been validated in Malaysia previously (Ng & Chia, 2008). Finally, FRS included age up to 75, but other models covered until age 65 (Assmann *et al.*, 2002; Cooper *et al.*, 2005; Ridker *et al.*, 2007).

This is the first nationally representative sample of Malaysians about which the predicted CVD risk profiles were assessed. It was the first study in the region and in Malaysia to evaluate the future risk of CVD. In addition, powerful international methodology was applied in prediction of CVD risk. The results obtained from both lipid-based models are available for international comparison.

CHAPTER 5

TACKLING CARDIOVASCULAR RISK FACTORS

5.1 Introduction

In more industrialized nations, an inverse association between SES level and CVD mortality and morbidity has been diagnosed (Choiniere *et al.*, 2000; Cooper *et al.*, 2000; Damiani *et al.*, 2011). Usually, this is because as socioeconomic gradient lowers, some people share some the followings: tend to smoke more tobacco, being less physically active, have higher BMI (i.e., being overweight or obese), being hypertensive and hypercholesterolemic, have higher blood glucose (diabetes), and suffer more from psychosocial distress such as anxiety, stress, and depression (Bruthans, 2008).

Individuals with less SES require modified strategies specifically targeting them to prevent CVD as conventional CVD risk lowering preventive programs are less likely to be influential on this social gradient (Bruthans, 2008). The conventional preventive policies are less successful to diminish CVD risk as they do not take SES level of individuals into account and underestimate the risk for CVD in lower SES people (Bruthans, 2008). Therefore, increased attention must be paid to this social class gradient so that they enjoy health equity comparing to the higher SES class people in the society.

In this chapter, we will try to identify a socioeconomic intervention to tackle future CVD risk in the developing country of Malaysia. Subsequently, we will provide an in details methodological process used in this study to analyze mediational effect of income level on the association between education level and cumulative cardiovascular disease risk factors. Then, results were presented and discussed consecutively.

5.2 Theoretical considerations

Apart from measuring socioeconomic inequalities in CVD risk factors, many studies have also ventured into measuring the true association between SES and CVD through methods of mediation and path analysis. Identifying these modifiable mechanisms that link SES to CVD risk factors is crucial to guide the development of effective interventions. A study on young adults in US examined the association between education and household income and systolic blood pressure. They found that when lower body mass, smaller waist circumference and lower resting heart rate were taken into account in meditational analyses, higher education was significantly associated with lower systolic blood pressure but not household income (Brummett *et al.*, 2013). Using path analysis, birth weight, breastfeeding duration and body mass index played a role in the association between maternal education and pre-hypertension in childhood (van den Berg *et al.*, 2013).

This study will mainly focus on the mediation analysis which explains the mechanism by which an independent variable exerts its influence on the dependent variable using mediators. The indirect relationship between the education level and cumulative risk factors of CVD using income adequacy level as mediator will be explained through meditation analysis. The models also test for the significance of the mediator variables and determine the type of mediation that may be present; partial mediation or full mediation. Mediation analysis explains the mechanism by which an independent variable exerts its influence on the dependent variable using mediators. The indirect relationship between SES and cumulative risk factors of CVD using mediators such as income adequacy level can be explained through mediation analysis.

The logistic regression method and the path analysis method are the two approaches of mediation analysis that will be applied in this study. The binary logistic regression models the association between the three variables; the mediator variables which are the risk factors for CVD, the independent variables which is the education and the dependent variable which is the cumulative risk factors for CVD. Several logistic models in various strata will be constructed to analyze the relationships between the SES and cumulative modifiable risk factors for CVD (direct effect), SES and the mediator variables which are the behavioral risk factors for CVD (indirect effect) and mediator variables (income incentive) with the cumulative modifiable risk factors of CVD (indirect effect). Each of these models will also be used to identify the significance of the independent (explanatory) variables on the dependent variable. The models also test for the significance of the mediator variables and determine the type of mediation that may be present; partial mediation or full mediation. The path analysis method helps to understand the mediation analysis better by illustrating the analysis using "path models". Using the path models, the mediation would be tested using the Karlson-Holm-Breen (KHB) method (Karlson *et al.*, 2012).

There is extensive work on the relationship between CVD risk factors and socioeconomic background. However, existing studies have been dominated by research on individual CVD risk factors, and the relationship between them and socio-economic variables. Not many studies have examined the relationship between cumulative CVD risk factors and socioeconomic variables, and even less have examined the mediating effect of one socioeconomic variable on the relationship between another socioeconomic variable and CVD risk factors. Hence, this study seeks to add to this limited literature by examining the mediating effect of income on the relationship between education and CVD risk factors using a Malaysian representative sample.

Past studies show a strong relationship between SES and the prevalence of CVD risk factors (Loucks *et al.*, 2009). Ethnicity also strongly plays a substantial role in the relationship between SES and CVD risk factors (Winkleby *et al.*, 1999). Karlamangla *et* *al.* (2010) showed an inverse relationship between SES and CVD risk factors but the strength of this association fell with obesity, smoking, and physical inactivity. Also, although the findings on high-income countries (e.g., USA or Canada) show an inverse relationship between SES and CVD risk factors (Steptoe *et al.*, 2002; Winkleby *et al.*, 1992), they were less associated with ethnicity and race than in the low and middle-income countries (Karlamangla *et al.*, 2010).

While past studies show that hypertension is inversely associated with SES levels (Bovet *et al.*, 2008), income and education (Kim *et al.*, 2008), they show a positive relationship with age (Stelmach *et al.*, 2005). Furthermore, some studies show that gender (Castanho *et al.*, 2001; Gebreab *et al.*, 2012), and ethnicity (Din-Dzietham *et al.*, 2000) have a strong influence on the prevalence of hypertension. Meanwhile, the prevalence of hypercholesterolemia can be predicted by age and gender (Castanho *et al.*, 2001; Stelmach *et al.*, 2004). Diabetes is inversely correlated with education (Cooper *et al.*, 2000), and income and differs with gender (Gebreab *et al.*, 2012). Additionally, inverse relationships have been found between SES levels, and income (Barbeau *et al.*, 2004; Karlamangla *et al.*, 2010; Kim *et al.*, 2008; Winkleby *et al.*, 1992), and education (Barbeau *et al.*, 2004; Cooper *et al.*, 2000; Stelmach *et al.*, 2004), while males (Barbeau *et al.*, 2004) dominate the prevalence of smoking. In addition, gender differences (Gebreab *et al.*, 2012), income (Kim *et al.*, 2008), education (Stelmach *et al.*, 2004), and ethnic groups (Cooper *et al.*, 2000) can predict the incidence of obesity. Finally, education is the most powerful SES predictor of CVD prevalence (Falkstedt & Hemmingsson, 2011; Loucks *et al.*, 2009; Winkleby *et al.*, 1992) followed by age, gender and education (Stelmach *et al.*, 2004).

5.3 Methodology

5.3.1 Binary logistic regression

Unlike Ordinary Least Square (OLS) regression analysis that enjoys a continuous dependent variable (DV), Logistic Regression Models (LRM) comes handy when the outcome is categorical (i.e., has two or more categories). The term binary (or binomial) logistic regression is used when the DV is comprised of dichotomous (binary or binomial) values (e.g., zero and one). In other words, if outcome variable just consists of two values (e.g., Yes/No or existence/non-existence of an attribute), the binary LRM is the most appropriate regression analysis to handle the analysis.

Nonetheless, independent variables (IV or predictors) can be both categorical and/or continuous. In addition, maximum likelihood will be used after DV into a logit form (i.e., the natural logarithm of odds or probability of DV occurring or not). This will result in the probability of a specific event. To calculate the goodness of fit (GOF), the χ^2 test is used.

An important characteristics of the logistic regression is that it calculates the changes in the log-odds of the DV, not changes in the DV itself. Also, one of the priority of the LRM is that it produces the relative importance of IV, assesses interaction effects, and understands the impact of covariate/control variables. The results obtained from LRM can be both interpreted as probability and/or odds ratio (OR) forms.

5.3.1.1 Logistic regression assumptions

In LRM, the various assumptions of OLS regressions are not needed (i.e., linearity of relationship between the IV and the DV, normally distributed variables, and homoscedasticity).

However, LRM requires observations to be independent and IV be linearly related to the logit of the DV. The logistic function is:

Equation 1 Logistic regression function

$$Z = \beta_0 + \beta_1 . X_1 + \varepsilon \qquad (1)$$

Note here that Z is not real and is a latent variable. The Z function is transformed to obtain either odds-ratio or probability of the $EVENT$ occurring or $[1 - EVENT]$ if not occurring. For binary logistic regression, the function is:

Equation 2 Binary logistic regression function

$$P[EVENT] = \frac{e^Z}{1 + e^Z} \qquad (2)$$

And the value is between [0, 1].

The followings are the assumptions of LRM:

- Independent variables must be metric or scale variables.
- Categories (grouping) sizes within a categorical (group) variable must not be excessively different.
- Residuals (error values) must be randomly distributed.
- Independent variables must not suffer from multicollinearity.

Note here that the sample size needed for the logistic regression for each case of DV must at least be 10 cases (Peduzzi *et al.*, 1996).

5.3.1.2 Estimation method in logistic regression

In logistic regressions, the maximum likelihood estimation (MLE) is used to assess the regression coefficients (logit model). MLE seeks to maximize the log-likelihood (LL) that reflects the odds that observed values of DV may be predicted from the observed values of IV. MLE's system of calculation follows an iterative algorithm starting with a "guesstimate" of what the logic coefficients might be, then it determines the size and direction of the logit coefficients, which increases LL. After estimation of this initial arbitrary function, this process is repeated many times (at least six times) until figures converge to a unique number, i.e., until LL's change is not significant [for an in detail explanation of logistic regression models see Scott Long (1997)]. To analyze the tests of significance, we followed the commonly used methods:

1. Log-likelihood (LL): In this test, the 'likelihood' is the probability that the observed values of DV may be predicted from the observed values of IV (this probability lies between zero and one). The LL is its log transformed of the likelihood and ranges from zero to $-\infty$ (minus infinity). This figure is calculated through various iteration using MLE. This is the basics of the tests of a logistic model.

2. The likelihood ratio (LR): The function of LL is called LR. This is because -2*LL follows an approximate χ^2 (chi-squared) distribution; therefore, -2*LL can be used for assessing the significance of logistic regression. The LR is -2*LL. It is also called goodness of fit (GOF), deviance χ^2, scaled deviance, deviation χ^2, D_M, L-squared. The LR reflects the significance of unexplained variance in DV.

3. The LR test: This test is based on -2*LL and it assesses the significance of the difference between the likelihood ratio (-2*LL) for the tested model minus the LR for a reduced model. There are two main forms of this test:

- Test of the overall model: this tests the proposed model as a whole. Therefore, a well-fitting model must be significance at 0.05 level.
- Test of individual model parameters: this LR test assesses the overall logistic model but does not specifically identify the importance of any particular IV in the model.

4. Chi-square (χ^2) test of goodness of fit:

This test identifies whether variables best fit in prediction of the DV. The criterion is satisfactory fit model when chi-square GOF is not significant. The author name of this test is Hosmer–Lemeshow's goodness of fit (Hosmer *et al.*, 1991; Lemeshow & Hosmer, 1982).

5.3.2 Mediation process

MacKinnon *et al.* (2007) defines mediational variables as "behavioral, biological, psychological, or social constructs that transmit the effect of one variable to another variable." Mediating variables are contemporarily applied in treatment and prevention research where interventions are designed to influence an interested outcome by changing the behavior of a mediating variable that is believed to be 'casually' related to outcome. The mediation analysis evaluates the influential level of a third variable on the association of two other variables. This process may seem simple but in fact it bears lots of complexities as it holds a 'three-variable' system (MacKinnon *et al.*, 2007).

In its simplest form of definition, mediation is a process where a mediator variable (M) interferes on the association of an explanatory variable (X) and an outcome (Y). In this association, X causes M, and M causes Y, so X → M → Y. This process must not be confused with confounding variable as a confounding variable causes both X and Y simultaneously. Therefore, excluding variable result in 'incorrect inference' about the relationship of X and Y (MacKinnon *et al.*, 2007; Preacher & Hayes, 2004).

Another probable interference by a third variable is an example of covariates. A covariate is a variable that is related to X but may or may not be related to Y. Thus, a covariate improves the prediction of Y by X, but does not necessarily alter the X-Y association. Distinctively, another interference for the third variable in X-Y domain is the moderator variable. A moderator by definition is a variable that modifies the association of X and Y such that this relationship varies at various levels of moderator values (Baron & Kenny, 1986). A mediator, in the end, is a variable that is in a causal sequence between two variables (Baron & Kenny, 1986).

5.3.3 Mediation Instruments

Following the collection and cleansing the data, we tabulated the descriptive statistics on the prevalence of each CVD risk factor by educational attainment. We then followed four statistical procedures for gender, rural-urban background, region (i.e. WPM, EPM, and EM), ethnicity, and total stratifications using MacKinnon *et al.* (2007), Preacher and Hayes (2004), and Karlson *et al.* (2012)'s test of mediation effect for binary outcomes.

Therefore, we followed four steps in each stratified categories to analyze the mediation effect of income on the association between education, and cumulative CVD risk factors (see Figure 5.1). In doing so, in all stratified models age and gender [not included in gender stratifications] acted as confounders.

The Spearman's rho (ρ) and its probability (prob. < 0.05) indicated the significant relationship between education level as the explanatory variable and income as the mediator (path (a) in Figure 5.1). In addition, binary logistic regression was used to evaluate whether income (i.e. mediator) can predict both cumulative CVD risk factors (prob. < 0.05) (path [b] in Figure 5.1). Subsequently, binary logistic regressions were used to identify the pre-mediation association of education level and cumulative CVD risk factors (path [c] in Figure 5.1). Finally, after inclusion of income level in the model, the post-mediation results were obtained.

Comparing the education odds-ratios we can define whether mediational effect of income exists (i.e. either partially or entirely) or does not exist (i.e. no mediation) on the relationship between education and cumulative risk factors (path [c’] in Figure 5.1). The statistically significant mediational effects in different stratification (i.e. comparing pre- and post-mediation results) were derived from Karlson *et al.* (2012) methodology.

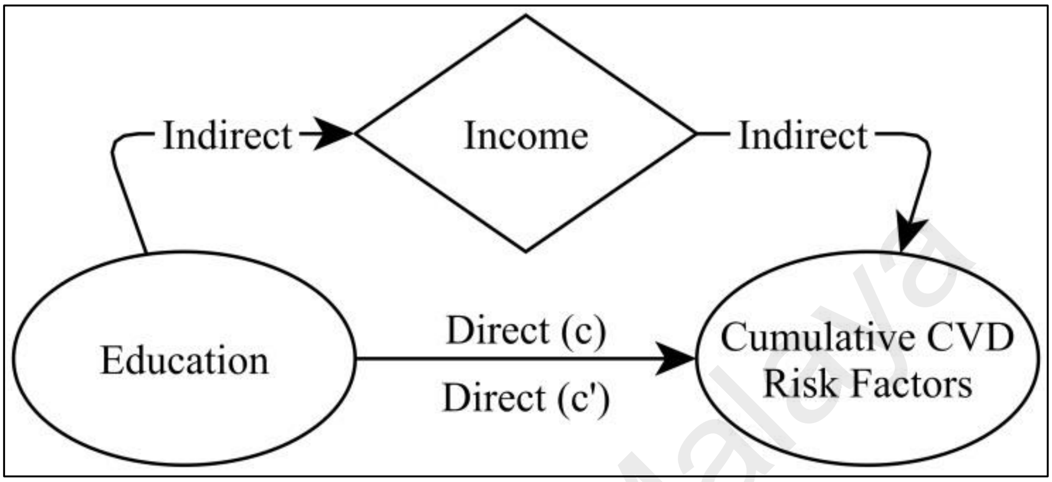

Figure 5.1: Hypothesized mediation model

5.4 Results

5.4.1 Descriptive Analyses

The descriptive statistics by education level of the sampled data is shown in Table 5.1. The prevalence of CVD risk factors of hypercholesterolemia and hypertension were quite high at 81.1 per cent and 50.6 per cent respectively, followed by obesity, smoking, and diabetes at 35.1 per cent, 25.4 per cent and 20.4 per cent respectively. The results also show that an increase in the level of education will bring down the prevalence of cumulative 1 CVD risk factors. However, a rise in education level will increase the cumulative 2 CVD risk factors (see Figure 5.2).

Table 5.1: Characteristics of the sample by education level

	Education Level				
	None	**Primary**	**Secondary**	**Tertiary**	**Total**
	n = 993	n = 2231	n = 2745	n = 1087	n = 7135
Age (Yrs, M[1], SD[2])	57.6 (9.3)	55.4 (8.7)	48.5 (8.2)	48.1 (7.7)	51.9 (9.3)
Gender (n, %)					
Male	278 (9.1)	1048 (34.1)	1183 (38.5)	561 (18.3)	3097
Female	715 (17.9)	1183 (29.7)	1562 (39.2)	526 (13.2)	4018
Ethnicity (n, %)					
Malay	616 (1.8)	1856 (32.4)	2346 (41.0)	907 (15.8)	5763
Chinese	9 (3.6)	33 (13.2)	107 (42.6)	102 (40.6)	253 (3.6)
Indian	8 (7.6)	10 (9.5)	41 (39.1)	46 (43.8)	105 (1.5)
Others	360 (36.9)	332 (34.1)	251 (25.7)	32 (13.3)	994
Location (n, %)					
Urban	102 (3.7)	461 (16.6)	1325 (47.6)	898 (32.2)	2799
Rural	891 (20.9)	1770 (41.5)	1420 (33.3)	189 (4.4)	4316
Income Level (n, %)					
Low	723 (24.6)	1342 (45.7)	836 (28.5)	36 (1.2)	2969
Middle	115 (4.7)	579 (23.7)	1345 (55.1)	401 (16.4)	2449
High	7 (1.0)	21 (2.6)	190 (23.3)	598 (73.3)	819

1. Mean; 2. Standard Deviation; 3. Systolic blood pressure; 4. Diastolic blood pressure; 5. Total cholesterol; 6. Body mass index; 7. Cumulative risk factor 1 including hypertension, diabetes, and smoking; 8. Cumulative risk factor 2 including hypercholesterolemia and obesity.

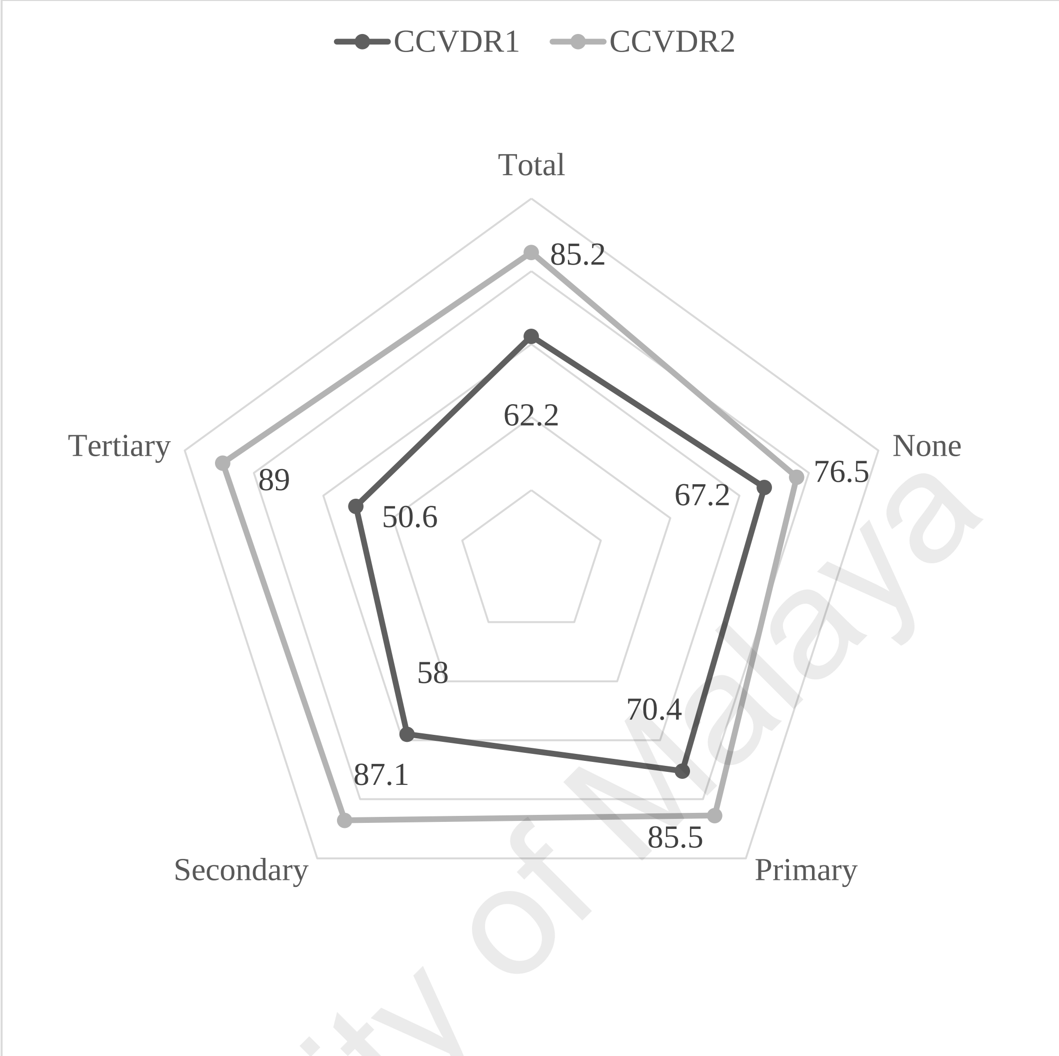

Figure 5.2: Prevalence of cumulative cardiovascular disease by education level

Note: CCVDRF1: Cumulative risk factor 1 including hypertension, diabetes, and smoking; CCVDRF2: Cumulative risk factor 2 including hypercholesterolemia and obesity.

5.4.2 Mediating Effect of Income

5.4.2.1 Education and Income

Table 5.2 shows the statistically significant associations between education, as the explanatory variable, and the income level, as the mediator variable in all the stratified categories. For instance, controlling for age and gender covariates, the Spearman's Rho (ρ) scores of education and income levels in female (0.64, $p<0.0001$) and males (0.66, $p<0.0001$) stratifications illustrate significant relationships among the explanatory variable and the mediator adjusting for age and gender.

Table 5.2: The association between income level and education level

	Spearman's ρ	prob.
Gender		
Female	0.6405	p <0.0001
Male	0.6598	p <0.0001
Location		
Urban	0.6413	p <0.0001
Rural	0.4923	p <0.0001
Region		
WPM	0.6535	p <0.0001
EPM	0.4737	p <0.0001
EM	0.4253	p <0.0001
Ethnicity		
Malay	0.6277	p <0.0001
Chinese	0.6127	p <0.0001
Others	0.539	p <0.0001
Total	0.6508	p <0.0001

Disaggregation by gender shows a statistically significant association between education and income in urban (0.64, p<0.0001) and rural (0.49, p<0.0001), and WPM (0.65, p<0.0001), EPM (0.47, p<0.0001) and EM (0.43, p<0.0001) respondents. Ethnically, Malays (0.63, p<0.0001), Chinese (0.61, p<0.0001) and Others (0.54, p<0.0001) exhibited significant relationships between the explanatory variable and the mediator. As shown in Table 5.2, the first criterion of the mediation process is fulfilled by all classifications.

5.4.2.2 Income and Cumulative CVD Risk Factors

The binary logistic regression results show that cumulative 1 and 2 CVD risk factors correlate differently with income level in each of the classifications (see Table 5.3). Cumulative 1 CVD risk factors show an inverse association with income levels. Increasing income levels are associated with a fall in the probability of having cumulative 1 CVD risk factors (Odds-ratios < 1.00). Considering the cumulative 1 CVD risk factors, the stratifications of female (OR = 0.80; 95% Confidence Interval [CI]: 0.75 – 0.86), male (OR = 0.88; 95% CI: 0.81 – 0.96), urban (OR = 0.86; 95% CI: 0.79 – 0.93), WPM (OR =

0.80; 95% CI: 0.74 – 0.87), EPM (OR = 0.80; 95% CI: 0.71 – 0.89), Malay (OR = 0.82; 95% CI: 0.78 – 0.88), Others (OR = 0.86; 95% CI: 0.75 – 0.98), and total (OR = 0.83; 95% CI: 0.79 – 0.88) showed significant odds-ratios (prob. < 0.05, prob. < 0.01, or prob. < 0.0001).

In contrast, hypercholesterolemia and obesity that formed the second category of cumulative CVD risk factors used in the paper, demonstrated a direct association with income level, rising income levels raise the likelihood of having at least one of the cumulative 2 CVD risk factors (see Table 5.3). In the stratifications of female (OR = 1.16; 95% CI: 1.05 – 1.27), male (OR = 1.99; 95% CI: 1.74 – 2.27), rural (OR = 1.55; 95% CI: 1.38 – 1.74), EPM (OR = 1.40; 95% CI: 1.16 – 1.69), Malay (OR = 1.28; 95% CI: 1.17 – 1.41), Others (OR = 1.41; 95% CI: 1.20 – 1.66), and total (OR = 1.42; 95% CI: 1.31 – 1.53) we identified statistically significant association between income and outcome of cumulative 2 CVD risk factors. All the above-mentioned odd-ratios were highly significant at 95%, 99%, or higher confidence levels.

Table 5.3: Association between income level and cumulative CVD risk factors

	Cumulative 1	**Cumulative 2**
Gender		
Female	0.80 (0.75 – 0.86) [1]	1.16 (1.05 – 1.27)
Male	0.88 (0.81 – 0.96)	1.99 (1.74 – 2.27)
Location		
Urban	0.86 (0.79 - 0.93)	1.02 (0.89 - 1.17)
Rural	0.97 (0.89 - 1.06)	1.55 (1.38 - 1.74)
Region		
WPM	0.80 (0.74 - 0.87)	1.05 (0.92 - 1.19)
EPM	0.80 (0.71 - 0.89)	1.40 (1.16 - 1.69)
EM	1.01 (0.86 - 1.19)	1.17 (0.99 - 1.38)
Ethnicity		
Malay	0.82 (0.78 - 0.88)	1.28 (1.17 - 1.41)
Chinese	0.84 (0.61 - 1.16)	0.94 (0.60 - 1.47)
Others	0.86 (0.75 - 0.98)	1.41 (1.20 - 1.66)
Total	0.83 (0.79 - 0.88)	1.42 (1.31 - 1.53)

Note: Figures in **bold** indicate p<0.05 and are statistically significant.
1. Income odds-ratio (95% confidence interval) in different categories.

5.4.2.3 Education and Cumulative CVD Risk Factors (pre-mediation)

Like income, education showed the same relationship with both cumulative CVD risk factors. While its relationship with cumulative 1 CVD risk factors was inverse, it enjoyed a direct association with cumulative 2 CVD risk factors. The binary logistic regression results of pre-mediation analysis are presented in the pre-mediation columns of Table 5.4 (for cumulative 1 CVD risk factors) and Table 5.5 (for cumulative 2 CVD risk factors).

Holding the non-educated category as the reference group in the binary logistic analysis (OR = 1.00), the secondary and tertiary educated respondents illustrated significant association with cumulative 1 CVD risk factors. For example, among females, while the odds of having at least one of the cumulative 1 CVD risk factors in tertiary educated respondents was 0.38 (95% CI: 0.29 – 0.50), it was 2.11 (1.49 – 2.98) in the cumulative 2 CVD risk factors relative to the odds of respondents in the no education group (see Table 5.4 and Table 5.5).

Table 5.4: Effect of income level on education and CCVDRF1 association

	Education Levels[1]								
	Primary			**Secondary**			**Tertiary**		
	Pre-mediation	**Post-mediation**	**Diff.**	**Pre-mediation**	**Post-mediation**	**Diff.**	**Pre-mediation**	**Post-mediation**	**Diff.**
Gender									
Female	0.98 (0.80 – 1.20)[2]	1.08 (0.87 – 1.34)	(p<0.05)	0.73 (0.60 – 0.90)	0.88 (0.69 – 1.13)	(p<0.05)	0.38 (0.29 – 0.50)	0.55 (0.38 – 0.79)	(p<0.05)
Male	1.11 (0.78 – 1.57)	1.11 (0.76 – 1.62)	(p>0.1)	0.85 (0.60 – 1.20)	0.83 (0.56 – 1.24)	(p>0.1)	0.61 (0.42 – 0.88)	0.66 (0.41 – 1.07)	(p>0.1)
Location									
Urban	0.79 (0.48 - 1.30)	0.94 (0.55 - 1.61)	(p>0.1)	0.57 (0.35 - 0.91)	0.63 (0.37 - 1.06)	(p>0.1)	0.40 (0.24 - 0.65)	0.50 (0.28 - 0.89)	(p>0.1)
Rural	1.05 (0.86 - 1.26)	1.07 (0.87 - 1.31)	(p>0.1)	0.96 (0.77 - 1.19)	1.03 (0.81 - 1.31)	(p>0.1)	0.72 (0.49 - 1.06)	0.79 (0.51 - 1.22)	(p>0.1)
Region									
WPM	0.73 (0.47 – 1.12)	0.87 (0.55 - 1.37)	(P>0.1)	0.47 (0.31 - 0.72)	0.60 (0.38 - 0.96)	(P>0.1)	0.30 (0.19 - 0.46)	0.44 (0.26 - 0.73)	(P>0.1)
EPM	1.09 (0.81 - 1.46)	1.26 (0.92 - 1.72)	(p<0.05)	0.87 (0.64 - 1.19)	1.06 (0.76 - 1.49)	(p<0.05)	0.60 (0.39 - 0.94)	0.88 (0.52 - 1.48)	(p<0.05)
EM	0.86 (0.64 - 1.15)	0.83 (0.61 - 1.13)	(P>0.1)	0.76 (0.54 - 1.07)	0.69 (0.46 - 1.03)	(P>0.1)	0.58 (0.26 - 1.30)	0.50 (0.20 - 1.25)	(P>0.1)
Ethnicity									
Malay	0.96 (0.78 - 1.19)	1.07 (0.85 - 1.34)	(p<0.05)	0.72 (0.58 - 0.89)	0.87 (0.68 - 1.11)	(P<0.01)	0.47 (0.36 - 0.60)	0.66 (0.48 - 0.91)	(P<0.01)
Chinese	0.45 (0.04 - 4.55)	9.52 (2.35 - 38.49)	N/A	0.22 (0.02 - 1.99)	3.80 (1.52 - 9.48)	N/A	0.08 (0.00 0.75)	N/A	N/A
Others	0.91 (0.64 - 1.28)	0.96 (0.66 - 1.39)	(p>0.1)	0.75 (0.51 - 1.10)	0.75 (0.47 - 1.19)	(p>0.1)	0.42 (0.24 - 0.75)	0.57 (0.25 - 1.27)	(p>0.1)
Total	0.97 (0.82 - 1.16)	1.05 (0.87 - 1.27)	(p<0.05)	0.74 (0.62 - 0.88)	0.84 (0.68 - 1.03)	(p<0.05)	0.45 (0.37 - 0.56)	0.60 (0.45 - 0.79)	(p<0.05)

Note: Figures in **bold** indicate p<0.05 and show statistically significant mediation effect.

1. None educated category is the reference

2. Odds-ratios (95% confidence intervals)

Meanwhile, in urban areas, secondary and tertiary educated respondents experienced cumulative 1 CVD risk factors of 0.57 (95% CI: 0.35 – 0.91) and 0.40 (95% CI: 0.24 – 0.65) respectively, while cumulative 2 CVD risk factors did not show significant results in this classification. Based on cumulative 1 CVD risk factors, while secondary educated respondents showed statistically significant results among WPM (OR = 0.47; 95% CI: 0.31 – 0.72), Malay (OR = 0.72; 95% CI: 0.58 – 0.89), and total (OR = 0.74; 95% CI: 0.62 – 0.88), the tertiary educated respondents showed significant results in WPM (OR = 0.30; 95% CI: 0.19 – 0.46), EPM (OR = 0.60; 95% CI: 0.39 – 0.94), Malays (OR = 0.47; 95% CI: 0.36 – 0.60), Others (OR = 0.42; 95% CI: 0.24 – 0.75), and the whole (OR = 0.45; 95% CI: 0.37 – 0.56) sample.

However, according to results obtained from cumulative 2 CVD risk factors, the pre-mediational associations between education and the outcome were significant ($p < 0.05$) at both gender stratifications (see Table 5.5). Besides, in the rural category, the primary, secondary, and tertiary educated respondents illustrated significant odds ratios of 2.05 (95% CI: 1.66 – 2.53), 2.69 (95% CI: 2.10 – 3.45), and 4.26 (95% CI: 2.41 – 7.52) respectively. Whereas, the primary educated group was significant among Malays, the secondary and tertiary educated groups were statistically significant in EPM and among all ethnic groups (see Table 5.5). The overall sample involving all education levels were significant at 95% confidence level, i.e., primary (OR = 1.93; 95% CI: 1.59 – 2.35), secondary (OR = 2.99; 95% CI: 2.42 – 3.71), and tertiary (OR = 3.47; 95% CI: 2.63 – 4.58).

Table 5.5: Effect of income level on education and CCVDRF2 association

	Education Levels[1]								
	Primary			**Secondary**			**Tertiary**		
	Pre-mediation	**Post-mediation**	**Diff.**	**Pre-mediation**	**Post-mediation**	**Diff.**	**Pre-mediation**	**Post-mediation**	**Diff.**
Gender									
Female	1.98 (1.53 – 2.58)	1.70 (1.27 – 2.27)	(p>0.1)	2.50 (1.90 – 3.29)	1.94 (1.39 – 2.69)	(p>0.05)	2.11 (1.49 – 2.98)	1.43 (0.87 – 2.35)	(p>0.05)
Male	2.30 (1.69 – 3.13)	1.90 (1.36 – 2.67)	(p<0.0001)	4.48 (3.18 – 6.30)	2.57 (1.72 – 3.83)	(p<0.0001)	7.94 (4.96 – 12.72)	3.32 (1.76 – 6.24)	(p<0.0001)
Location									
Urban	0.52 (0.21 - 1.28)[2]	0.50 (0.19 - 1.32)	(p>0.1)	0.76 (0.32 - 1.81)	0.75 (0.28 - 1.96)	(p>0.1)	0.63 (0.26 - 1.81)	0.70 (0.25 - 1.98)	(p>0.1)
Rural	2.05 (1.66 - 2.53)	1.74 (1.38 - 2.20)	(p<0.0001)	2.69 (2.10 - 3.45)	1.88 (1.41 - 2.51)	(p<0.0001)	4.26 (2.41 - 7.52)	2.25 (1.19 - 4.23)	(p<0.0001)
Region									
WPM	0.58 (0.29 - 1.18)	0.62 (0.29 - 1.30)	(P>0.1)	0.88 (0.44 - 1.79)	1.02 (0.48 - 2.18)	(P>0.1)	0.84 (0.41 - 1.72)	1.06 (0.46 - 2.43)	(P>0.1)
EPM	1.32 (0.87 - 2.01)	1.17 (0.75 - 1.85)	(p<0.05)	1.64 (1.03 - 2.59)	1.30 (0.78 - 2.17)	(p<0.05)	2.42 (1.10 - 5.31)	1.56 (0.63 - 3.88)	(p<0.01)
EM	1.23 (0.93 - 1.64)	1.18 (0.87 - 1.61)	(P>0.1)	1.35 (0.95 - 1.91)	1.02 (0.68 - 1.52)	(P>0.1)	2.36 (0.92 - 6.00)	1.88 (0.64 - 5.45)	(P>0.1)
Ethnicity									
Malay	1.78 (1.37 - 2.31)	1.54 (1.15 - 2.06)	(p<0.05)	2.45 (1.85 - 3.24)	1.94 (1.40 - 2.68)	(P<0.01)	2.81 (1.98 - 3.98)	1.95 (1.23 - 3.10)	(P<0.01)
Chinese	3.96 (0.65 - 23.80)	3.54 (0.41 - 30.16)	(p>0.1)	7.18 (1.39 - 37.07)	9.43 (1.21 - 73.26)	(p>0.1)	2.95 (0.62 - 13.89)	4.55 (0.55 - 37.16)	(p>0.1)
Others	1.06 (0.75 - 1.49)	1.02 (0.70 - 1.48)	(p>0.1)	1.58 (1.06 - 2.35)	0.97 (0.60 - 1.57)	(p<0.01)	3.58 (1.62 - 7.87)	1.84 (0.64 - 5.22)	(p<0.01)
Total	1.93 (1.59 - 2.35)	1.66 (1.34 - 2.06)	(p<0.0001)	2.99 (2.42 - 3.71)	2.11 (1.64 - 2.72)	(p<0.0001)	3.47 (2.63 - 4.58)	1.96 (1.33 - 2.87)	(p<0.0001)

Note: Figures in **bold** indicate p<0.05 and show statistically significant mediation effect.

1. None educated category is the reference
2. Odds-ratios (95% confidence intervals)

5.4.2.4 Post-Mediation

We identified post-mediation results of the strata in which we had statistically significant pre-mediation associations mentioned in step III. In the female stratum, the secondary and tertiary educated people showed fully (OR = 0.88; 95% CI: 0.69 – 1.13) and partially (OR = 0.55; 95% CI: 0.38 – 0.79) mediating effect of income on the education and cumulative 1 CVD risk factors association. Moreover, tertiary educated respondents were fully mediated as the odds-ratio became insignificant at 95% level of confidence, i.e., OR = 0.88; 95% CI: 0.52 – 1.48. In addition, secondary (OR = 0.87; 95% CI: 0.68 – 1.11) and tertiary (OR = 0.66; 95% CI: 0.48 – 0.91) educated Malays illustrated full and partial mediation respectively. Finally, in the whole dataset (i.e. the total category), while the secondary level of education was fully mediated (OR = 0.84; 95% CI: 0.68 – 1.03), the tertiary level was partially mediated by 15% increase in the odds of having cumulative 1 CVD risk factors. In conclusion, the mediation impact of income worsened the relationship between education level and cumulative 1 CVD risk factors.

All education levels have been mediated in male, rural, Malays, and the overall sample respondents. The EPM and Others illustrated mediation effects in secondary and tertiary educated respondents. The primary (OR = 1.90; 95% CI: 1.36 – 2.67), secondary (OR = 2.57; 95% CI: 1.72 – 3.83), and tertiary (OR = 3.32; 95% CI: 1.76 – 6.24) educated males were partially mediated by income level. In the rural areas, Malays, and total categories were partially mediated by income. In the EPM stratum, the association between education levels and cumulative 2 CVD risk factors in secondary (OR = 1.30; 95% CI: 0.78 – 2.17), and tertiary (OR = 1.56; 95% CI: 0.63 – 3.88) levels of education were fully mediated. Besides, the Others group revealed the same characteristics regarding the impact of mediating variables, while the secondary (OR = 0.97; 95% CI: 0.60 – 1.57) and tertiary (OR = 1.84; 95% CI: 0.64 – 5.22) educated groups were fully mediated by income.

To sum up, the mediation effect of income was desirable and positive on the relationship between education and cumulative 2 CVD risk factors.

According to Figure 5.3 and Figure 5.4 where the post-mediation figure (i.e. the post-mediation OR and/or its 95% CI) crosses the dashed line (OR = 1.00), the stratum experienced the full mediational effect and it is partially mediated if otherwise. Hence, the income level fully mediates the female, Malay, all secondary educated, and in EPM the tertiary educated respondents (see Figure 5.3). All other associations were partially mediated. The relationship between education and cumulative 2 CVD risk factors were fully mediated among secondary and tertiary educated respondents in EPM and in the overall sample (see Figure 5.4). The remaining significant mediation impacts were partial.

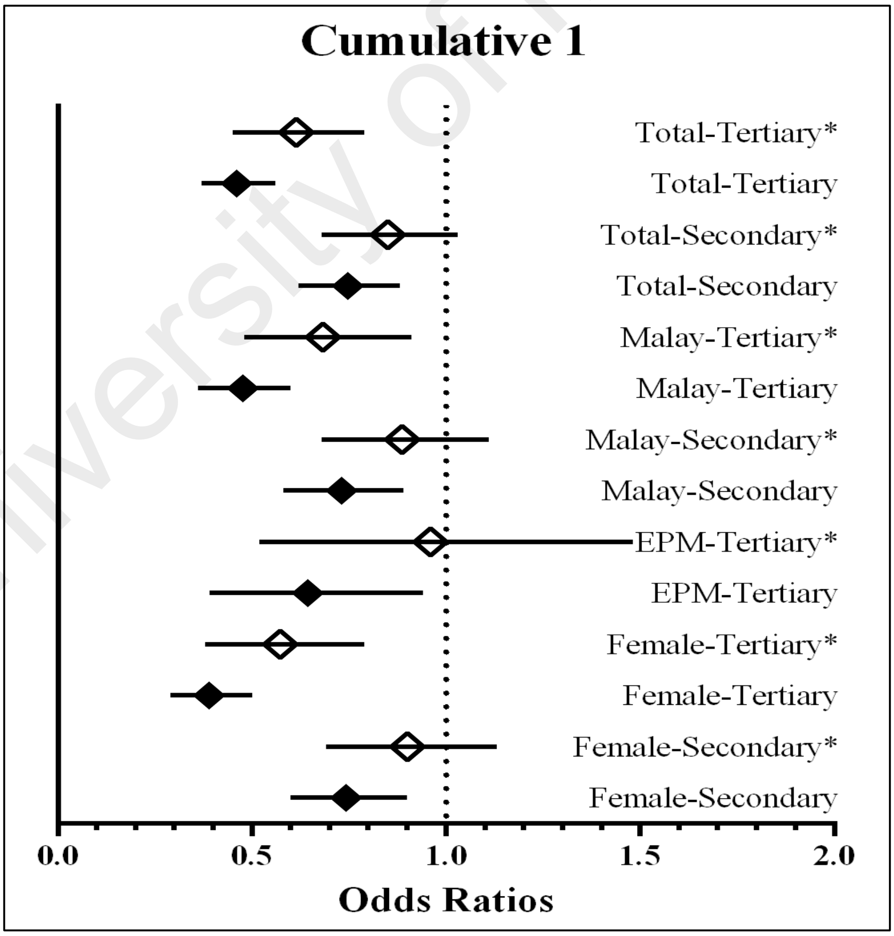

Figure 5.3: Cumulative 1 CVD Risk Factors and Mediated Figures

Note: Asterisks indicate the post-mediation odds-ratios

Figure 5.3 and Figure 5.4 show the pre- and post-mediational effect of income on the association between education and cumulative 1 and cumulative 2 CVD risk factors respectively. It is clear that the mediation effect of income on the relationship between education level and cumulative 1 CVD risk factors is not desirable as increasing income aggravates the situation as education levels worsen the odds of having cumulative 1 CVD risk factors. However, the mediation effect of income on the relationship between education level and cumulative 2 CVD risk factors is desirable as increasing incomes helps education lower the odds of having cumulative 2 CVD risk factors.

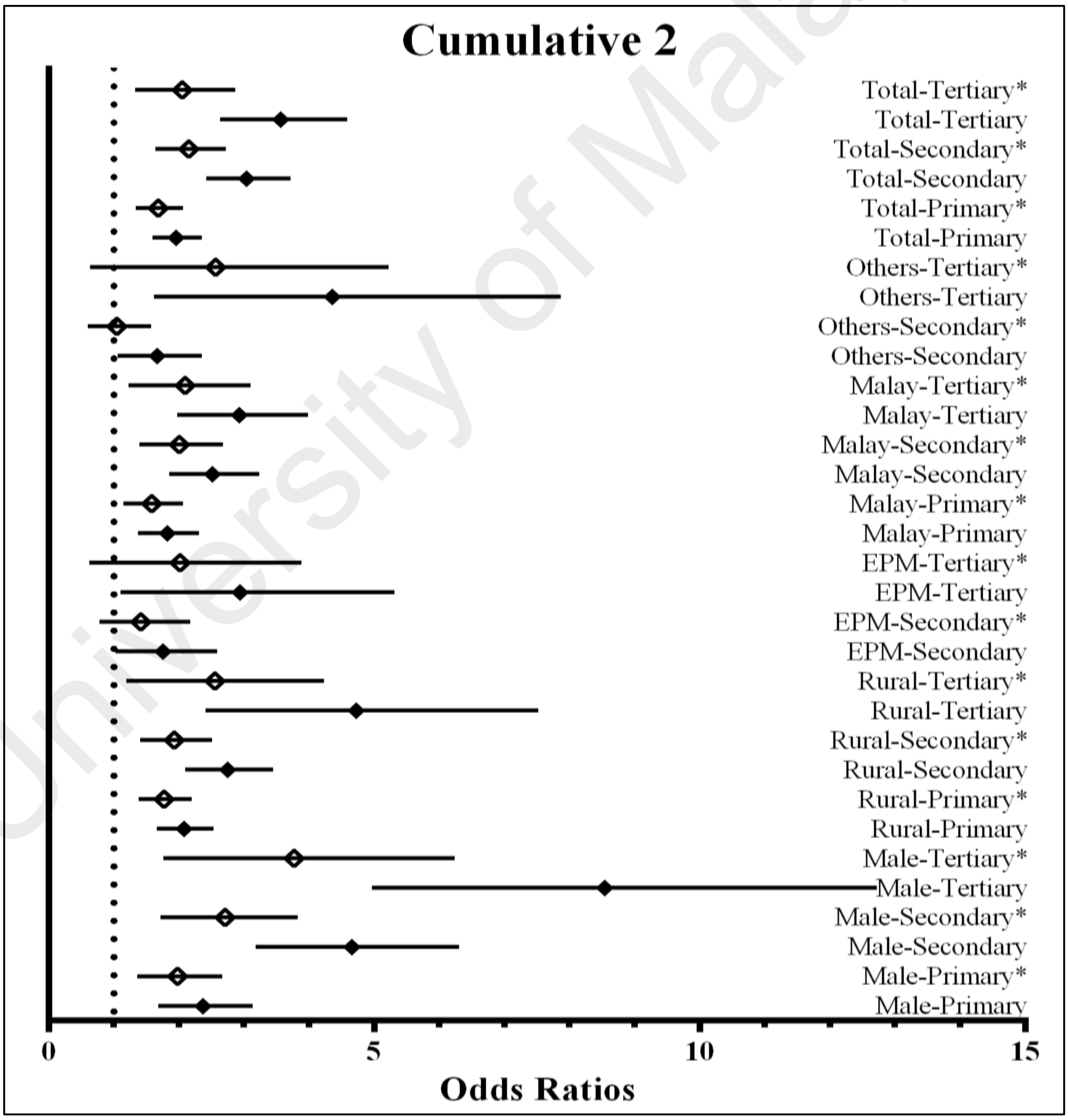

Figure 5.4: Cumulative 2 CVD Risk Factors and Mediated Figures

Note: Asterisks indicate the post-mediation odds-ratios

5.5 Discussion

Education and income could significantly predict both categories of cumulative CVD risk factors. We can say that income can partially mediate the association between education and cumulative CVD risk factors. However, the mediational effects varied in the two categories of CVD risk factors. Education could significantly and inversely affect the existence of cumulative 1 CVD risk factors, and significantly but proportionately affect cumulative 2 CVD risk factors.

The mediational analysis also showed opposite impacts. Firstly, the mediational effect was undesirable with cumulative 1 CVD risk factors as rising income levels aggravated the cumulative CVD risk factors. The results were consistently the same with all socioeconomic categories when the mediation criteria were met. The outcome of the mediation of income worsened the prevalence levels in the whole sample, and among the secondary educated respondents. The impact was the same among Malays with tertiary and secondary education, the tertiary educated in EPM and females with tertiary and secondary education. However, the mediational effect of income on cumulative 2 CVD risk factors was desirable as rising income levels improved on the incidence of CVD risk factors. The results were consistently the same with all the socioeconomic categories when the mediation criteria were met. Respondents with tertiary, secondary and primary education faced the same worsening mediation effect from income. Ethnic Malay, rural and male respondents with all education levels experienced the same mediation adverse impact. The prevalence levels of respondents from the others ethnic group and EPM with tertiary and secondary education also worsened.

The inverse association between education and cumulative 1 CVD risk factors are consistent with previous studies (Barbeau *et al.*, 2004; Bovet *et al.*, 2008; Cooper *et al.*, 2000; Kim *et al.*, 2008; Rampal *et al.*, 2008; Wu & Rudkin, 2000). However, our results of cumulative 1 CVD risk factors contradict the findings of Karlamangla *et al.* (2010) that show a positive association between CVD risk factors and education levels.

The findings on cumulative 2 CVD risk factors are consistent with the findings of Karlamangla *et al.* (2010). Overall, we found that income and education are good predictors of cumulative CVD risk factors in Malaysia, which are in line with previous findings (Cooper *et al.*, 2000; Kim *et al.*, 2008; Winkleby *et al.*, 1992).

CHAPTER 6

CONCLUSION

6.1 Overview

Following the objectives of this study, we were able to diagnose interesting findings. First, on the status of the risk factors contributing to CVD based on socioeconomic background. Second, prediction of CVD risk profile based on demographic and SES of individuals. Third, evaluation of the mediation effect of income on the association between education level and cumulative CVDRF.

Seeking the first objective of this study, we found that people with low SES level suffer more from risk factors of smoking (i.e., inversely associated with education level), hypertension (i.e., inversely associated with education and income levels), diabetes (i.e., inversely related to education level), and hypercholesterolemia (i.e., inversely associated with income level). However, in men the prevalence of overweight/obesity and hypercholesterolemia were directly associated with social class (i.e., directly associated with education and income levels).

Responding to the second objective of this study, we estimated that in ten years the mean risk of CVD is higher in men comparing to women, and is greatest in Malays comparing to the other ethnic groups. In addition, the married and divorced individuals had the highest mean CVD risk, while residing in rural areas was associated with higher CVD risk. When the CVD risk was analyzed socioeconomically, there consistently was a greater mean CVD risk among people who had low social class (i.e., low income and education levels, and elementary occupations).

The mediation analysis of income level on the association of education level and cumulative CVD risk factors illustrated that in general income can partially affect the aforementioned association. This theoretical finding imply that manipulating income level among female and Malays in regard to CCVDRF1, and among tertiary educated males and rural residents in relation to CCVDRF2 may improve their experience of cumulative risk factors of CVD.

6.2 Synthesis of findings

Rapid modernization, industrialization, and urbanization in developing nations have been accompanied by increasing mortalities and morbidities due to cardiovascular related diseases. This unfortunate but preventable phenomenon has been a motive to conduct this study to dig deeply in the status of risk factors contributing to CVD, as well as estimating the future risk of CVDs based on different sociodemographic and socioeconomic characteristics of the residents of the country of Malaysia. In the end, I tried to suggest a possible socioeconomic intervention as a strong mediator to tackle future prevalence and more importantly incidents of CVDs in Malaysia.

This study encompasses a Malaysian representative data that was collected from randomly selected provinces between 2007 and 2010. A comprehensive socio-demographic, anthropometric and blood pressure measurements, and blood sampling to assess lipid and fasting blood glucose levels, as well as socioeconomic variables were collected by professionally trained research assistants and nurses supervised by a supervisor and a medical doctor respectively. The most important risk factors contributing to CVDs (i.e., smoking, hypertension, diabetes, hypercholesterolemia, and overweight/obesity) were diagnosed among respondents. The age-standardized prevalence rate of each risk factors was evaluated using population census data and with statistical software Stata V. 12. To assess future risk of CVD in each individual, the validated Framingham risk-scoring model has been employed. Subsequently, the ten-year risk scores were tabulated against all population determinants to diagnose trends among various classifications of sociodemographic and socioeconomic status variables. Finally using mediation process analysis, we presented a possible theoretical socioeconomic solution to alleviate the future incidents of CVDs.

Findings of this study implies that in all education and income levels more men smoke than women. There is an inverse relationship between hypertension prevalence and education level in both men and women indicating that people in higher social class are aware of smoking tobacco defects on health outcome. Although respondents with higher levels of education had lower prevalence of diabetes mellitus comparing to lower educational levels, but there was no obvious trend between educational level and diabetes risk factor. Except technically educated respondents, women in educational attainment levels were more overweight than men.

Results from income categories (i.e., low, middle, and high) were more straightforward comparing to the ones for educational attainment. For instance, we diagnosed inverse relationships between income level and risk factors of hypertension, diabetes mellitus, and hypercholesterolemia. Therefore, results indicated that when income level was decreasing an increasing prevalence of hypertension, diabetes, and hypercholesterolemia were seen among women. However, in men we found a direct association between the level of income and hypercholesterolemia and overweight/obesity prevalence. This implies that higher income men tend to be more hypercholesterolemic and/or overweight/obese.

The findings of the predicted ten-year risk of cardiovascular disease indicated interesting results. First, results showed that Malaysian men have higher risk of CVD. Second, among ethnic groups Malays had the greatest risk followed by others, Indians, and Chinese (lowest CVD risk). Among marital status categories, the greatest risk of CVD belonged to married respondents followed by divorced individuals. In addition, people living in rural areas had higher CVD risk average comparing to people who live in urban areas.

Evaluating CVD risk levels by SES variables, we found that the level of CVD risk was inversely associated with income level and educational attainment. This implies that Malaysian people who share lower SES levels are more exposed to risk of CVD in ten-years from now. In addition, the elementary occupational status, which requires no significant education and also earn not much money, had the highest risk of CVD.

Finally, we found that theoretically income level could mediate the association of educational attainment and cumulative CVD risk factors (i.e., CCVDRF1 and CCVDRF2). The greatest mediation effect of income level in CCVDRF1 was among secondary educated females (52%), Malays (44%), and in the whole respondents (37%). Whereas income accounted for 50, 48, and 42 percent of the mediation effect among tertiary educated males, overall sample respondents, and rural residents respectively in the association between education and CCVDRF2. The results show that low SES respondents will experience greater CVDR in ten years from now.

6.3 Implications for theory

We found an inverse association between income level and hypertension, diabetes and hypercholesterolemia risk factors in women, while in men there were direct relationships between income level and hypercholesterolemia and overweight/obesity risk factors. In addition, the ten-year CVD risk was negatively related to the income level in both men and women. We also found that income has a substantial effect in determination of SES level (i.e., educational attainment as the most important proxy) and CVD relationship (i.e., the mediation effect). These findings support the argument presented by Grossman (1972a) that an increment in income level increases the likelihood of individuals' investment (or demand) in health outcomes. Grossman (1972a) states that the individual's healthy time raises as income level increases as the individual will demand more in health investments. Therefore, the health investment demand has a direct association with income level. However, findings of men do not support Grossman (1972a)'s conclusion where increasing income levels raises the likelihood of being hypercholesterolemic and overweight/obese. These results suggest that men in higher income groups may be less physically active in their leisure time and/or have unhealthy dietary habits.

However, association of education and health outcomes was not following a vivid trend at the first glance, though in details inspection revealed interesting findings. For instance, in both genders individuals with higher education levels had lower rates of hypertension, diabetes, and overweight/obesity (except the technically educated respondents). In addition, people with higher education level tended to have lower ten-year risk which are in line with the conclusion results from Grossman (1972a). This implies that individuals with lower education levels are less aware of the cause-effect of lifestyle behaviors such as smoking tobacco, unhealthy dietary habits (e.g., sodium and fatty food intake), and physical inactivity. This finding further highlights the importance of education on health knowledge of individuals as it enhances the allocative and productive efficiency of producing health. Moreover, results from residential areas (i.e., rural residents have a higher ten-year risk comparing to urban residents) further endorses the fact that health behavior is much affected by information on health (Kenkel, 1991).

6.4 Implications for policy

The findings of this study suggest scientifically supported population-based interventions but in a channeled procedure to address the findings of this study. These interventions studied the Malaysian populations and intended to improve their health status and to prevent future mortalities and morbidities of CVDs.

First, there is an urgent need to address smoking cessation among men in Malaysia. The government led interventions can be channeled through newspapers as well as social media and broadcasting media. These interventions may follow the previously research backed method among Malaysians.

Second, as ageing has a direct association with hypertension (i.e., due to physiological effects on veins), interventions may specifically address elder people who suffer more from higher likelihood of being hypertensive. These interventions may include physical activity motivation and increasing awareness on sodium intake from unhealthy dietary habits. Previous studies in Malaysia showed that adherence to sodium intake reduction result in decreasing blood pressure levels among hypertensive individuals.

Third, several population-based interventional studies showed that in Malaysia diabetes could be intervened and/or prevented. An intervention policy which may be addressed by health policymakers is to increase awareness of individuals about the self-monitoring of blood glucose (SMBG) levels. This simple act was shown to significantly reduce the levels of HbA1c (i.e., Glycated hemoglobin) resulting in treatment of diabetes. This intervention policies must be spread among people with lower levels of education (had the highest prevalence of diabetes).

Forth, the overweight or obesity risk factors were most prevalent among people who had the lowest educational attainments. People who had higher education levels were presumably more aware of the risks of overweight and obesity and therefore had a lower likelihood to have these risk factors. Therefore, interventions should target Malaysians who have lower education level (i.e., from lower SES levels) and increase their awareness about the danger of these culprit risk factors. In addition to spreading information among these people, other drug therapies has been shown to significantly reduce BMI levels. Government of Malaysia may address these pharmacy led interventions for lower educational levels to decrease their BMI decreasing these risk factors. Moreover, other possible interventions may include dietary intake advice and promotions of physical activity among lower educational level individuals.

Fifth, as lower income women were more exposed to risk factors of hypertension, diabetes, and hypercholesterolemia, policies must address these risk factors focusing on women comparing to men. In addition, we found that Malaysians who were married and divorce had higher future of CVD risk that may exacerbate the fact that women are more exposed to the above-mentioned risk factors. Therefore, interventions should address specifically designed physical activity promotions for women who are house maker, unemployed or employed. Another possible intervention targeting women is the therapeutic lifestyle change (TLC) which may result in treatment of diabetes and hypercholesterolemia.

Sixth, to tackle high prevalence of hypercholesterolemia and overweight or obesity among high income men, policies should aim at improving physical activity among them and address them to invest in healthier lifestyle behaviors (i.e., eating healthier food and more physical activities).

Seventh, as the ten-year CVD risk is increasing by age, the interventional policies should focus more on elderly and spread information on preventing future CVDs treating their current risk factors and then avoiding high risk lifestyle behaviors.

Eighth, the future CVD risk is higher in men comparing to women. Therefore, government interventions must address the most important CVD risk factors among men (i.e., smoking and overweight/obesity) and then increase their awareness about the high risk behaviors to reduce the ten-year risk of CHD/CVD.

Ninth, as ethnic/race significantly predicts the ten-year CVD risk, government may lay separate ethnic/race intervention policies to tackle the future CVD risk for each ethnic groups in Malaysia. Furthermore, more focus must be devoted to Malays and others ethnic groups as they have the greatest future risk in the country.

Tenth, residential location has a big impact in determination of future CVD risk in Malaysia as rural residents have higher average CVD risk comparing to urban dwellers. This may be due to lack of awareness and knowledge about the high risk lifestyle behaviors (e.g., smoking rate is higher among rural residents). Therefore, information dissemination among rural residents may result in increasing their awareness of the risk factors contributing to CVD/CHD and therefore avoiding them by enhancing their lifestyle behaviors.

Eleventh, lower SES Malaysians (i.e., lower income and educational attainment levels) have worst figures of the predicted CVDs. Thus, public health policies must concentrate more on disadvantaged residential areas by spreading health information and promoting physical activity and healthy food intake among them. In addition, our results indicated that the people with lowest occupational status (i.e., elementary occupations) had the greatest CVD risk. Therefore, a workplace health promotion strategy must address the people with this occupation status.

Last, we found that income level mediates the association of education and cumulative CVD risk factors indicating that income level has an indirect and significant effect on this relationship. We suggest that policies focused on strata showing to be fully mediated by income level (i.e., tertiary educated males and rural residents in CCVDRF2) may result in enhancement of the risk factors of hypercholesterolemia and obesity.

6.5 Limitations

This study has some limitations that future studies should avoid. First, the use of particular education and income categories provide a crude estimate of SES. Second, although the data avert the effects of inflation, panel data is superior when analyzing causal factors. Nevertheless, the prevalence of CVD risk factors between high and low levels of SES is still evident, and the results show a need to address them when formulating preventive programs. Third, using a probability sampling method from all residential locations in both peninsular and east Malaysia may result in a more robust representative population of Malaysians. Besides, following ethnic structure of Malaysian population, the quota for each ethnic groups may be applied to ensure the ethnicity representativeness is also covered. Finally, since a local CVD or CHD risk prediction model in unavailable, we used a validated risk prediction model that may result in over- or under-prediction of the CVD risk.

6.6 Future studies

Future studies should account for all risk factors contributing to CVD. In addition, a local CVD/CHD risk estimation model considering all ethnic/race groups must be prepared to estimate the CVD risk with minimum deviation.

REFERENCES

Abegunde, D. O., Mathers, C. D., Adam, T., Ortegon, M., & Strong, K. (2007). The burden and costs of chronic diseases in low-income and middle-income countries. *Lancet, 370*(9603), 1929-1938. doi: 10.1016/S0140-6736(07)61696-1

Adler, N. E., Boyce, T., Chesney, M. A., Cohen, S., Folkman, S., Kahn, R. L., & Syme, S. L. (1994). Socioeconomic status and health. The challenge of the gradient. *American Psychologist, 49*(1), 15-24.

Adler, N. E., & Newman, K. (2002). Socioeconomic disparities in health: Pathways and policies. *Health Affairs, 21*(2), 60-76. doi: DOI 10.1377/hlthaff.21.2.60

Adler, N. E., & Ostrove, J. M. (1999). Socioeconomic status and health: What we know and what we don't. *Socioeconomic Status and Health in Industrial Nations, 896*(1), 3-15. doi: DOI 10.1111/j.1749-6632.1999.tb08101.x

Albert, M. A., Glynn, R. J., Buring, J., & Ridker, P. M. (2006). Impact of traditional and novel risk factors on the relationship between socioeconomic status and incident cardiovascular events. *Circulation, 114*(24), 2619-2626. doi: 10.1161/CIRCULATIONAHA.106.660043

Alberti, K. G., & Zimmet, P. Z. (1998). Definition, diagnosis and classification of diabetes mellitus and its complications. Part 1: diagnosis and classification of diabetes mellitus provisional report of a WHO consultation. *Diabetic Medicine, 15*(7), 539-553. doi: 10.1002/(SICI)1096-9136(199807)15:7<539::AID-DIA668>3.0.CO;2-S

Amal, N. M., Paramesarvathy, R., Tee, G. H., Gurpreet, K., & Karuthan, C. (2011). Prevalence of Chronic Illness and Health Seeking Behaviour in Malaysian Population: Results from the Third National Health Morbidity Survey (NHMS III) 2006. *Medical Journal of Malaysia, 66*(1), 36-41.

American Heart Association. (2011). Understand your risk of heart attack. Retrieved 21 August, 2013, from http://www.heart.org/HEARTORG/Conditions/HeartAttack/UnderstandYourRiskofHeartAttack/Understand-Your-Risk-of-Heart-Attack_UCM_002040_Article.jsp

American Psychological Association. (2014a). Education and socioeconomic status. Retrieved 15 June, 2014, from http://www.apa.org/pi/ses/resources/publications/factsheet-education.aspx

American Psychological Association. (2014b). Ethnic and Racial Minorities & Socioeconomic Status. Retrieved 15 June, 2014, from http://www.apa.org/pi/ses/resources/publications/factsheet-erm.aspx

Amiri, M., Majid, H. A., Hairi, F., Thangiah, N., Bulgiba, A., & Su, T. T. (2014). Prevalence and determinants of cardiovascular disease risk factors among the residents of urban community housing projects in Malaysia. *BMC Public Health, 14*, S3. doi: Artn S310.1186/1471-2458-14-S3-S3

Amplavanar, N. T., Gurpreet, K., Salmiah, M. S., & Odhayakumar, N. (2010). Prevalence of cardiovascular disease risk factors among attendees of the Batu 9, Cheras Health Centre, Selangor, Malaysia. *Medical Journal of Malaysia, 65*(3), 173.

Asia Pacific Cohort Studies Collaboration, Barzi, F., Patel, A., Gu, D., Sritara, P., Lam, T. H., . . . Woodward, M. (2007). Cardiovascular risk prediction tools for populations in Asia. *Journal of Epidemiology and Community Health, 61*(2), 115-121. doi: 10.1136/jech.2005.044842

Assmann, G., Cullen, P., & Schulte, H. (2002). Simple scoring scheme for calculating the risk of acute coronary events based on the 10-year follow-up of the prospective cardiovascular Munster (PROCAM) study. *Circulation, 105*(3), 310-315.

Assmann, G., Schulte, H., Cullen, P., & Seedorf, U. (2007). Assessing risk of myocardial infarction and stroke: new data from the Prospective Cardiovascular Münster (PROCAM) study‡. *European Journal of Clinical Investigation, 37*(12), 925-932.

Azmi, M. Y., Jr., Junidah, R., Siti Mariam, A., Safiah, M. Y., Fatimah, S., Norimah, A. K., . . . Tahir, A. (2009). Body Mass Index (BMI) of Adults: Findings of the Malaysian Adult Nutrition Survey (MANS). *Malaysian Journal of Nutrition, 15*(2), 97-119.

Barbeau, E. M., Krieger, N., & Soobader, M. J. (2004). Working class matters: socioeconomic disadvantage, race/ethnicity, gender, and smoking in NHIS 2000. *American Journal of Public Health, 94*(2), 269-278.

Baron, R. M., & Kenny, D. A. (1986). The moderator-mediator variable distinction in social psychological research: conceptual, strategic, and statistical considerations. *Journal of Personality and Social Psychology, 51*(6), 1173-1182.

Batty, G. D., & Leon, D. A. (2002). Socio-economic position and coronary heart disease risk factors in children and young people. Evidence from UK epidemiological studies. *European Journal of Public Health, 12*(4), 263-272.

Beaglehole, R. (1992). Cardiovascular disease in developing countries. *BMJ, 305*(6863), 1170-1171.

Biggerstaff, K. D., & Wooten, J. S. (2004). Understanding lipoproteins as transporters of cholesterol and other lipids. *Advances in Physiology Education, 28*(3), 105-106. doi: 10.1152/advan.00048.2003

Blane, D., Hart, C. L., Smith, G. D., Gillis, C. R., Hole, D. J., & Hawthorne, V. M. (1996). Association of cardiovascular disease risk factors with socioeconomic position during childhood and during adulthood. *BMJ, 313*(7070), 1434-1438.

Bovet, P., Gervasoni, J. P., Mkamba, M., Balampama, M., Lengeler, C., & Paccaud, F. (2008). Low utilization of health care services following screening for hypertension in Dar es Salaam (Tanzania): a prospective population-based study. *BMC Public Health, 8*, 407. doi: 10.1186/1471-2458-8-407

Brindle, P., Emberson, J., Lampe, F., Walker, M., Whincup, P., Fahey, T., & Ebrahim, S. (2003). Predictive accuracy of the Framingham coronary risk score in British men:

prospective cohort study. *BMJ, 327*(7426), 1267. doi: 10.1136/bmj.327.7426.1267

Brummett, B. H., Babyak, M. A., Singh, A., Jiang, R., Williams, R. B., Harris, K. M., & Siegler, I. C. (2013). Socioeconomic indices as independent correlates of C-reactive protein in the National Longitudinal Study of Adolescent Health. *Psychosomatic Medicine, 75*(9), 882-893. doi: 10.1097/PSY.0000000000000005

Bruthans, J. (2008). The role of social and economic factors in the prevention of cardiovascular disease. *Cor et Vasa, 50*(7-8), 309-312.

Buitrago, F., Calvo-Hueros, J. I., Canon-Barroso, L., Pozuelos-Estrada, G., Molina-Martinez, L., Espigares-Arroyo, M., . . . Lillo-Bravo, F. J. (2011). Original and REGICOR Framingham functions in a nondiabetic population of a Spanish health care center: a validation study. *Annals of Family Medicine, 9*(5), 431-438. doi: 10.1370/afm.1287

Cai, L., He, J., Song, Y., Zhao, K., & Cui, W. (2013). Association of obesity with socio-economic factors and obesity-related chronic diseases in rural southwest China. *Public Health, 127*(3), 247-251. doi: 10.1016/j.puhe.2012.12.027

Callow, A. D. (2006). Cardiovascular disease 2005--the global picture. *Vascular Pharmacology, 45*(5), 302-307. doi: 10.1016/j.vph.2006.08.010

Carmena, R., Duriez, P., & Fruchart, J. C. (2004). Atherogenic lipoprotein particles in atherosclerosis. *Circulation, 109*(23 Suppl 1), III2-7. doi: 10.1161/01.CIR.0000131511.50734.44

Castanho, V. S., Oliveira, L. S., Pinheiro, H. P., Oliveira, H. C., & de Faria, E. C. (2001). Sex differences in risk factors for coronary heart disease: a study in a Brazilian population. *BMC Public Health, 1*(1), 3.

Chaudhry, S., Fink, A., Gelberg, L., & Brook, R. (2003). Utilization of papanicolaou smears by South Asian women living in the United States. *Journal of General Internal Medicine, 18*(5), 377-384.

Cheah, W. L., Lee, P. Y., Khatijah, Y., & Rasidah, A. W. (2011). A preliminary study on the prevalence of cardiovascular disease risk factors in selected rural communities in samarahan and kuching division, sarawak, malaysia. *Malaysian Journal of Medical Sciences, 18*(2), 58-65.

Cheah, Y. K., & Naidu, B. M. (2012). Exploring factors influencing smoking behaviour in Malaysia. *Asian Pacific Journal of Cancer Prevention, 13*(4), 1125-1130.

Chee, H. L., Kandiah, M., Khalid, M., Shamsuddin, K., Jamaluddin, J., Nordin, N. A. M. M., . . . Osman, I. (2004). Body mass index and factors related to overweight among women workers in electronic factories in Peninsular Malaysia. *Asia Pacific Journal of Clinical Nutrition, 13*(3), 248-254.

Chia, Y. C. (2011). Review of tools of cardiovascular disease risk stratification: interpretation, customisation and application in clinical practice. *Singapore Medical Journal, 52*(2), 116-123.

Chia, Y. C., Gray, S. Y., Ching, S. M., Lim, H. M., & Chinna, K. (2015). Validation of the Framingham general cardiovascular risk score in a multiethnic Asian population: a retrospective cohort study. *BMJ Open, 5*(5), e007324. doi: 10.1136/bmjopen-2014-007324

Chia, Y. C., Jenkins, C. A., & Tang, S. Y. W. (2012). 318 Validation of the Framingham general cardiovascular risk prediction score in a multi-ethnic primary care cohort. *Journal of Hypertension, 30*, e93.

Chin, C. Y., & Pengal, S. (2009). Cardiovascular disease risk in a semirural community in Malaysia. *Asia-Pacific Journal of Public Health, 21*(4), 410-420. doi: 10.1177/1010539509343973

Choiniere, R., Lafontaine, P., & Edwards, A. C. (2000). Distribution of cardiovascular disease risk factors by socioeconomic status among Canadian adults. *Canadian Medical Association Journal, 162*(9), S13-S24.

Clark, A. M., DesMeules, M., Luo, W., Duncan, A. S., & Wielgosz, A. (2009). Socioeconomic status and cardiovascular disease: risks and implications for care. *Nature Reviews: Cardiology, 6*(11), 712-722. doi: 10.1038/nrcardio.2009.163

Claussen, B., Davey Smith, G., & Thelle, D. (2003). Impact of childhood and adulthood socioeconomic position on cause specific mortality: the Oslo Mortality Study. *Journal of Epidemiology and Community Health, 57*(1), 40-45.

Cohen, B., Stren, R., Montgomery, M. R., & Reed, H. E. (2003). *Cities Transformed:: Demographic Change and Its Implications in the Developing World*: National Academies Press.

Cole, M. A., & Neumayer, E. (2006). The impact of poor health on total factor productivity. *Journal of Development Studies, 42*(6), 918-938. doi: 10.1080/00220380600774681

Conroy, R. M., Pyorala, K., Fitzgerald, A. P., Sans, S., Menotti, A., De Backer, G., . . . group, S. p. (2003). Estimation of ten-year risk of fatal cardiovascular disease in Europe: the SCORE project. *European Heart Journal, 24*(11), 987-1003.

Cooper, J. A., Miller, G. J., & Humphries, S. E. (2005). A comparison of the PROCAM and Framingham point-scoring systems for estimation of individual risk of coronary heart disease in the Second Northwick Park Heart Study. *Atherosclerosis, 181*(1), 93-100. doi: 10.1016/j.atherosclerosis.2004.12.026

Cooper, R., Cutler, J., Desvigne-Nickens, P., Fortmann, S. P., Friedman, L., Havlik, R., . . . Thom, T. (2000). Trends and disparities in coronary heart disease, stroke, and other cardiovascular diseases in the United States: findings of the national conference on cardiovascular disease prevention. *Circulation, 102*(25), 3137-3147.

Corcoran, J., & Nichols-Casebolt, A. (2004). Risk and resilience ecological framework for assessment and goal formulation. *Child and Adolescent Social Work Journal, 21*(3), 211-235.

Cornaz, S., Taffe, P., & Santos-Eggimann, B. (2009). Life-course socioeconomic environment and health risk behaviours. A multilevel small-area analysis of young-old persons in an urban neighbourhood in Lausanne, Switzerland. *Health Place, 15*(1), 273-283. doi: 10.1016/j.healthplace.2008.05.007

Corsi, D. J., Subramanian, S. V., Chow, C. K., McKee, M., Chifamba, J., Dagenais, G., . . . Yusuf, S. (2013). Prospective Urban Rural Epidemiology (PURE) study: Baseline characteristics of the household sample and comparative analyses with national data in 17 countries. *American Heart Journal, 166*(4), 636-646 e634. doi: 10.1016/j.ahj.2013.04.019

Cutter, J., Tan, B. Y., & Chew, S. K. (2001). Levels of cardiovascular disease risk factors in Singapore following a national intervention programme. *Bulletin of the World Health Organization, 79*(10), 908-915.

D'Agostino, R. B., Sr., Grundy, S., Sullivan, L. M., Wilson, P., & Group, C. H. D. R. P. (2001). Validation of the Framingham coronary heart disease prediction scores: results of a multiple ethnic groups investigation. *JAMA, 286*(2), 180-187.

D'Agostino, R. B., Sr., Vasan, R. S., Pencina, M. J., Wolf, P. A., Cobain, M., Massaro, J. M., & Kannel, W. B. (2008). General cardiovascular risk profile for use in primary care: the Framingham Heart Study. *Circulation, 117*(6), 743-753. doi: 10.1161/CIRCULATIONAHA.107.699579

Damiani, G., Federico, B., Bianchi, C. B., Ronconi, A., Basso, D., Fiorenza, S., & Sassi, F. (2011). Socio-economic status and prevention of cardiovascular disease in Italy: evidence from a national health survey. *European Journal of Public Health, 21*(5), 591-596. doi: 10.1093/eurpub/ckq075

Dantas, A. P., Jimenez-Altayo, F., & Vila, E. (2012). Vascular aging: facts and factors. *Frontiers in Physiology, 3*, 325. doi: 10.3389/fphys.2012.00325

Department of Statistics Malaysia. (2013a). Codes & Classifications. Retrieved 01.08.2013, from http://www.statistics.gov.my/portal/index.php?option=com_content&view=article&id=1492&Itemid=99&lang=en

Department of Statistics Malaysia. (2013b). Population Distribution And Basic Demographic Characteristic Report 2010 (pp. 15-17). http://www.statistics.gov.my/portal/index.php?option=com_content&id=1215&Itemid=89&lang=en.

Diez-Roux, A. V., Link, B. G., & Northridge, M. E. (2000). A multilevel analysis of income inequality and cardiovascular disease risk factors. *Social Science and Medicine, 50*(5), 673-687.

Din-Dzietham, R., Liao, D., Diez-Roux, A., Nieto, F. J., Paton, C., Howard, G., . . . Tyroler, H. A. (2000). Association of educational achievement with pulsatile arterial diameter change of the common carotid artery: the Atherosclerosis Risk in Communities (ARIC) Study, 1987-1992. *American Journal of Epidemiology, 152*(7), 617-627. doi: 10.1093/aje/152.7.617

Dubow, E. F., Edwards, S., & Ippolito, M. F. (1997). Life stressors, neighborhood disadvantage, and resources: a focus on inner-city children's adjustment. *Journal of Clinical Child Psychology, 26*(2), 130-144. doi: 10.1207/s15374424jccp2602_2

Durrington, P. (2003). Dyslipidaemia. *Lancet, 362*(9385), 717-731. doi: 10.1016/S0140-6736(03)14234-1

Eagle, T. F., Sheetz, A., Gurm, R., Woodward, A. C., Kline-Rogers, E., Leibowitz, R., . . . Eagle, K. A. (2012). Understanding childhood obesity in America: linkages between household income, community resources, and children's behaviors. *American Heart Journal, 163*(5), 836-843. doi: 10.1016/j.ahj.2012.02.025

Economic Planning Unit Malaysia. (2013). Household Income & Poverty. Retrieved 20.08.2013, from http://www.epu.gov.my/en/household-income-poverty;jsessionid=9DDF39109601FE21030AD5461AE49660

Empana, J. P., Ducimetiere, P., Arveiler, D., Ferrieres, J., Evans, A., Ruidavets, J. B., . . . Group, P. S. (2003). Are the Framingham and PROCAM coronary heart disease risk functions applicable to different European populations? The PRIME Study. *European Heart Journal, 24*(21), 1903-1911.

Ezeamama, A. E., Viali, S., Tuitele, J., & McGarvey, S. T. (2006). The influence of socioeconomic factors on cardiovascular disease risk factors in the context of economic development in the Samoan archipelago. *Social Science and Medicine, 63*(10), 2533-2545. doi: 10.1016/j.socscimed.2006.06.023

Falkstedt, D., & Hemmingsson, T. (2011). Educational level and coronary heart disease: a study of potential confounding from factors in childhood and adolescence based on the Swedish 1969 conscription cohort. *Annals of Epidemiology, 21*(5), 336-342. doi: 10.1016/j.annepidem.2010.12.005

Federman, A. D., Adams, A. S., Ross-Degnan, D., Soumerai, S. B., & Ayanian, J. Z. (2001). Supplemental insurance and use of effective cardiovascular drugs among elderly Medicare beneficiaries with coronary heart disease. *JAMA, 286*(14), 1732-1739. doi: DOI 10.1001/jama.286.14.1732

Finegold, J. A., Asaria, P., & Francis, D. P. (2013). Mortality from ischaemic heart disease by country, region, and age: statistics from World Health Organisation and United Nations. *International Journal of Cardiology, 168*(2), 934-945. doi: 10.1016/j.ijcard.2012.10.046

Fiscella, K., & Franks, P. (2004). Should years of schooling be used to guide treatment of coronary risk factors? *The Annals of Family Medicine, 2*(5), 469-473.

Fiscella, K., Franks, P., Gold, M. R., & Clancy, C. M. (2000). Inequality in quality: addressing socioeconomic, racial, and ethnic disparities in health care. *JAMA, 283*(19), 2579-2584.

Fiscella, K., & Holt, K. (2008). Racial disparity in hypertension control: tallying the death toll. *Annals of Family Medicine, 6*(6), 497-502. doi: 10.1370/afm.873

Fiscella, K., & Tancredi, D. (2008). Socioeconomic status and coronary heart disease risk prediction. *JAMA, 300*(22), 2666-2668. doi: 10.1001/jama.2008.792

Fiscella, K., Tancredi, D., & Franks, P. (2009). Adding socioeconomic status to Framingham scoring to reduce disparities in coronary risk assessment. *American Heart Journal, 157*(6), 988-994. doi: 10.1016/j.ahj.2009.03.019

Fuster, V., & Kelly, B. B. (2010). Committee on preventing the global epidemic of cardiovascular disease: meeting the challenges in developing countries.

Gaziano, T. A., Opie, L. H., & Weinstein, M. C. (2006). Cardiovascular disease prevention with a multidrug regimen in the developing world: a cost-effectiveness analysis. *Lancet, 368*(9536), 679-686. doi: 10.1016/S0140-6736(06)69252-0

Gebreab, S. Y., Diez-Roux, A. V., Hickson, D. A., Boykin, S., Sims, M., Sarpong, D. F., . . . Wyatt, S. B. (2012). The contribution of stress to the social patterning of clinical and subclinical CVD risk factors in African Americans: the Jackson Heart Study. *Social Science and Medicine, 75*(9), 1697-1707. doi: 10.1016/j.socscimed.2012.06.003

Giovino, G. A., Mirza, S. A., Samet, J. M., Gupta, P. C., Jarvis, M. J., Bhala, N., . . . Morton, J. (2012). Tobacco use in 3 billion individuals from 16 countries: an analysis of nationally representative cross-sectional household surveys. *Lancet, 380*(9842), 668-679.

Goode, E. (1999). For good health, it helps to be rich and important. *New York Times, 1*, F1.

Goodman, E., McEwen, B. S., Huang, B., Dolan, L. M., & Adler, N. E. (2005). Social inequalities in biomarkers of cardiovascular risk in adolescence. *Psychosomatic Medicine, 67*(1), 9-15. doi: 10.1097/01.psy.0000149254.36133.1a

Govil, S. R., Weidner, G., Merritt-Worden, T., & Ornish, D. (2009). Socioeconomic status and improvements in lifestyle, coronary risk factors, and quality of life: the Multisite Cardiac Lifestyle Intervention Program. *American Journal of Public Health, 99*(7), 1263-1270. doi: 10.2105/AJPH.2007.132852

Gregory, C. O., Dai, J., Ramirez-Zea, M., & Stein, A. D. (2007). Occupation is more important than rural or urban residence in explaining the prevalence of metabolic and cardiovascular disease risk in Guatemalan adults. *Journal of Nutrition, 137*(5), 1314-1319.

Grossman, M. (1972a). The demand for health: a theoretical and empirical investigation. *NBER Books*.

Grossman, M. (1972b). On the concept of health capital and the demand for health. *The journal of political economy, 80*(2), 223-255.

Grotto, I., Huerta, M., Grossman, E., & Sharabi, Y. (2007). Relative impact of socioeconomic status on blood pressure lessons from a large-scale survey of young adults. *American Journal of Hypertension, 20*(11), 1140-1145. doi: 10.1016/j.amjhyper.2007.06.004

Grundy, S. M., Bilheimer, D., Chait, A., Clark, L. T., Denke, M., Havel, R. J., . . . Kreisberg, R. A. (1993). Summary of the second report of the National Cholesterol Education Program (NCEP) Expert Panel on detection, evaluation, and treatment of high blood cholesterol in adults (Adult Treatment Panel II). *JAMA, 269*(23), 3015-3023.

Gwatkin, D. R. (2002). Reducing health inequalities in developing countries. *Oxford textbook of public health, 3*, 1791-1810.

Hamer, M., & Chida, Y. (2008). Active commuting and cardiovascular risk: a meta-analytic review. *Preventive Medicine, 46*(1), 9-13. doi: 10.1016/j.ypmed.2007.03.006

Hedblad, B., Jonsson, S., Nilsson, P., Engstrom, G., Berglund, G., & Janzon, L. (2002). Obesity and myocardial infarction--vulnerability related to occupational level and marital status. A 23-year follow-up of an urban male Swedish population. *Journal of Internal Medicine, 252*(6), 542-550. doi: 10.1046/j.1365-2796.2002.01069.x

Heidenreich, P. A., Trogdon, J. G., Khavjou, O. A., Butler, J., Dracup, K., Ezekowitz, M. D., . . . Quality, I. C. (2011). Forecasting the Future of Cardiovascular Disease in the United States A Policy Statement From the American Heart Association. *Circulation, 123*(8), 933-944. doi: 10.1161/CIR.0b013e31820a55f5

Hippisley-Cox, J., Coupland, C., Vinogradova, Y., Robson, J., May, M., & Brindle, P. (2007). Derivation and validation of QRISK, a new cardiovascular disease risk score for the United Kingdom: prospective open cohort study. *BMJ, 335*(7611), 136. doi: 10.1136/bmj.39261.471806.55

Hippisley-Cox, J., Coupland, C., Vinogradova, Y., Robson, J., Minhas, R., Sheikh, A., & Brindle, P. (2008). Predicting cardiovascular risk in England and Wales: prospective derivation and validation of QRISK2. *BMJ, 336*(7659), 1475-1482. doi: 10.1136/bmj.39609.449676.25

Hoang, V. M., Byass, P., Dao, L. H., Nguyen, T., & Wall, S. (2007). Risk factors for chronic disease among rural Vietnamese adults and the association of these factors with sociodemographic variables: findings from the WHO STEPS survey in rural Vietnam, 2005. *Preventing Chronic Disease, 4*(2), A22-A22.

Hong, C. Y., Chia, K. S., Hughes, K., & Ling, S. L. (2004). Ethnic differences among Chinese, Malay and Indian patients with type 2 diabetes mellitus in Singapore. *Singapore Medical Journal, 45*(4), 154-160.

Hosmer, D. W., Taber, S., & Lemeshow, S. (1991). The importance of assessing the fit of logistic regression models: a case study. *American Journal of Public Health, 81*(12), 1630-1635.

House, J. S., & Williams, D. R. (2000). Understanding and reducing socioeconomic and racial/ethnic disparities in health. *Promoting health: Intervention strategies from social and behavioral research*, 81-124.

Howard, B. V., & Wylie-Rosett, J. (2002). Sugar and cardiovascular disease - A statement for healthcare professionals from the committee on nutrition of the council on nutrition, physical activity, and metabolism of the American Heart Association. *Circulation, 106*(4), 523-527. doi: 10.1161/01.Cir.0000019552.77778.04

Hubert, H. B., Feinleib, M., Mcnamara, P. M., & Castelli, W. P. (1983). Obesity as an Independent Risk Factor for Cardiovascular-Disease - a 26-Year Follow-up of Participants in the Framingham Heart-Study. *Circulation, 67*(5), 968-977.

Huff, N. C., & Gray, D. (2001). Coronary heart disease inequalities: deaths and the socio-economic environment in Nottingham, England. *Health Place, 7*(1), 57-61.

Huxley, R. R., & Woodward, M. (2011). Cigarette smoking as a risk factor for coronary heart disease in women compared with men: a systematic review and meta-analysis of prospective cohort studies. *Lancet, 378*(9799), 1297-1305. doi: 10.1016/S0140-6736(11)60781-2

Ismail, M. N., Chee, S. S., Nawawi, H., Yusoff, K., Lim, T. O., & James, W. P. (2002). Obesity in Malaysia. *Obesity Reviews, 3*(3), 203-208.

Ismail, M. N., & Vickneswary, E. N. (1999). *Prevalence of obesity in Malaysia: data from three ethnic populations. Country Report at the Asian BMI.* Paper presented at the Obesity Workshop, Milan, Italy.

Jani, B., & Rajkumar, C. (2006). Ageing and vascular ageing. *Postgraduate Medical Journal, 82*(968), 357-362. doi: 10.1136/pgmj.2005.036053

Jenkinson, C., Peto, V., Fitzpatrick, R., Greenhall, R., & Hyman, N. (1995). Self-reported functioning and well-being in patients with Parkinson's disease: comparison of the short-form health survey (SF-36) and the Parkinson's Disease Questionnaire (PDQ-39). *Age and Ageing, 24*(6), 505-509.

Jha, P., & Chaloupka, F. J. (2000). *Tobacco control in developing countries*: Oxford University Press.

Joint National Committee. (1993). The fifth report of the Joint National Committee on detection, evaluation, and treatment of high blood pressure (JNC-V). *Archives of Internal Medicine, 153*, 154-183.

Jousilahti, P., Vartiainen, E., Tuomilehto, J., & Puska, P. (1999). Sex, age, cardiovascular risk factors, and coronary heart disease: a prospective follow-up study of 14 786 middle-aged men and women in Finland. *Circulation, 99*(9), 1165-1172.

Karlamangla, A. S., Merkin, S. S., Crimmins, E. M., & Seeman, T. E. (2010). Socioeconomic and ethnic disparities in cardiovascular risk in the United States, 2001-2006. *Annals of Epidemiology, 20*(8), 617-628. doi: 10.1016/j.annepidem.2010.05.003

Karlson, K. B., Holm, A., & Breen, R. (2012). Comparing Regression Coefficients Between Same-sample Nested Models Using Logit and Probit: A New Method. *Sociological Methodology, 42*(1), 286-313. doi: Doi 10.1177/0081175012444861

Kenkel, D. S. (1991). Health Behavior, Health Knowledge, and Schooling. *Journal of Political Economy, 99*(2), 287-305. doi: Doi 10.1086/261751

Khoo, K. L., Tan, H., & Khoo, T. H. (1991). Cardiovascular mortality in Peninsular Malaysia: 1950-1989. *Medical Journal of Malaysia, 46*(1), 7-20.

Kim, D., Kawachi, I., Hoorn, S. V., & Ezzati, M. (2008). Is inequality at the heart of it? Cross-country associations of income inequality with cardiovascular diseases and risk factors. *Social Science and Medicine, 66*(8), 1719-1732. doi: 10.1016/j.socscimed.2007.12.030

King, J. E. (2006). *Gender equity in higher education: 2006*: American Council on Education.

Kivimaki, M., Gimeno, D., Ferrie, J. E., Batty, G. D., Oksanen, T., Jokela, M., . . . Vahtera, J. (2009). Socioeconomic position, psychosocial work environment and cerebrovascular disease among women: the Finnish public sector study. *International Journal of Epidemiology, 38*(5), 1265-1271. doi: 10.1093/ije/dyn373

Kivimaki, M., Leino-Arjas, P., Luukkonen, R., Riihimaki, H., Vahtera, J., & Kirjonen, J. (2002). Work stress and risk of cardiovascular mortality: prospective cohort study of industrial employees. *BMJ, 325*(7369), 857.

Kivimaki, M., Nyberg, S. T., Batty, G. D., Fransson, E. I., Heikkila, K., Alfredsson, L., . . . Consortium, I.-W. (2012). Job strain as a risk factor for coronary heart disease: a collaborative meta-analysis of individual participant data. *Lancet, 380*(9852), 1491-1497. doi: 10.1016/S0140-6736(12)60994-5

Klein, B. E., Klein, R., & Lee, K. E. (1997). Cardiovascular disease, selected cardiovascular disease risk factors, and age-related cataracts: the Beaver Dam Eye Study. *American Journal of Ophthalmology, 123*(3), 338-346.

Klein, R. J., & Schoenborn, C. A. (2001). Age Adjustment using the 2000 projected U.S. population *Healthy People Statistical Notes* (Vol. 20). Hyattsville, Maryland: National Center for Health Statistics.

Ko, G. T., Chan, J. C., Cockram, C. S., & Woo, J. (1999). Prediction of hypertension, diabetes, dyslipidaemia or albuminuria using simple anthropometric indexes in Hong Kong Chinese. *International Journal of Obesity and Related Metabolic Disorders, 23*(11), 1136-1142.

Kontush, A., & Chapman, M. J. (2006). Antiatherogenic small, dense HDL—guardian angel of the arterial wall? *Nature Clinical Practice Cardiovascular Medicine, 3*(3), 144-153.

Kunst, A. E., del Rios, M., Groenhof, F., Mackenbach, J. P., & European Union Working Grp Socioeconomic Inequa. (1998). Socioeconomic inequalities in stroke mortality among middle-aged men - An international overview. *Stroke, 29*(11), 2285-2291.

Lawlor, D. A., Tooth, L., Lee, C., & Dobson, A. (2005). A comparison of the association between socioeconomic position and cardiovascular disease risk factors in three age cohorts of Australian women: findings from the Australian Longitudinal

Study on Women's Health. *J Public Health (Oxf), 27*(4), 378-387. doi: 10.1093/pubmed/fdi052

Lee, P., & Paxman, D. (1997). Reinventing public health. *Annual Review of Public Health, 18*(1), 1-35. doi: 10.1146/annurev.publhealth.18.1.1

Leigh, A., Jencks, C., & Smeeding, T. (2009). Health and economic inequality. *The Oxford handbook of economic inequality*, 384-405.

Lemeshow, S., & Hosmer, D. W., Jr. (1982). A review of goodness of fit statistics for use in the development of logistic regression models. *American Journal of Epidemiology, 115*(1), 92-106.

Letchuman, G. R., Wan Nazaimoon, W. M., Wan Mohamad, W. B., Chandran, L. R., Tee, G. H., Jamaiyah, H., . . . Ahmad Faudzi, Y. (2010). Prevalence of diabetes in the Malaysian National Health Morbidity Survey III 2006. *Medical Journal of Malaysia*, *65*(3), 180-186.

Liberatos, P., Link, B. G., & Kelsey, J. L. (1988). The measurement of social class in epidemiology. *Epidemiologic Reviews*, *10*(1), 87-121.

Liew, Y. M., Zulkifli, A., Tan, H., Ho, Y. N., & Khoo, K. L. (1997). Health status of senior civil servants in Kuala Lumpur. *Medical Journal of Malaysia, 52*(4), 348-366.

Lim, S. S., Gaziano, T. A., Gakidou, E., Reddy, K. S., Farzadfar, F., Lozano, R., & Rodgers, A. (2007). Prevention of cardiovascular disease in high-risk individuals in low-income and middle-income countries: health effects and costs. *Lancet, 370*(9604), 2054-2062. doi: 10.1016/S0140-6736(07)61699-7

Liu, J., Hong, Y., D'Agostino, R. B., Sr., Wu, Z., Wang, W., Sun, J., . . . Zhao, D. (2004a). Predictive value for the Chinese population of the Framingham CHD risk assessment tool compared with the Chinese Multi-Provincial Cohort Study. *JAMA, 291*(21), 2591-2599. doi: 10.1001/jama.291.21.2591

Liu, J., Hong, Y. L., D'Agostino, R. B., Wu, Z. S., Wang, W., Sun, J. Y., . . . Zhao, D. (2004b). Predictive value for the Chinese population of the Framingham CHD risk assessment tool compared with the Chinese multi-provincial cohort study. *Jama-Journal of the American Medical Association, 291*(21), 2591-2599. doi: DOI 10.1001/jama.291.21.2591

Loucks, E. B., Lynch, J. W., Pilote, L., Fuhrer, R., Almeida, N. D., Richard, H., . . . Benjamin, E. J. (2009). Life-course socioeconomic position and incidence of coronary heart disease: the Framingham Offspring Study. *American Journal of Epidemiology, 169*(7), 829-836. doi: 10.1093/aje/kwn403

Lynch, J. W., Kaplan, G. A., Cohen, R. D., Tuomilehto, J., & Salonen, J. T. (1996). Do cardiovascular risk factors explain the relation between socioeconomic status, risk of all-cause mortality, cardiovascular mortality, and acute myocardial infarction? *American Journal of Epidemiology, 144*(10), 934-942.

Lyngbaek, S., Marott, J. L., Sehestedt, T., Hansen, T. W., Olsen, M. H., Andersen, O., . . . Jeppesen, J. (2013). Cardiovascular risk prediction in the general population with use of suPAR, CRP, and Framingham Risk Score. *International Journal of Cardiology, 167*(6), 2904-2911. doi: 10.1016/j.ijcard.2012.07.018

Mackay, J., & Mensah, G. A. (2004). The atlas of heart disease and stroke. *The atlas of heart disease and stroke*.

MacKinnon, D. P., Fairchild, A. J., & Fritz, M. S. (2007). Mediation analysis. *Annual Review of Psychology, 58*, 593-614. doi: 10.1146/annurev.psych.58.110405.085542

Macleod, J., Davey Smith, G., Metcalfe, C., & Hart, C. (2005). Is subjective social status a more important determinant of health than objective social status? Evidence from a prospective observational study of Scottish men. *Social Science and Medicine, 61*(9), 1916-1929. doi: 10.1016/j.socscimed.2005.04.009

Majed, B., Tafflet, M., Kee, F., Haas, B., Ferrieres, J., Montaye, M., . . . group, P. s. (2013). External validation of the 2008 Framingham cardiovascular risk equation for CHD and stroke events in a European population of middle-aged men. The PRIME study. *Preventive Medicine, 57*(1), 49-54. doi: 10.1016/j.ypmed.2013.04.003

Marmot, M. (1993). Epidemiological approach to the explanation of social differentiation in mortality: the Whitehall studies. *Sozial- und Praventivmedizin, 38*(5), 271-279.

Marmot, M. (1995). Social differentials in mortality: the Whitehall studies. 243-260.

Marmot, M. G., Bosma, H., Hemingway, H., Brunner, E., & Stansfeld, S. (1997). Contribution of job control and other risk factors to social variations in coronary heart disease incidence. *Lancet, 350*(9073), 235-239.

Marrugat, J., Subirana, I., Comin, E., Cabezas, C., Vila, J., Elosua, R., . . . Investigators, V. (2007). Validity of an adaptation of the Framingham cardiovascular risk function: the VERIFICA Study. *Journal of Epidemiology and Community Health, 61*(1), 40-47. doi: 10.1136/jech.2005.038505

Marrugat, J., Subirana, I., Ramos, R., Vila, J., Marin-Ibanez, A., Guembe, M. J., . . . Investigators, F. (2014). Derivation and validation of a set of 10-year cardiovascular risk predictive functions in Spain: the FRESCO Study. *Preventive Medicine, 61*, 66-74. doi: 10.1016/j.ypmed.2013.12.031

Maselko, J., Bates, L. M., Avendano, M., & Glymour, M. M. (2009). The intersection of sex, marital status, and cardiovascular risk factors in shaping stroke incidence: results from the health and retirement study. *Journal of the American Geriatrics Society, 57*(12), 2293-2299. doi: 10.1111/j.1532-5415.2009.02555.x

Maton, A. (1997). *Human biology and health*: Prentice Hall.

Menotti, A., Lanti, M., Puddu, P. E., & Kromhout, D. (2000). Coronary heart disease incidence in northern and southern European populations: a reanalysis of the seven countries study for a European coronary risk chart. *Heart, 84*(3), 238-244.

Metcalf, P., Scragg, R., & Davis, P. (2007). Relationship of different measures of socioeconomic status with cardiovascular disease risk factors and lifestyle in a New Zealand workforce survey. *New Zealand Medical Journal, 120*(1248), U2392.

Ministry of Health Malaysia. (1986). The First National Health and Morbidity Survey (NHMS I). Kuala Lumpur, Malaysia.: Institute of Public Health.

Ministry of Health Malaysia. (1996a). Report of the Second National Health and Morbidity Survey (NHMS II). Kuala Lumpur, Malaysia.: Institute of Public Health.

Ministry of Health Malaysia. (1996b). The Second National Health and Morbidity Survey (NHMS II). Kuala Lumpur, Malaysia.: Institute of Public Health.

Ministry of Health Malaysia. (2004). Malaysian Clinical Practice Guidelines of Obesity. Retrieved Feb 26, 2013, from http://www.moh.gov.my/attachments/3932.pdf

Ministry of Health Malaysia. (2006a). Report of the Third National Health and Morbidity Survey (NHMS III). Kuala Lumpur, Malaysia.: Institute of Public Health.

Ministry of Health Malaysia. (2006b). The Third National Health and Morbidity Survey (NHMS III) Kuala Lumpur, Malaysia.: Institute of Public Health.

Ministry of Health Malaysia. (2011). The Fourth National Health and Morbidity Survey (NHMS IV). Kuala Lumpur, Malaysia.: Institute of Public Health.

Ministry of Health Malaysia. (2013). Health Facts 2005. Retrieved 2 April, 2015, from http://vlib.moh.gov.my/cms/documentstorage/com.tms.cms.document.Document_3ed88777-c0a81049-874bd300-b0870a96/2005.pdf

Ministry of Health Malaysia. (2015). The Fifth National Health and Morbidity Survey (NHMS V). Kuala Lumpur, Malaysia: Ministry of Health Malaysia.

Nair, C., Colburn, H., McLean, D., & Petrasovits, A. (1988). Cardiovascular disease in Canada. *Health Reports, 1*(1), 1-22.

National Center for Educational Statistics. (2013). Improving the Measurement of Socioeconomic Status. Retrieved 5 December, 2014, from http://nces.ed.gov/nationsreportcard/researchcenter/socioeconomic_factors.aspx

National Public Radio. (2014). Diabetes Raises Women's Risk Of Heart Disease More Than For Men. Retrieved 10 December, 2014, from http://www.npr.org/blogs/health/2014/05/22/314869923/diabetes-raises-womens-risk-of-heart-disease-more-than-for-men

Neter, J., Kutner, M. H., Nachtsheim, C. J., & Wasserman, W. (1996). *Applied linear statistical models* (Vol. 4): Irwin Chicago.

Ng, K. K., & Chia, Y. C. (2008). Utility of Framingham's Model in Predicting Coronary Heart Disease Risk in Malaysia, a Developing Country. *Atherosclerosis Supplements, 9*(1), 92-92. doi: Doi 10.1016/S1567-5688(08)70367-2

NHANES. (2013). Age Standardization and Population Counts. *Continuous NHANES web tutorial.* Retrieved 1 June, 2013, from http://www.cdc.gov/nchs/tutorials/NHANES/NHANESAnalyses/agestandardization/age_standardization_intro.htm

O'Donnell, C. J., & Elosua, R. (2008). [Cardiovascular risk factors. Insights from Framingham Heart Study]. *Revista Española de Cardiología, 61*(3), 299-310. doi: 10.1016/s1885-5857(08)60118-8

Pan, W. H., Flegal, K. M., Chang, H. Y., Yeh, W. T., Yeh, C. J., & Lee, W. C. (2004). Body mass index and obesity-related metabolic disorders in Taiwanese and US whites and blacks: implications for definitions of overweight and obesity for Asians. *American Journal of Clinical Nutrition, 79*(1), 31-39.

Peduzzi, P., Concato, J., Kemper, E., Holford, T. R., & Feinstein, A. R. (1996). A simulation study of the number of events per variable in logistic regression analysis. *Journal of Clinical Epidemiology, 49*(12), 1373-1379.

Peto, R., Darby, S., Deo, H., Silcocks, P., Whitley, E., & Doll, R. (2000). Smoking, smoking cessation, and lung cancer in the UK since 1950: combination of national statistics with two case-control studies. *British Medical Journal, 321*(7257), 323-329. doi: DOI 10.1136/bmj.321.7257.323

Peto, R., Lopez, A. D., Boreham, J., Thun, M., Heath, C., Jr., & Doll, R. (1996). Mortality from smoking worldwide. *British Medical Bulletin, 52*(1), 12-21.

Pocock, S. J., Shaper, A. G., Cook, D. G., Phillips, A. N., & Walker, M. (1987). Social class differences in ischaemic heart disease in British men. *Lancet, 2*(8552), 197-201.

Preacher, K. J., & Hayes, A. F. (2004). SPSS and SAS procedures for estimating indirect effects in simple mediation models. *Behavior Research Methods, Instruments, & Computers, 36*(4), 717-731.

PURE Investigators. (2007). Protocol of A Prospective Cohort Study to Track Changing Lifestyles, Risk Factors and Chronic Disease in Urban and Rural Areas of: Argentina, Bangladesh, Brazil, Canada, Chile, China, Colombia, India, Iran, Malaysia, Pakistan, Poland, South Africa, Sweden, Tanzania, Turkey, UAE, Zimbabwe. Retrieved 23 Feb, 2016, from http://www2.phri.ca/pure/baseline-docs/Protocol_International_Sep2007.pdf

Rampal, L., Rampal, S., Azhar, M. Z., & Rahman, A. R. (2008). Prevalence, awareness, treatment and control of hypertension in Malaysia: a national study of 16,440 subjects. *Public Health, 122*(1), 11-18. doi: 10.1016/j.puhe.2007.05.008

Rampal, S., Rampal, L., Rahmat, R., Zain, A. M., Yap, Y. G., Mohamed, M., & Taha, M. (2010). Variation in the prevalence, awareness, and control of diabetes in a multiethnic population: a nationwide population study in Malaysia. *Asia-Pacific Journal of Public Health, 22*(2), 194-202. doi: 10.1177/1010539509334816

Rasiah, R., Yusoff, K., Mohammadreza, A., Manikam, R., Tumin, M., Chandrasekaran, S. K., . . . Bakar, N. A. (2013). Cardiovascular disease risk factors and socioeconomic variables in a nation undergoing epidemiologic transition. *BMC Public Health, 13*(1), 886. doi: 10.1186/1471-2458-13-886

Raymond, S. U., Leeder, S., & Greenberg, H. M. (2006). Obesity and cardiovascular disease in developing countries: a growing problem and an economic threat. *Current Opinion in Clinical Nutrition and Metabolic Care, 9*(2), 111-116. doi: 10.1097/01.mco.0000214568.52192.91

Reddy, K. S., Prabhakaran, D., Jeemon, P., Thankappan, K. R., Joshi, P., Chaturvedi, V., . . . Ahmed, F. (2007). Educational status and cardiovascular risk profile in Indians. *Proceedings of the National Academy of Sciences of the United States of America, 104*(41), 16263-16268. doi: 10.1073/pnas.0700933104

Ridker, P. M., Buring, J. E., Rifai, N., & Cook, N. R. (2007). Development and validation of improved algorithms for the assessment of global cardiovascular risk in women: the Reynolds Risk Score. *JAMA, 297*(6), 611-619. doi: 10.1001/jama.297.6.611

Rodgers, A. (2003). A cure for cardiovascular disease? Combination treatment has enormous potential, especially in developing countries. *BMJ, 326*(7404), 1407-1408. doi: 10.1136/bmj.326.7404.1407

Rose, G., & Marmot, M. G. (1981). Social class and coronary heart disease. *British Heart Journal, 45*(1), 13-19.

Rutledge, T., Reis, S. E., Olson, M., Owens, J., Kelsey, S. F., Pepine, C. J., . . . Matthews, K. A. (2003). Socioeconomic status variables predict cardiovascular disease risk factors and prospective mortality risk among women with chest pain. The WISE Study. *Behavior Modification, 27*(1), 54-67.

Saegert, S. C., Adler, N. E., Bullock, H. E., Cauce, A. M., Liu, W. M., & Wyche, K. F. (2007). Report of the APA task force on socioeconomic status. *Washington, DC: American Psychological Association*.

Scholes, S., Bajekal, M., Love, H., Hawkins, N., Raine, R., O'Flaherty, M., & Capewell, S. (2012). Persistent socioeconomic inequalities in cardiovascular risk factors in England over 1994-2008: a time-trend analysis of repeated cross-sectional data. *BMC Public Health, 12*, 129. doi: 10.1186/1471-2458-12-129

Schulz, A. J., House, J. S., Israel, B. A., Mentz, G., Dvonch, J. T., Miranda, P. Y., . . . Koch, M. (2008). Relational pathways between socioeconomic position and cardiovascular risk in a multiethnic urban sample: complexities and their implications for improving health in economically disadvantaged populations. *Journal of Epidemiology and Community Health, 62*(7), 638-646. doi: 10.1136/jech.2007.063222

Scott, J., & Leonhardt, D. (2005). Class Matters: A Special Edition. *New York Times, 14*.

Scott Long, J. (1997). Regression models for categorical and limited dependent variables. *Advanced quantitative techniques in the social sciences, 7*.

Shaper, A. G., Pocock, S. J., Walker, M., Cohen, N. M., Wale, C. J., & Thomson, A. G. (1981). British Regional Heart Study: cardiovascular risk factors in middle-aged men in 24 towns. *British Medical Journal (Clinical Research Ed.), 283*(6285), 179-186.

Shi, Y., & Hu, F. B. (2014). The global implications of diabetes and cancer. *Lancet, 383*(9933), 1947-1948. doi: 10.1016/S0140-6736(14)60886-2

Shishehbor, M. H., Litaker, D., Pothier, C. E., & Lauer, M. S. (2006). Association of socioeconomic status with functional capacity, heart rate recovery, and all-cause mortality. *JAMA, 295*(7), 784-792. doi: 10.1001/jama.295.7.784

Shiwaku, K., Anuurad, E., Enkhmaa, B., Kitajima, K., & Yamane, Y. (2004). Appropriate BMI for Asian populations. *Lancet, 363*(9414), 1077. doi: 10.1016/S0140-6736(04)15856-X

Sidik, S. M., & Rampal, L. (2009). The prevalence and factors associated with obesity among adult women in Selangor, Malaysia. *Asia Pacific Family Medicine, 8*(1), 1-6.

Sim, H. C. (2003). The impact of urbanization on family structure: the experience of Sarawak, Malaysia. *Sojourn, 18*(1), 89-109.

Stelmach, W., Kaczmarczyk-Chalas, K., Bielecki, W., & Drygas, W. (2005). How education, income, control over life and life style contribute to risk factors for cardiovascular disease among adults in a post-communist country. *Public Health, 119*(6), 498-508. doi: 10.1016/j.puhe.2004.09.006

Stelmach, W., Kaczmarczyk-Chalas, K., Bielecki, W., Stelmach, I., & Drygas, W. (2004). How income and education contribute to risk factors for cardiovascular disease in the elderly in a former Communist country. *Public Health, 118*(6), 439-449. doi: 10.1016/j.puhe.2003.12.012

Steptoe, A., Feldman, P. J., Kunz, S., Owen, N., Willemsen, G., & Marmot, M. (2002). Stress responsivity and socioeconomic status: a mechanism for increased cardiovascular disease risk? *European Heart Journal, 23*(22), 1757-1763.

Stewart, B. W., Kleihues, P., & International Agency for Research on Cancer. (2003). *World cancer report* (Vol. 57): IARC press Lyon.

Subramanian, S. V., Corsi, D. J., Subramanyam, M. A., & Smith, G. D. (2013). Jumping the gun: the problematic discourse on socioeconomic status and cardiovascular health in India. *International Journal of Epidemiology, 42*(5), 1410-1426. doi: 10.1093/ije/dyt017

Suka, M., Sugimori, H., & Yoshida, K. (2002). Validity of the Framingham risk model applied to Japanese men. *Methods of Information in Medicine, 41*(3), 213-215.

Swinburn, B. A., Sacks, G., Hall, K. D., McPherson, K., Finegood, D. T., Moodie, M. L., & Gortmaker, S. L. (2011). The global obesity pandemic: shaped by global drivers and local environments. *Lancet, 378*(9793), 804-814. doi: 10.1016/S0140-6736(11)60813-1

Tai, E. S., Poulton, R., Thumboo, J., Sy, R., Castillo-Carandang, N., Sritara, P., . . . Woodward, M. (2009). An update on cardiovascular disease epidemiology in South East Asia. Rationale and design of the LIFE course study in CARdiovascular disease Epidemiology (LIFECARE). *CVD Prevention and Control, 4*(2), 93-102. doi: 10.1016/j.cvdpc.2009.02.003

Tan, A. K., Yen, S. T., & Feisul, M. I. (2012). Determinants of body weight status in Malaysia: an ethnic comparison. *International Journal of Public Health, 57*(2), 279-288. doi: 10.1007/s00038-011-0238-8

Tan, A. K., Yen, S. T., & Nayga, R. M. (2009). Role of Education in Cigarette Smoking: An Analysis of Malaysian Household Survey Data. *Asian Economic Journal, 23*(1), 1-17. doi: 10.1111/j.1467-8381.2009.02004.x

Teo, K., Chow, C. K., Vaz, M., Rangarajan, S., Yusuf, S., & Group, P. I.-W. (2009). The Prospective Urban Rural Epidemiology (PURE) study: examining the impact of societal influences on chronic noncommunicable diseases in low-, middle-, and high-income countries. *American Heart Journal, 158*(1), 1-7 e1. doi: 10.1016/j.ahj.2009.04.019

Teo, K., Lear, S., Islam, S., Mony, P., Dehghan, M., Li, W., . . . Investigators, P. (2013). Prevalence of a healthy lifestyle among individuals with cardiovascular disease in high-, middle- and low-income countries: The Prospective Urban Rural Epidemiology (PURE) study. *JAMA, 309*(15), 1613-1621. doi: 10.1001/jama.2013.3519

The HLS-EU Consortium. (2012). Final report Executive summary (D17) *The European Health Literacy Project (HLS-EU).* http://www.maastrichtuniversity.nl/web/file?uuid=b994bc0b-bf89-477c-af47-125cfbea4666&owner=5113a977-24b4-40c8-96e3-4b38cf5e99f5.

Tomiak, M., & Gentleman, J. F. (1992). Risk factors for hypertension as measured by the Canada Health Survey. *Health Reports, 5*(4), 419-428.

Torun, B., Stein, A. D., Schroeder, D., Grajeda, R., Conlisk, A., Rodriguez, M., . . . Martorell, R. (2002). Rural-to-urban migration and cardiovascular disease risk factors in young Guatemalan adults. *International Journal of Epidemiology, 31*(1), 218-226.

Tully, M. A., Cupples, M. E., Chan, W. S., McGlade, K., & Young, I. S. (2005). Brisk walking, fitness, and cardiovascular risk: a randomized controlled trial in primary care. *Preventive Medicine, 41*(2), 622-628. doi: 10.1016/j.ypmed.2004.11.030

Tyroler, H. A. (1999). The influence of socioeconomic factors on cardiovascular disease risk factor development. *Preventive Medicine, 29*(6 Pt 2), S36-40. doi: 10.1006/pmed.1998.0441

van den Berg, G., van Eijsden, M., Galindo-Garre, F., Vrijkotte, T. G., & Gemke, R. J. (2013). Explaining socioeconomic inequalities in childhood blood pressure and prehypertension: the ABCD study. *Hypertension, 61*(1), 35-41. doi: 10.1161/HYPERTENSIONAHA.111.00106

Vorster, H. H., Kruger, A., Wentzel-Viljoen, E., Kruger, H. S., & Margetts, B. M. (2014). Added sugar intake in South Africa: findings from the Adult Prospective Urban and Rural Epidemiology cohort study. *American Journal of Clinical Nutrition, 99*(6), 1479-1486. doi: 10.3945/ajcn.113.069005

Wallace Jr, J. M., Forman, T. A., Guthrie, B. J., Bachman, J. G., O'Malley, P. M., & Johnston, L. D. (1999). The epidemiology of alcohol, tobacco and other drug use among black youth. *Journal of Studies on Alcohol and Drugs, 60*(6), 800.

Weil, D. N. (2005). Accounting for the effect of health on economic growth. *Quarterly Journal of Economics, 122*(3), 1265-1306.

Werner, S., Malaspina, D., & Rabinowitz, J. (2007). Socioeconomic status at birth is associated with risk of schizophrenia: population-based multilevel study. *Schizophrenia Bulletin, 33*(6), 1373-1378. doi: 10.1093/schbul/sbm032

Whiting, D. R., Guariguata, L., Weil, C., & Shaw, J. (2011). IDF Diabetes Atlas: Global estimates of the prevalence of diabetes for 2011 and 2030. *Diabetes Research and Clinical Practice, 94*(3), 311-321. doi: 10.1016/j.diabres.2011.10.029

WHO. (2008). The global burden of disease: 2004 update. Geneva.

WHO. (2009a). Global health risks: mortality and burden of disease attributable to selected major risks. Retrieved 27.10.2014, from http://www.who.int/healthinfo/global_burden_disease/global_health_risks/en/

WHO. (2009b). World Health Organization: World health statistics. Retrieved 27 May 2014, from http://www.who.int/whosis/whostat/2009/en/index.html

WHO. (2010a). Global status report on non-communicable diseases. Retrieved 01.10.2014, from www.who.int/nmh/publications/ncd_report_full_en.pdf

WHO. (2010b). Noncommunicable disease risk factors and socioeconomic inequalities-what are the links?: a multicountry analysis of noncommunicable disease surveillance data. Geneva.

WHO. (2012a). *2012 global progress report on implementation of the WHO Framework Convention on Tobacco Control*. Geneva: World Health Organization.

WHO. (2012b). World Health Statistics 2012. Retrieved 01.08.2013, from http://www.who.int/gho/publications/world_health_statistics/EN_WHS2012_Full.pdf

WHO. (2014a). Cardiovascular disease risk factors. Retrieved 01 December, 2014, from http://www.world-heart-federation.org/cardiovascular-health/cardiovascular-disease-risk-factors

WHO. (2014b). Diabetes fact sheet. Retrieved 5 December, 2014, from http://www.who.int/mediacentre/factsheets/fs312/en/

WHO. (2014c). Global status report on noncommunicable diseases 2014. Geneva, Swithzerland.

WHO. (2014d). Top 10 causes of death. Retrieved 20 December, 2014, from http://www.who.int/mediacentre/factsheets/fs310/en/

WHO, & UNAIDS. (2007). *Prevention of cardiovascular disease*: World Health Organization.

WHO Expert Consultation. (2004). Appropriate body-mass index for Asian populations and its implications for policy and intervention strategies. *Lancet, 363*(9403), 157.

WHO MONICA Project Principal Investigators. (1988). The World Health Organization MONICA Project (monitoring trends and determinants in cardiovascular disease): a major international collaboration. *Journal of Clinical Epidemiology, 41*(2), 105-114.

Wigle, D., Mao, Y., Semenciw, R., McCann, C., & Davies, J. (1989). Premature deaths in Canada: impact, trends and opportunities for prevention. *Canadian journal of public health= Revue canadienne de sante publique, 81*(5), 376-381.

Wild, S., Roglic, G., Green, A., Sicree, R., & King, H. (2004). Global prevalence of diabetes: estimates for the year 2000 and projections for 2030. *Diabetes Care, 27*(5), 1047-1053.

Wildman, R. P., Gu, D. F., Reynolds, K., Duan, X. F., & He, J. (2004). Appropriate body mass index and waist circumference cutoffs for categorization of overweight and central adiposity among Chinese adults. *American Journal of Clinical Nutrition, 80*(5), 1129-1136.

Wilkinson, R. G. (1994). Inequalities and health. *Lancet, 343*(8896), 538.

Wilkinson, R. G. (1999). Income inequality, social cohesion, and health: clarifying the theory--a reply to Muntaner and Lynch. *International Journal of Health Services, 29*(3), 525-543.

Wilson, P. W. F., D'Agostino, R. B., Levy, D., Belanger, A. M., Silbershatz, H., & Kannel, W. B. (1998). Prediction of coronary heart disease using risk factor categories. *Circulation, 97*(18), 1837-1847. doi: 10.1161/01.cir.97.18.1837

Winkleby, M. A., Cubbin, C., Ahn, D. K., & Kraemer, H. C. (1999). Pathways by which SES and ethnicity influence cardiovascular disease risk factors. In N. E. Adler, M. Marmot, B. McEwen & J. Stewart (Eds.), *Socioeconomic Status and Health in Industrial Nations: Social, Psychological, and Biological Pathways* (Vol. 896, pp. 191-209).

Winkleby, M. A., Fortmann, S. P., & Barrett, D. C. (1990). Social class disparities in risk factors for disease: eight-year prevalence patterns by level of education. *Preventive Medicine, 19*(1), 1-12.

Winkleby, M. A., Jatulis, D. E., Frank, E., & Fortmann, S. P. (1992). Socioeconomic status and health: how education, income, and occupation contribute to risk factors for cardiovascular disease. *American Journal of Public Health, 82*(6), 816-820.

Wisdom Supreme. (2014). Absolute income hypothesis. Retrieved 01 August, 2014, from http://www.wisdomsupreme.com/dictionary/absolute-income-hypothesis.php

World Bank. (2013). How we classify countries. Retrieved 01.12.2013, 2013, from http://data.worldbank.org/about/country-classifications

Wu, Z. H., & Rudkin, L. (2000). Social contact, socioeconomic status, and the health status of older Malaysians. *Gerontologist, 40*(2), 228-234.

Yasin, S., Chan, C. K., Reidpath, D. D., & Allotey, P. (2012). Contextualizing chronicity: a perspective from Malaysia. *Global Health, 8*, 4. doi: 10.1186/1744-8603-8-4

Yu, Z. J., Nissinen, A., Vartiainen, E., Song, G., Guo, Z. Y., Zheng, G. W., . . . Tian, H. G. (2000). Associations between socioeconomic status and cardiovascular risk factors in an urban population in China. *Bulletin of the World Health Organization, 78*(11), 1296-1305.

Yusuf, S., Hawken, S., Ounpuu, S., Dans, T., Avezum, A., Lanas, F., . . . Investigators, I. S. (2004a). Effect of potentially modifiable risk factors associated with myocardial infarction in 52 countries (the INTERHEART study): case-control study. *Lancet, 364*(9438), 937-952. doi: 10.1016/S0140-6736(04)17018-9

Yusuf, S., Islam, S., Chow, C. K., Rangarajan, S., Dagenais, G., Diaz, R., . . . Investigators, P. S. (2011). Use of secondary prevention drugs for cardiovascular disease in the community in high-income, middle-income, and low-income countries (the PURE Study): a prospective epidemiological survey. *Lancet, 378*(9798), 1231-1243. doi: Doi 10.1016/S0140-6736(11)61215-4

Yusuf, S., Rangarajan, S., Teo, K., Islam, S., Li, W., Liu, L., . . . Investigators, P. (2014). Cardiovascular risk and events in 17 low-, middle-, and high-income countries. *New England Journal of Medicine, 371*(9), 818-827. doi: 10.1056/NEJMoa1311890

Yusuf, S., Reddy, S., Ounpuu, S., & Anand, S. (2001a). Global burden of cardiovascular diseases: part I: general considerations, the epidemiologic transition, risk factors, and impact of urbanization. *Circulation, 104*(22), 2746-2753. doi: 10.1161/hc4601.099487

Yusuf, S., Reddy, S., Ounpuu, S., & Anand, S. (2001b). Global burden of cardiovascular diseases: Part II: variations in cardiovascular disease by specific ethnic groups and geographic regions and prevention strategies. *Circulation, 104*(23), 2855-2864. doi: 10.1161/hc4701.099488

Yusuf, S., Vaz, M., & Pais, P. (2004b). Tackling the challenge of cardiovascular disease burden in developing countries. *American Heart Journal, 148*(1), 1-4. doi: 10.1016/j.ahj.2004.03.045

Zaini, A. (2000). Where is Malaysia in the midst of the Asian epidemic of diabetes mellitus? *Diabetes Research and Clinical Practice, 50*, S23-S28.

Zhang, Q., & Wang, Y. (2004). Socioeconomic inequality of obesity in the United States: do gender, age, and ethnicity matter? *Social Science and Medicine, 58*(6), 1171-1180.

Zomer, E., Owen, A., Magliano, D. J., Liew, D., & Reid, C. (2011). Validation of two Framingham cardiovascular risk prediction algorithms in an Australian population: the 'old' versus the 'new' Framingham equation. *European Journal of Cardiovascular Prevention and Rehabilitation, 18*(1), 115-120. doi: 10.1097/HJR.0b013e32833ace24

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Cardiovascular disease risk factors and socioeconomic variables in a nation undergoing epidemiologic transition

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Abstract

Background: Cardiovascular disease (CVD) related deaths is not only the prime cause of mortality in the world, it has also continued to increase in the low and middle income countries. Hence, this study examines the relationship between CVD risk factors and socioeconomic variables in Malaysia, which is a rapidly growing middle income nation undergoing epidemiologic transition.

Methods: Using data from 11,959 adults aged 30 years and above, and living in urban and rural areas between 2007 and 2010, this study attempts to examine the prevalence of CVD risk factors, and the association between these factors, and socioeconomic and demographic variables in Malaysia. The socioeconomic and demographic, and anthropometric data was obtained with blood pressure and fasting venous blood for glucose and lipids through a community-based survey.

Results: The association between CVD risk factors, and education and income was mixed. There was a negative association between smoking and hypertension, and education and income. The association between diabetes, hypercholesterolemia and being overweight with education and income was not clear. More men than women smoked in all education and income groups. The remaining consistent results show that the relationship between smoking, and education and income was obvious and inverse among Malays, others, rural women, Western Peninsular Malaysia (WPM) and Eastern Peninsular Malaysia (EPM). Urban men showed higher prevalence of being overweight than rural men in all education and income categories. Except for those with no education more rural men smoked than urban men. Also, Malay men in all education and income categories showed the highest prevalence of smoking among the ethnic groups.

Conclusions: The association between CVD risk factors and socioeconomic variables should be considered when formulating programmes to reduce morbidity and mortality rates in low and middle income countries. While general awareness programmes should be targeted at all, specific ones should be focused on vulnerable groups, such as, men and rural inhabitants for smoking, Malays for hypertension and hypercholesterolemia, and Indians and Malays, and respondents from EPM for diabetes.

Keywords: Cardiovascular disease risk factors, Education, Income, Malaysia

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