The socioeconomic inequalities in and determinants of obesity in developing countries

By

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Abstract

Obesity, a widely known risk factor for many chronic diseases, is rapidly increasing in developing countries. Unlike in the developed world, where obesity is largely associated with low socioeconomic status, there is an ongoing debate on whether obesity is a problem of the rich or that of the poor in developing countries. This thesis comprises four studies that seek to improve our understanding of the socioeconomic associations, inequalities in and determinants of obesity in developing countries. In the first study, a systematic review of the literature published between 2004 and 2010 looking at the association between socioeconomic status (SES) and obesity in developing countries was undertaken. This review revealed that in poorer

countries obesity is a problem of both men and women with higher socioeconomic status, while it is primarily a problem of women with low SES in middle income countries, implying that the burden of obesity shifts from women with higher SES towards those with lower SES as a country progresses economically. Typically, the burden of obesity switches from women with higher SES to those with lower SES at a Gross National Income per capita of approximately US$1000. This shift is less visible, or takes place more slowly, among men while child obesity is exclusively associated with affluence in developing countries. In the second study, a cross-country analysis was undertaken comparing the Middle East and North African (MENA), a developing region severely affected by obesity, with the rest of the world in order to understand how MENA is different in terms of key socioeconomic determinants of obesity. The cross-country analysis revealed that MENA has seen the biggest increase in calorie supply in the last few decades compared with the rest of the world, and calorie supply is positively associated with obesity in this region. In the third study, an individual-level analysis of more than 800,000 women from 54 low and middle income countries was undertaken to understand individual level factors making women in MENA susceptible to obesity. The individual-level analysis showed that MENA is endowed with obesity risk factors such as the largest number of passenger cars per 1000 people, the highest level of urbanisation, and the highest television viewing frequency compared with other low and middle income countries. In addition, the individual-level analysis revealed that about 80% of MENA women are homemakers (do not participate in the labour force) compared with 50% or less in other developing countries, and being a homemaker is positively associated with obesity in MENA. In the fourth study, the effect of migrating from a developing to developed country was analysed using an innovative treatment group from the UK Understanding Society survey and control groups from the nationally representative Demographic and Health Surveys undertaken in six developing countries (Bangladesh, Ghana, India, Kenya, Nigeria and Uganda). After adjusting for selection bias, this study found that migrating from one of these countries to the UK raised BMI by 1 to 1.6 units for women and 2.5 to 3.2 units for (Indian) men. Likewise, obesity among migrants increased by 3.3 to 5.0 percentage points for women and 3.5 to 6.7 percentage points for Indian men. Analytical information on the emerging problem of obesity in developing countries is crucial for designing intervention programs and policies.

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Contents

List of Abbreviations

ATT	Average treatment effects
BMI	Body mass index
DHS	Demographic and Health Survey
FAO	Food and Agriculture Organisation
GDP	Gross Domestic Product
GNI	Gross National Income
HDI	Human Development Index
IOTF	International Obesity Taskforce
Kcal	Kilo calorie
kg/m^2	Weight (in kilogram) divided by height (in metre) squared
MENA	Middle East and North Africa
OLS	Ordinary Least Squares
PPP	Purchasing Power Parity
PSM	Propensity Score Matching
SES	Socioeconomic status
TV	Television
WC	Waist circumference
WHO	World Health Organisation
WHR	Waist-to-hip ratio

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Chapter 1 Introduction

1.1. Rationale

Obesity is a well-known risk factor for several chronic conditions including cardiovascular disease, type 2 diabetes, stroke, hypertension, depression, and some types of cancers (Weyer, Funahashi et al. 2001, Chertow, Hsu et al. 2006, Schillaci and Pirro 2007, Ho 2009). A rapid increase in obesity (Popkin 2001, Prentice 2006) and related chronic diseases (Yach, Hawkes et al. 2004, Nugent 2008) is a major health concern in many developing countries. The latest data from the World Health Organization (WHO) shows that over 30% of women are obese in some developing countries such as Egypt, South Africa and the United Arab Emirates (World Health Organization 2015).

A growing, but still limited, literature exists concerning the socioeconomic inequalities in and determinants of obesity in developing countries. Understanding the determinants of obesity is crucial for designing effective intervention programs and policies. This thesis contributes new knowledge to the ongoing global efforts towards understanding the socioeconomic inequalities in and determinants of obesity among populations living in or originating from developing countries. It does so by reviewing more recent evidence on the association between socioeconomic status and obesity, analysing socioeconomic inequalities in obesity in a region characterised by one of the highest prevalence of obesity, and by analysing the effect of migration, from developing to a developed economy, on obesity.

The systematic review provides a synthesis of the recent evidence regarding socioeconomic inequalities in obesity in developing countries. In addition to updating the evidence base in a systematic manner, the literature review revealed the existence of limited analytical research in the Middle East and North Africa (MENA), a region with one of the heaviest burdens of obesity in the developing world. As a result, the two chapters following the systematic review focus on identifying the country- and individual-level associations and determinants of obesity in the Middle East and North African countries. In the process of reviewing the literature and analysing the socioeconomic associations of obesity in MENA, urbanisation, which is largely driven by rural-urban migration in developing countries, was shown to have a positive and statistically significant association with obesity. However, the literature that assesses the association between in-country or international migration and obesity is very limited among populations living in or originating from developing countries. The fourth analytical study in this thesis attempts to fill this gap.

1.2. Objectives

The thesis has three main objectives which are closely related to the four studies included in this dissertation:

1) To understand whether obesity is a problem of the rich or poor in developing countries by synthesising literature published between 2004 and 2010.

2) To identify the macro- and micro-level socioeconomic associations and inequalities in obesity in the Middle East and North Africa, a developing region that has been severely affected by obesity.

3) To assess the effect of migration (moving from a relatively less to a more obesogenic environment or an environment with a high concentration of obesity risk factors) on obesity, using data from a UK immigrant group originating in developing countries as a

treatment group and a similar group of people living in six developing countries as a control group.

1.3. Organisation of Thesis

This thesis consists of four stand-alone manuscripts (one published and three ready for submission to scientific journals) that examined the socioeconomic inequalities in and determinants of obesity among people living in or originating from developing countries. Chapter two presents a general background to the study of socioeconomic inequalities in and determinants of obesity in developing countries. Chapter three to six consist of manuscripts of the four core studies. Chapter seven is a synthesis of the four studies, a discussion of their policy implications, limitations and recommendations for future research.

Chapter 2 Background

2.1 Definition and measurement of obesity

Obesity is defined as excess body weight or fat tissue. Measuring body fat, separately from other tissues, has been one of the challenges encountered in the study of obesity. Anthropometric measures are the most commonly applied tools for estimating body fat. These measures, which include waist circumference (WC), waist-to-hip ratio (WHR) and body mass index (BMI), are inexpensive and easy to administer in population-level surveys. Similarly, anthropometric measures such as weight-for-age, height-for-age or Z-score are the most widely used instruments for measuring weight among children.

The World Health Organisation (WHO) and the International Obesity Task Force (IOTF) suggest a BMI cut-off of 30 or above to define obesity among adults. While this BMI cut-off point is widely adopted by researchers worldwide, there are some concerns on whether it is appropriate in general (Wildman, Gu et al. 2004) and in particular, whether it is equally applicable to all populations or ethnic groups (Chiu, Austin et al. 2011). In addition, some of the anthropometric measures have been criticised for being inaccurate. For example, while WC and WHR are considered to be more reliable for estimating body fat, BMI has been criticised for not differentiating between fat and muscle tissues (Burkhauser and Cawley 2008). However, in the absence of a more effective and practical measurement tool that is cost effective and easy to administer at population level, BMI is still the most commonly applied measure of obesity. This study adopts the WHO recommended BMI cut-off points of BMI greater than 30 for obesity and BMI ranging between 25 and 29.99 to define overweight, while adjusting the cut-off points for relevant populations according to WHO recommendations.

2.2. Prevalence of obesity in developing countries

The most recent data (sourced from the International obesity taskforce, IOTF database; www.iotf.org) show that the prevalence of obesity in developing countries (defined by the World Bank as countries with GNI per capita less than or equal to US$12,275) is approximately 13% among women. However, there is a large variation within developing countries: low income countries such as Vietnam, Ethiopia and Madagascar have obesity prevalence rates of less than 1% while middle or high income developing countries such as Egypt, Qatar and Saudi Arabia have an obesity prevalence rate above 40%.

While the prevalence of obesity is generally low in low income countries, the recent trends in most of these countries (where repeated Demographic and Health Surveys have been carried out) reveal a rapid increase in obesity. For example, the prevalence of overweight and obesity increased by 5% every year between 1992 and 2005 in urban areas of Sub Saharan African countries (Ziraba, Fotso et al. 2009). Obesity prevalence is more common among the rich in poorer countries (Dinsa, Goryakin et al. 2012), while it tends to increase faster among the poor in such countries (Ziraba, Fotso et al. 2009).

2.3 Health consequences of obesity

The strong link between overweight/obesity and non-communicable diseases such as diabetes, hypertension, cardiovascular diseases, stroke and some cancers has widely been documented (Hill 1998, Kahn, Hull et al. 2006, Kahn, Zinman et al. 2006) (Teucher, Rohrmann et al. 2010). In particular, obesity is considered responsible for more than 80% of type 2 diabetes (Astrup and Finer 2000). Similarly, obesity is linked to increased morbidity or mortality, reduced quality of life as well as increased disabilities (Fontaine and Barofsky 2001). Likewise, obesity has also been reported to reduce fertility and disrupt metabolic functions (Kahn, Zinman et al. 2006). Furthermore, obese individuals are more likely to be affected by depression or to have low self-esteem compared with people within the ‘normal’ weight category (Luppino, de Wit et al. 2010).

The increasing burden of obesity in several regions of the developing world is becoming a significant public health concern (Ells, Lang et al. 2006, Kahn, Hull et al. 2006). Regions that have seen a significant increase in the prevalence of obesity, such as the Middle East and North Africa, Southern Africa, Latin America and the Caribbean, are also known to have a high prevalence of chronic diseases such as type 2 diabetes (Ajlouni, Khader et al. 2008, Ginter and Simko 2012). In addition to the middle and high income countries that have a high prevalence of obesity, urban areas of several low income developing countries have also reported a high prevalence of obesity and type 2 diabetes (Ziraba, Fotso et al. 2009).

Apart from the high concentration of obesity in the developing regions mentioned above, the increasing trend in chronic diseases in all developing countries signifies the scope of the obesity problem (Raymond, Leeder et al.

2006, Ajlouni, Khader et al. 2008, Nugent 2008). Improvements in socioeconomic conditions, resulting from the recent economic growth in low and middle income countries, have been linked with lifestyle changes as well as increased obesity and chronic diseases (Misra and Khurana 2008). The socioeconomic improvements that increase body weight include those that increase food consumption or calorie intake, and/or those that reduce physical exercise.

Economic growth is likely to increase food consumption and/or change diet composition. With increased incomes, people are able to afford more food or substitute consumption of home-cooked with that of restaurants, which may include substituting relatively healthy foods with fast or processed foods (Cutler, Glaeser et al. 2003). Economic growth may also reduce physical exercise as a result of more people being able to afford cars, home appliances such as cooking and washing machines, and when occupations become more sedentary due to technological progresses (Philipson and Posner 1999). Hence, economic growth may create an environment that is conducive for larger body weight including obesity, by facilitating a higher level of calorie intake and reducing energy expenditure (physical exercise) (Lakdawalla and Philipson 2009).

The increasing prevalence of obesity and chronic diseases in developing countries, when the prevalence of infectious diseases is still high, puts these countries in the “double-burden” of diseases (Boutayeb 2006, Prentice 2006). Health facilities in developing countries are largely structured and equipped for the prevention and treatment of infectious diseases, much less for non-communicable diseases. In the short term, this will affect the prevention and treatment of non-communicable diseases as well as their risk factors. Health policies and resource allocation by governments and donors in many developing countries are focussed on prevention and treatment of the most common infectious diseases such as HIV/AIDS, tuberculosis and malaria, leaving less attention and resources for chronic diseases, including obesity, which are still perceived as “diseases of affluence” in many countries (Prentice 2006).

2.4 Economic consequences of obesity

The obvious economic consequence of obesity is an increase in health care expenditures (Finkelstein, Ruhm et al. 2005). Compared with people in ‘normal’ weight category, obese individuals have a higher frequency of physician visits ((Quesenberry, Caan et al. 1998, Thompson and Wolf 2001), more inpatient days as well as a higher number of pharmacy dispenses (Thompson and Wolf 2001). Sturn 2002 found that annual medical expenditures of obese adults were 36% higher than adults in normal-weight category (Sturm 2002). Finkelstein, Fiebelkron et al. 2003 computed the average increase in annual medical expenditure associated with obesity to be 37.4% (Finkelstein, Fiebelkorn et al. 2003). Several other studies that used different costing methods reported similar estimates (Thompson, Edelsberg et al. 1998, Wolf and Colditz 1998, McCormick and Stone 2007). The annual cost attributable to obesity has also been computed at aggregate levels (McCormick and Stone 2007). In the United States, this cost is estimated to range between 5% and 7% of annual health care expenditure (Wolf and Colditz 1990; Finkelstein, Fiebelkom et al. 2003, 2004)

While there is consensus that annual medical expenditure is higher for obese individuals (whether it is paid out-of-pocket or by tax-payers), there is an ongoing debate whether lifetime medical costs for obese individuals are higher than their leaner counterparts, since life expectancy of obese individuals is shorter than those of 'normal' weight. (Fontaine, Redden et al. 2003)) argue that lifetime medical cost is lower for these obese individuals with shorter life expectancy and hence there is a social gain or 'saving' for public funds such as Medicare and Medicaid as a result of obesity. Other studies (Allison, Fontaine et al. 1999, Thompson, Edelsberg et al. 1999, van Baal, Polder et al. 2008) argued that there is no ‘saving’ in lifetime medical expenditure associated with obesity. Consequently, while the social cost of or ‘gain’ from obesity is debatable, there is agreement that obesity increases individual health care costs.

Another economic consequence of obesity is increased non-medical costs such as a higher level of absenteeism from the workplace (Tucker and Friedman 1998, Cawley, Rizzo et al. 2007) and a higher probability of disability (Wolf and Colditz 1998, Ells, Lang et al. 2006), both resulting in lower productivity (Finkelstein, DiBonaventura et al. 2010). Whether it is due to lower productivity or workplace discrimination based on body weight by their employers, obese individuals tend to have lower occupational status and lower wage than their leaner counterparts (Pagan and Davila 1997, Allman-Farinelli, T. Chey et al. 2010). Haskins KM and HE Ransford 1999 reported that 65% of normal weight women in aerospace were in managerial posts while only 39% of overweight women were in such posts (Haskins KM and HE Ransford 1999). Furthermore, obese individuals face higher long term unemployment, higher level of poverty, and lower wages (Sarlio-Lahteenkorva S. and E. Lahelma 1999).

Several studies reported a negative correlation between wage and obesity, particularly among women (Conley D. & R. Glauber 2007) (Mitra A. 2001, Euna Han 2009). Key explanations for the inverse relationship between wages and obesity are: (1) obesity lowers wages by lowering productivity or because of workplace discrimination against obese individuals, (2) lower wage individuals become obese because they consume cheaper foods which are energy-dense, (3) some other unobserved characteristics cause both obesity and low wages. While the inverse correlation between obesity and wage is well established (Mitra A. 2001, Brunello G. and Béatrice D'Hombres 2007, Conley D. & R. Glauber 2007), significantly fewer studies attempted to observe the direction of causation. Some of these limited studies found that obese people earn lower wage, not vice versa (Cawley 2005).

Another consequence of obesity, particularly among children, is that it has physical and psychological effects which are likely to affect educational achievement and lifetime earnings (Hejazi, Dahinten et al. 2009). One can argue that government intervention in preventing obesity among adults is less justified as long as adults make 'informed' and 'rational' decisions regarding their food consumption. The same cannot be said of children for whom consumption decisions are made by their parents. As such, childhood obesity is likely to be affected by decisions made regarding diet and physical exercise, by parents, guardians, schools, or even as a result of public policies.

While parental SES (for example income or education) and child health outcomes are generally positively associated (Fotso 2006), this is not always the case when it comes to childhood obesity in developing countries where a higher level of obesity has been observed among children whose parents have high SES (Dinsa et al. 2012). Child obesity is also affected by the level of adult obesity since there is evidence that maternal deprivation, such as malnutrition during pregnancy, affects child body weight in later life (Oken, Taveras et al. 2007, Ludwig and Currie 2010). Hence, in addition to the genetic pathways, obesity in children is likely to be affected by the high prevalence of obesity among women, as a result of their socioeconomic conditions.

2.5 Socioeconomic determinants of obesity

The SES of an individual determines his or her health conditions. The positive association between SES and (good) health is well established, particularly in the developed world (Wagstaff 2002, Cutler and Lleras-

Muney 2010). This relationship has also been explored in various studies conducted in developing countries (Wagstaff 2002, Hosseinpoor, Bergen et al. 2012). While the prevalence of communicable diseases is generally lower among people with higher SES in developing countries, the evidence on the association between obesity and many of the non-communicable diseases or their risk factors, including obesity, is mixed in several developing countries (McLaren 2007, Hosseinpoor, Bergen et al. 2012).

Obesity is influenced by various socioeconomic conditions that are related to diet and lifestyle. In developing countries, various studies have shown that obesity is independently influenced by socioeconomic factors such as income, education, marital status and occupational status (Sobal and Stunkard 1989, Monteiro, Moura et al. 2004). The nature and the strength of the relationship between socioeconomic conditions and obesity in developing countries are widely debated. While earlier studies (Sobal and Stunkard 1989) reported a higher level of obesity among people with higher SES (using various indicators of socioeconomic status), more recent studies (Monteiro, Moura et al. 2004, Dinsa, Goryakin et al. 2012) reported mixed results or a lower level of obesity among people with higher SES, particularly amongst women. In children, however, a positive relationship has been observed between SES and obesity in developing countries (Dinsa, Goryakin et al. 2012). The SES-obesity relationship is discussed in more detail in chapter three.

Chapter 3 Obesity and socioeconomic status in developing countries: a systematic review

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Abstract

Background: Previous studies showed a positive association between socioeconomic status (SES) and obesity in developing countries while a more recent review found mixed results. The evidence on the subject has grown markedly since an earlier influential review was published in 2004. This study seeks to take stock of the recent evidence on the subject to understand the association between SES and obesity in developing countries.

Methods: A systematic review of studies assessing the association between SES and measured obesity in low and middle income countries (defined by the World Bank as countries with per capita income up to US$12,275) among children, men and women was conducted.

Results: The study finds that in low income countries or in countries with low human development index (HDI), the association between SES and

obesity appears to be positive for both men and women: the more affluent and/or those with higher educational attainment tend to be more likely to be obese. However, in middle income countries or in countries with medium HDI, the association becomes largely mixed for men and mainly negative for women. This particular shift appears to occur at an even lower level of per capita income than suggested by an influential earlier review. By contrast, obesity in children appears to be predominantly a problem of the rich in low and middle income countries.

Conclusions: In low income countries, obesity is a problem of the rich for both men and women. In middle income countries, it is mixed, particularly for men, while obesity is becoming disproportionately a problem of the poor among women. On the basis of these results, there is no immediate justification for a major focus on obesity prevention policies in low income countries from an equity point of view. In middle income developing countries, however, obesity deserves considerable attention both from an equity perspective, since it is becoming disproportionately a problem of poor women already at a lower level of economic development than previously thought, and from population public health perspective.

3.1. Introduction

In developed countries, obesity is widely considered a condition that affects people of lower SES more so than those of higher SES (Wang and Beydoun 2007). In developing countries, however, the debate continues as to whether obesity primarily affects the poor or the rich. In their comprehensive review (Sobal and Stunkard 1989) found a positive relationship between SES and obesity in developing countries: obesity appeared to be a problem predominantly of the more affluent in those countries. Subsequent reviews covering publications from 1988 through 2003 found mixed associations (Monteiro, Moura et al. 2004, McLaren 2007). McLaren 2007 found that a positive association between higher SES and obesity tended to turn into an inverse association as one moved from countries with lower human development index (HDI) to countries with higher HDI. HDI seeks to capture the level of socioeconomic development of a country by combining three indicators, income per capita, literacy rate and life expectancy, into one composite measure.

A highly influential review of studies on the adult population in developing countries by (Monteiro, Moura et al. 2004) found mixed associations for men, but mostly inverse associations for women, concluding rather firmly that obesity was no longer solely a problem of the higher socioeconomic groups in developing countries. That review also suggested that the burden of obesity was shifting from the rich towards the poor, as one moved from countries with lower gross GNI per capita to countries with higher GNI per capita (Monteiro, Moura et al. 2004).

This study reviews articles published between 2004 and 2010 on the association between SES and obesity in men, women and children in developing countries. This review adds value for several reasons. Firstly, there has been a notable growth in the number of relevant studies that merit critical synthesis since the last review had been carried out: this study identified 35 studies for adults during the recent 7 years compared with 14 publications found by the last comparable review (Monteiro, Moura et al. 2004) over the preceding 14 years it did cover. Secondly, this study uses GNI per capita generated by two different methods in order to examine whether using one or the other affects the pattern of socioeconomic inequalities in obesity in relation to the level of economic development. The World Bank uses GNI per capita generated by Atlas method in its income classification (differences between GNI per capita generated using the Atlas versus Purchasing Power Parity methods are discussed below). Thirdly, this review uses two indicators of development: GNI per capita and HDI. Employing these two indicators is useful in assessing how far each of them acts as a factor that may account for a potentially reversing the socioeconomic gradient of obesity. As an index comprising per capita income, literacy rate and life expectancy in one composite metric, it is conceivable that HDI is a more appropriate indicator of ‘development’ than GNI per capita (see www.undp.org) and thus possibly, a more appropriate mediator of the relationship between SES and obesity. Finally, this is the first review that synthesises the existing evidence on the association between SES and obesity among children in developing countries.

The rest of this chapter is organized as follows. The next section describes the search methods and selection criteria. The third section presents the evidence on the association between SES and obesity and sheds light on how the association between SES and obesity varies by the precise SES indicator employed (i.e. education or income/wealth). This section also examines how the association between SES and obesity varies by either the countries’ GNI per capita or their HDI. The subsequent section provides a discussion of the results and the limitations of the chapter. The final section provides the general conclusions of the chapter as well as recommendations for future research.

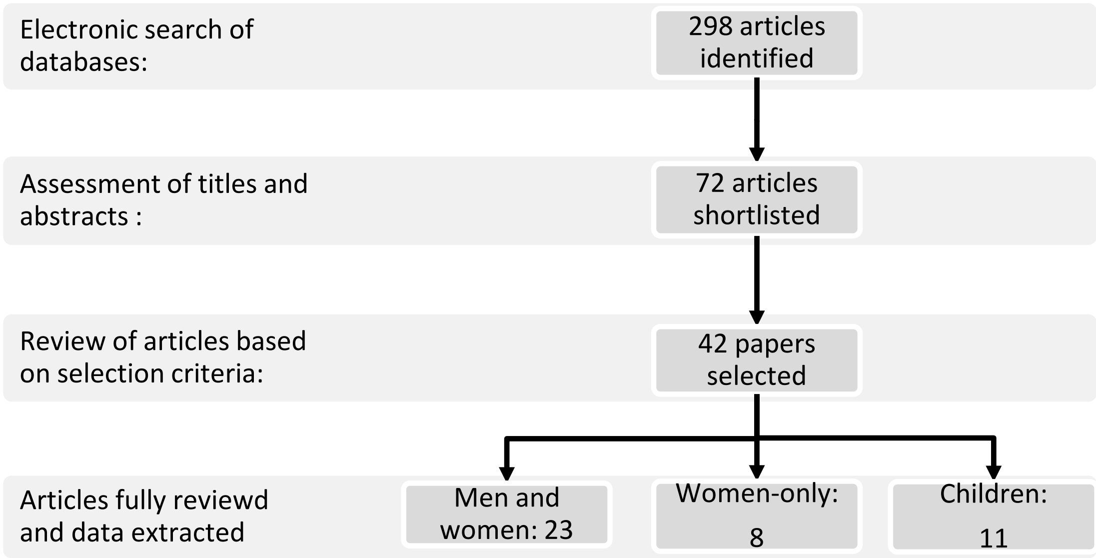
3.2. Methods

The search strategy focused on extracting studies that empirically assessed the association between SES and weight indicators in men, women and children in developing countries, using individual-level data. The sole restriction imposed on the type of study was that the underlying data had been collected on the basis of random sampling over a defined geographical unit. The main search database was MEDLINE. In addition, ECONLIT and Google scholar were searched. The search terms included *obesity, overweight, body fat, body weight, body mass index* on one hand and *socioeconomic status, social class, income, wealth, education, occupation, employment and culture* on the other. The term '*developing countries*' and the list of all developing countries according to the 2010 World Bank income classification (i.e. low-income <US$1,005, lower middle income US$1,006-3,975 and upper middle income US$3,976-12,275; www.data.worldbank.org) were included to ensure the search captured all relevant countries (The World Bank). Obesity or overweight/obesity is used interchangeably throughout the text because not all studies reported obesity and overweight separately. After restricting the search period to

publications post-2004, in order to avoid overlap with the previous review (Monteiro, Moura et al. 2004), the final search generated 298 studies.

Assessing the titles and abstracts of each study resulted in a shortlist of 72 articles. This assessment was based on whether the abstract reported on the relationship between SES and obesity, and whether the country of study was a developing country, according to the definition specified above. A further scrutiny of the full text of these 72 articles was undertaken to select studies that collected data from a major city, region or nationwide (excluding small town or community-based studies since these studies are less likely to be representative of national prevalence of obesity) through random sampling (to exclude convenience or clinic-based sampling). In addition, the studies had to use measured, instead of potentially biased self-reported, weight and height data. One study on children that was undertaken in South Africa used Dual energy X-ray absorptiopmetry (DXA) data to measure Fat Mass Index (FMI) and Lean Mass Index (LMI). Finally, a list of 42 articles that fulfilled the selection criteria and entered the actual review was generated, including 23 papers on adult men and women, 8 on women only and 11 on children (See Figure 1 for further details of the search and screening strategy).

Figure 1 – Electronic search and screening methods



3.3. Results

Four of the 42 studies selected for review were multi-country studies, two of which, one on seven Sub-Saharan African countries (Ziraba, Fotso et al. 2009), and another including 28 developing countries (Kim, Yount et al. 2007), do not present data on socioeconomic inequalities by country. Hence, they were excluded from the country-specific analysis. The sample sizes for these multi-country studies were 19,992 in the Sub-Saharan Africa study and 275,704 in the study comprising 28 developing countries. These studies reported a positive relationship between SES and obesity on average for the sample as a whole.

The remaining two multi-country studies provide a breakdown of socioeconomic inequalities in obesity by country and are thus included in the analysis and summary Table 1. These include a study undertaken in three Eastern and Central European countries (Czech Republic, Poland and Russia) (Pikhart, Bobak et al. 2007) with data on both adult men and women, as well as a study covering women in three Asian countries (Bangladesh, India and Nepal) (Balarajan and Villamor 2009). Table 1 presents a summary of 33 country-specific studies on adult men and women (six country-specific reports from two multi-country studies and 27 single-country studies), while Table 2 shows a summary of 11 studies on children. Hereafter, the analysis of this chapter is based on studies summarised in the two tables below.

Table 1: Association between obesity and socioeconomic status in adults in developing countries

Country	Survey year	GNI per capita PPP (USD)	GNIPC Atlas method	HDI	Study location	Age range	Sample size		Obesity prevalence (%)		SES Indicator	Association between SES and obesity		Reference
							men	women	men	women		men	women	
Seychelles	1989, 1994, 2004	11700	6400	0.71	National	25-64	1525	1818	4-15	23-34	Education, Occupation	Positive	Inverse	(Bovet, Chiolero et al. 2008)
Vietnam	1992-2002	1175	280	0.47	National	>18	5512-43500	6470-51065	1.2-4.4*	3.0-6.6*	Income	Positive	Positive	(Nguyen, Beresford et al. 2007)
											Education	Inverse	Inverse	
											Occupation	Positive	Positive	
Jamaica	1993-1998	5235	2240	0.62	Semi-urban, around Kingston	25-74	847	1249	8.9	33.5	Income	Positive	Positive	(Mendez, Cooper et al. 2004)
Brazil	1995-96	6285	4105	0.64	Rio de Janeiro	>20	1413	1866	43.9*	43.2*	Education	Inverse	Inverse	(Marins, Almeida et al. 2007)
China	1998-2004	2775	1150	0.58	Shanghai	25-95	1264	1768	8.3	10	Education	None	Inverse	(Hou, Jia et al. 2008)
											Income	None	None	
Cameroon	2000	1520	620	0.42	Yaoundé	>25	1301	1530	7	22	Income/wealth/asset	Positive	Positive	(Fezeu, Minkoulou et al. 2006)
											Occupation	Positive	None	
Czech Republic	2002-2005	17720	8300	0.80	National	45-69	3223	3858	30	32	Education	Inverse	Inverse	(Pikhart, Bobak et al. 2007)
Poland	2002-2005	12200	5800	0.78	National	45-69	4451	4719	27	34	Education	Inverse	Inverse	(Pikhart, Bobak et al. 2007)
Russia	2002-2005	9500	3000	0.69	National	45-69	4201	5030	21	47	Education	None	Inverse	(Pikhart, Bobak et al. 2007)
Mexico	2003	10780	1000	0.72	Seven poorest states	18-65	2576	9071	13.4	22.5	Education, occupation, Asset	Positive	Positive	(Fernald 2007)
Burkina Faso	2004	960	350	0.29	Ouagadougou	>35	885	1114	5.5	21.9	Household equipment	Positive	Positive	(Ouedraogo, Fournet et al. 2008)

Country	Survey year	GNI per capita PPP (USD)	GNIPC Atlas method	HDI	Study location	Age range	Sample size		Obesity prevalence (%)		SES Indicator	Association of SES with obesity		Reference
							men	women	men	women		men	women	
Iran	2004	8590	2210	0.65	Mazandran province	20-70	1800	1800	9.9	27.8	Education	Inverse	Inverse	(Hajian-Tilaki and Heidari 2009)
South Africa	2004-05	8055	4235	0.60	Khayelitsha, Cape Town		426	549	10.1	50.3	Childhood food security, Adulthood income & education	None	Positive	(Case and Menendez 2009)
Argentina	2004-05	9775	4020	0.74	Gran Chaco district	>20	204	337	13	20	Income, Education	Positive	Positive	(Valeggia, Burke et al. 2010)
Bulgaria	2004-06	9260	3600	0.72	Sofia	30-60	453	553	6.0	4.7	Income	None	Inverse	(Ivanova, Dimitrov et al. 2008)
Brazil	2004-05	8090	3640	0.68	Pelotas, Southern Brazil	22-23	2122	1930	7.5	8.9	Childhood SES, Adulthood Income	Positive	Inverse	(Gigante, Minten et al. 2008)
Vietnam	2005	2100	620	0.54	Bavi district, Northern Vietnam	25-64	987	997	3.0	4.0	Income	Positive	Positive	(Hoang, Byass et al. 2007)
											Education	Inverse	Positive	
											Occupation	Positive	Positive	
Iran	2005	9140	2570	0.66	Tabriz	≥18	132	168	18	24	Income, education	Inverse	Inverse	(Dastgiri, Mahdavi et al. 2006)
Philippines	2005	2920	1160	0.60	Metropolitan Cebu	21-22	987	819	6.1	6.5	income/wealth or asset	Positive	None	(Dahly, Gordon-Larsen et al. 2010)
											Education	None	Inverse	
China	2005-06	4300	1900	0.60	Guangzhou Biobank	50-94	2702	6917	N/A		Childhood, early adult income, education	Positive	Inverse	(Kavikondala, Schooling et al. 2009)
Iran	2006	9800	2960	0.67	Razavi-Khorasan	>=30	917	1045	7.3	15.5	Education	Positive	Positive	(Nematy, Sakhdari et al. 2009)
Benin	2005-06	1310	560	0.43	Cotonou City	25-60	100	100	8	28	Education, occupation household amenities	Positive	Positive	(Sodjinou, Agueh et al. 2008)

Country	Survey year	GNI per capita PPP (USD)	GNIPC Atlas method	HDI	Study location	Age range	Sample size		Obesity prevalence (%)		SES Indicator	Association of SES with obesity		Reference
							men	women	men	women		men	women	
Ghana	2006	1270	590	0.45	Accra	>25	625	400	10	36	Wealth	Positive	None	(Addo, Smeeth et al. 2009)
Philippines	1980s-2002	1950	805	0.56	Cebu Metropolitan	18-55		2952		43*	Public amenities		Positive	(Colchero and Bishai 2008)
Bolivia	1994-98	2650	910	0.56	National	20-49		4527		9.0-10.5	Education		Positive	(Perez-Cueto and Kolsteren 2004)
India	1998-99	1440	430	0.49	National	15-49		77220		3	Income, education		Positive	(Subramanian and Smith 2006)
Malaysia	1999-2000	8075	3400	0.69	Selangor	17-55		972		16.7	Income		Positive	(Chee, Kandiah et al. 2004)
											Education		Inverse	
Bangladesh	2000-04	930	380	0.49	National	15-49		242433		4.8*	Education, Wealth		Positive	(Shafique, Akhter et al. 2007)
Bangladesh	2004	1050	410	0.42	Urban	13-49		3634		3.9	Education, Occupation		Positive	(Khan and Kraemer 2009)
Iran	2004-06	9230	2580	0.70	Sistan and Baluchestan provinces	>20		888		33.5	Education		Inverse	(Shahraki, Shahraki et al. 2008)
Nepal	1996-2006	810	265	0.40	National	15-49		19354		1.1	Income/wealth, Education		Positive	(Balarajan and Villamor 2009)
India	1998-2007	1810	635	0.47	National	15-49		161755		3.4	Income/wealth, Education		Positive	(Balarajan and Villamor 2009)
Bangladesh	1996-2004	855	385	0.42	National	15-49		19211		1.4	Income/wealth, Education		Positive	(Balarajan and Villamor 2009)

*, Overweight plus obese; SES, socioeconomic status; GNI, gross national income; PPP, purchasing power parity; HDI, human development index.

Table 2: Association between obesity and socioeconomic status in children in developing countries

Country	Survey year	GNI Per Capita (PPP) (USD)	GNI per capita, USD (atlas method)	Study location	SES indicator	Age range	Obesity Measurement method	Sample size		Obesity prevalence (%)		Association of SES with obesity	Reference
								Boys	Girls	Boys	Girls		
Ukraine	Mid 1990s	3000	900	Kyiv, Mariupol Dneprodzerzhinsk	Social class, meat consumption, neighbourhood type	3-year olds	BMI≥85th percentile	468	415	17.7	17.7	Positive	(Friedman, Lukyanova et al. 2009)
South Africa	1990 - 2000	6050	3100	Johannesburg-Soweto	Parental education, occupation, wealth	0-10	FMI, LMI, BMI	147	134	NA	NA	Positive	(Griffiths, E K Rousham et al. 2008)
Sri Lanka	2002	2820	860	Colombo	Income, type of school	8-12	BMI	588	636	4.3	3.1	Positive	(Wickramasinghe, Lamabadusuriya et al. 2004)
India	2002	1710	470	Hyderabad	Household possession, type of household, distance from school	11-16	BMI	586	622	1.6	1	Positive	(Laxmaiah, Nagalla et al. 2007)
Vietnam	2002	1610	430	Ho Chi Minh city	Income, wealth, type of residence	11-16	BMI	752	752	0.9	0.3	Positive	(Tang, Dibley et al. 2007)
Vietnam	2004	1900	*540*	*Ho Chi Minh city*	Wealth, education	Adolescents	BMI	2678	NA		NA	Positive	(Hong, Trang et al. 2010)
Guatemala	2005	4010	*2080*	*Quetzaltenango*	Income, type of schooling	8-10	Height-for-age, Weight-for-age, BMI		583	4.2-18.7	0.7-11.2	Positive	(Groeneveld, Solomons et al. 2007)
Vietnam	2005	2100	620	Ho Chi Minh city	Parents' education, wealth, occupation	4-6	Height-for-age, Weight-for-age, BMI	332	338	21.7*	11.0*	Positive	(Dieu, Dibley et al. 2009)
Colombia	2006	7640	3440	Bogota	Assets, place of residence; Time watching TV, games	5-12	BMI, height-for- age	1490	1585	11.5*	10.7*	Positive	(McDonald, Baylin et al. 2009)
India	2007	2860	1000	South Karnataka	Time spent watching TV, playing games and types of diet	12-15	BMI	461	539	5.2	4.3	Positive	(Kotian, S et al. 2010)
Iran	2006-2007	10400	3250	Rasht	Maternal education	12-17	BMI	N/A	2577	N/A	5.9	Positive	(Maddah and Nikooyeh 2010)

*, Overweight plus obesity; SES, socioeconomic status; GNI, gross national income; PPP, purchasing power parity; HDI, human development index; BMI, body mass index; FMI, fat mass index (fat mass (kg)/height (m4); LMI, lean mass index (lean mass (kg)/height (m2).

For the single-country studies, the sample size ranged from 200 in Benin to 242,433 in Bangladesh. Most of these studies employed two or more SES indicators. The two commonly employed SES indicators were education (measured by the number of years in schooling; or categorized as primary, secondary or tertiary education) and income, which is measured either by financial income or by wealth/asset indicators, generally considered as proxies for income (Filmer and Pritchett 2001). While the studies reviewed also employ occupation as a SES indicator, this study focuses on education and income/wealth because: 1) education and income/wealth are the two commonly used SES indicators, 2) all of the studies that used occupation as SES indicator also used either education or income/asset or both together, 3) the direction of the association between occupation and obesity turns out to be the same as the direction of the association between education and obesity. Hence, education appears to be a good proxy for occupation. For children, income was defined mainly based on parental/household income, wealth or asset. Some of the child-focused studies also used type of neighbourhood (place of residence) as proxy for income. The sample age groups in most of the adult-focused studies were 18+ for men and 15-49 (i.e. the reproductive age group) for women.

All of the studies reviewed employed BMI as the indicator of "fatness". Ten studies (seven for adult men and women and three for women only studies) also used WHR and/or WC which generally resulted in a higher prevalence estimate of obesity compared with BMI (in 8 out 10 studies), but did not affect the direction and significance of the association between SES and obesity. All adult studies but one used the common BMI cut-off points of 25-29.9 kg/m^2 for overweight and BMI $\geq$30 kg/m^2 for obesity. The study in China (Hou, Jia et al. 2008) used the Chinese BMI cut-off point of 28 kg/m^2 to define obesity in addition to the standard WHO threshold.

Overall, obesity prevalence in the reviewed studies ranged from 3 to 30% for men and from 1 to 50% for women (excluding the studies reporting overweight and obesity in a joint category). Low prevalence of obesity was recorded in low income countries such as Bangladesh, India and Vietnam while high prevalence of obesity were reported in upper middle income countries such as Russia, Poland and Seychelles. Slightly more than half the studies (nine for adult men and women, and 15 for women) report a positive relationship between SES and obesity (excluding six studies in which the association between SES and obesity varied depending on the SES indicator employed). Four studies on men and 11 studies on women reported a negative association while the findings of another four studies involving men and a study on women were inconclusive.

In order to examine whether socioeconomic inequalities in obesity vary by obesity prevalence, the study used the median obesity prevalence rate (9% for men and 20% for women) as cut-off points to categorise countries into a "low" and a "high" obesity prevalence. Most of the studies that reported low obesity prevalence (four out of six studies for men and 10 out of 14 studies for women) reported positive associations.

The studies were also categorised into those based on "small" and "large" sample sizes, using median sample sizes (approximately 1000 for men and 2000 for women) as cut-off points between these two groups of studies. No significant difference was found in the association between SES and obesity among those which used a small sample and studies with a large sample.

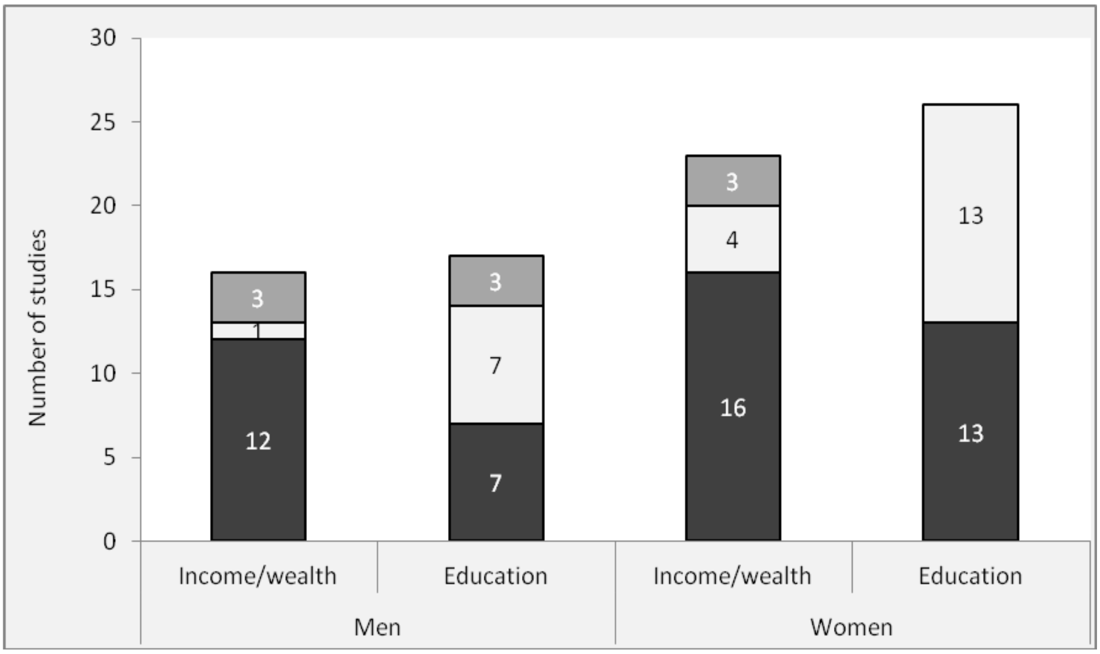
It is important to note that all of the studies reviewed had adjusted for age and gender (if applicable), and in addition, most of them accounted for some other factors such as smoking, alcohol consumption, parity, marital status, ethnicity or place of residence. As most studies that adjusted for more than age and gender did not provide estimates of the correlation for just the age- and gender-adjustment, it was not possible to report exclusively age- and gender-adjusted results. Tables 1 and 2 report the most fully adjusted results from each study.

Association between SES and obesity by the type of SES indicator

This review examined whether the type of SES indicator employed affects the pattern of socioeconomic inequalities in obesity. For men, 16 studies employed income or wealth as a SES indicator, out of which 11 reported a positive association, one reported a negative and four reported no association between income/wealth and obesity. For women, out of the 23 studies which employed income/wealth as SES indicator, 16 reported positive, four reported negative and three reported no association between income/wealth and obesity (Figure 2). Hence, for both men and women, the majority of the studies (i.e. 69% for men and 70% for women), which used income/wealth as a SES indicator showed that the rich were more likely to be obese.

Education was used as a SES indicator by 17 studies on men, out of which seven studies reported men with more education were more likely to be obese compared with men with no (or a lower level of) education, while another seven studies reported that men with a lower level of education were more likely to be obese. The remaining three studies found no significant association between the level of education and obesity. Among women, out of the 26 studies that employed education as a SES indicator, 13 studies found a positive association while the remaining 13 reported negative association (Figure 2).

Figure 2 - Summary of associations between socioeconomic status (SES) and obesity by main SES indicators



Legend: Black, studies with positive association; white, studies with negative association; grey, studies with no significant association.

An even more reliable assessment of whether the type of SES indicator employed affects the shape of the association between SES and obesity can be derived from studies that used both income/wealth and education as SES indicators (the studies that did use both SES indicators did control simultaneously for both SES indicators). A sub-sample of 10 studies for men and 16 studies for women fulfilled this criterion. Among men, in seven out of these 10 studies, the direction of the association between obesity and either income/wealth or education is the same (i.e. positive in five studies, negative in one study and no association in one study). The remaining three studies find a positive association between income/wealth and obesity, but either a negative or no association between education and obesity.

Among women, in 12 out of the 16 studies which used both income/wealth and education, the choice of SES indicator does not alter the direction of the association between SES and obesity (i.e. 10 studies reported positive associations and two studies reported negative associations). For the remaining four studies, the sign of the association does depend on the SES indicator employed (positive or no relation between income/wealth and obesity, but inverse relation between education and obesity).

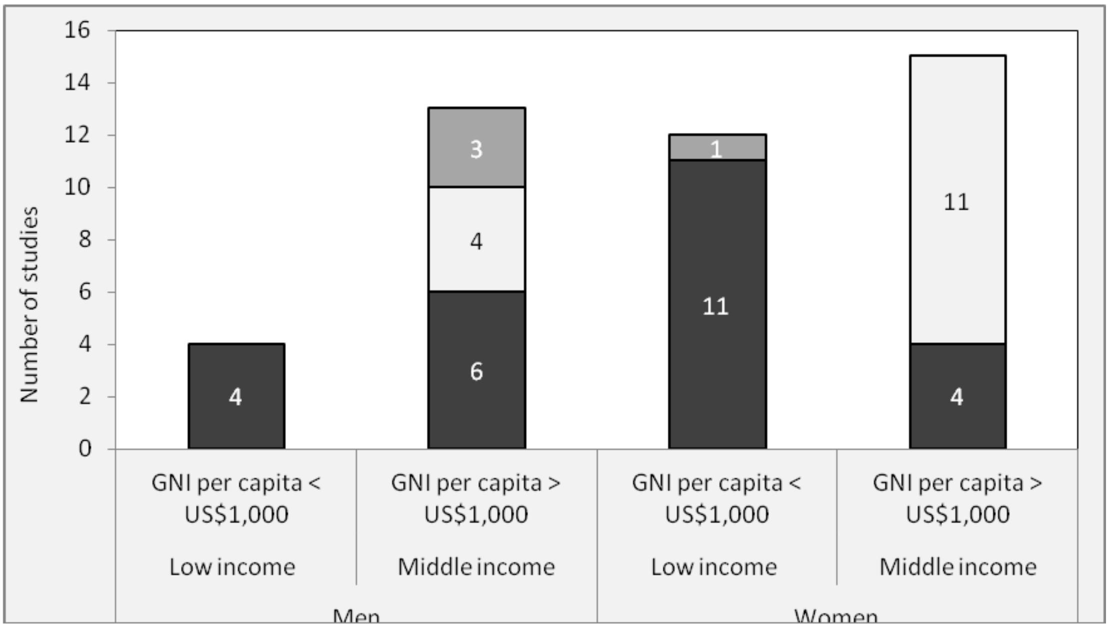
Association between SES and obesity by the countries' level of economic development

Figure 3 (below) shows that the association between SES and obesity in low income countries is mostly positive for both men and women, excluding the six studies in which the association between SES and obesity differs depending on the chosen SES indicator. By contrast, in the middle income countries, the association is largely mixed for men while it is mainly negative for women. For women, out of 12 studies undertaken in low-income countries, eleven (>90%) reported that women with higher SES were more likely to be overweight/obese. On the other hand, out of 15 studies undertaken in the middle income countries, 11 (73%) reported a higher level of obesity among the lower-SES individuals. Sensitivity tests of these results were undertaken using only studies that employed nationwide datasets and no significant difference was found (see details in the Discussion section).

Association between SES and obesity by the level of HDI – in comparison to the use of GNI per capita

All but one of the 12 studies undertaken in low HDI countries, defined as countries with HDI<0.50, reported positive associations between SES and overweight/obesity for both men and women (Figure 4). In countries with medium HDI (HDI between 0.50 and 0.79), the association between SES and obesity is mixed for both men and women. However, a slight majority (11 out of 18) of the studies undertaken in medium HDI countries reported a negative association between SES and obesity among women, replicating the result observed using GNI per capita as development indicator (see Figures 3 and 4 in comparison).

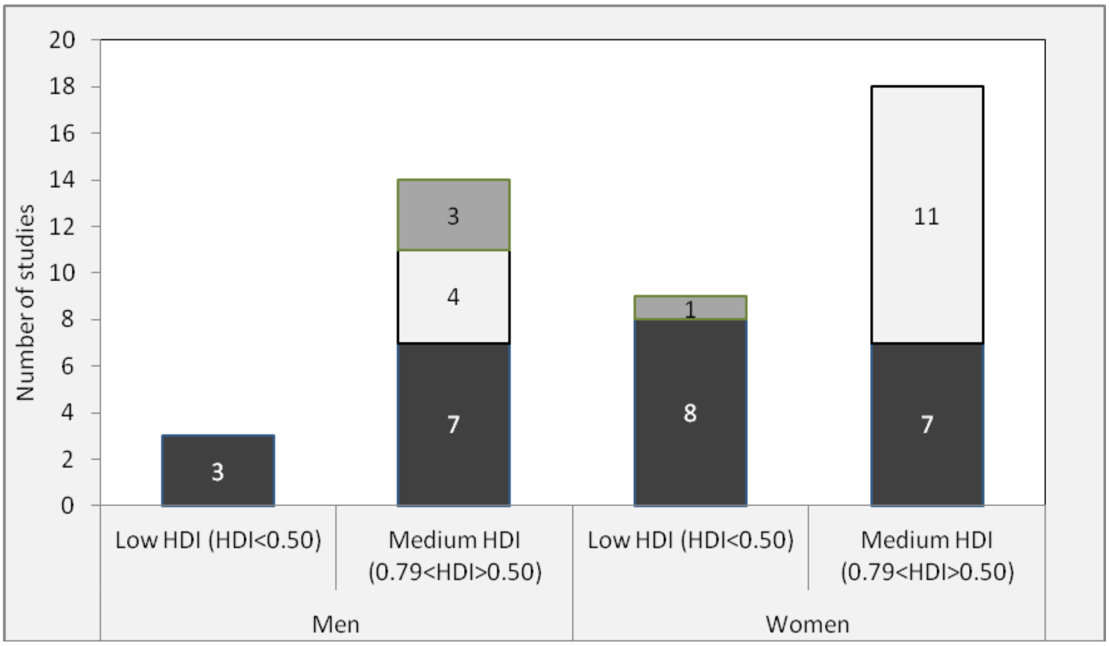
Figure 3 - Summary of associations between SES and obesity by gross national income per capita



Legend: Black, studies with positive association; white, studies with negative association; grey, studies with no significant association.

GNI; Gross National Income

Figure 4 – Association between SES and obesity for men and women, in relation to Human Development Index (HDI)



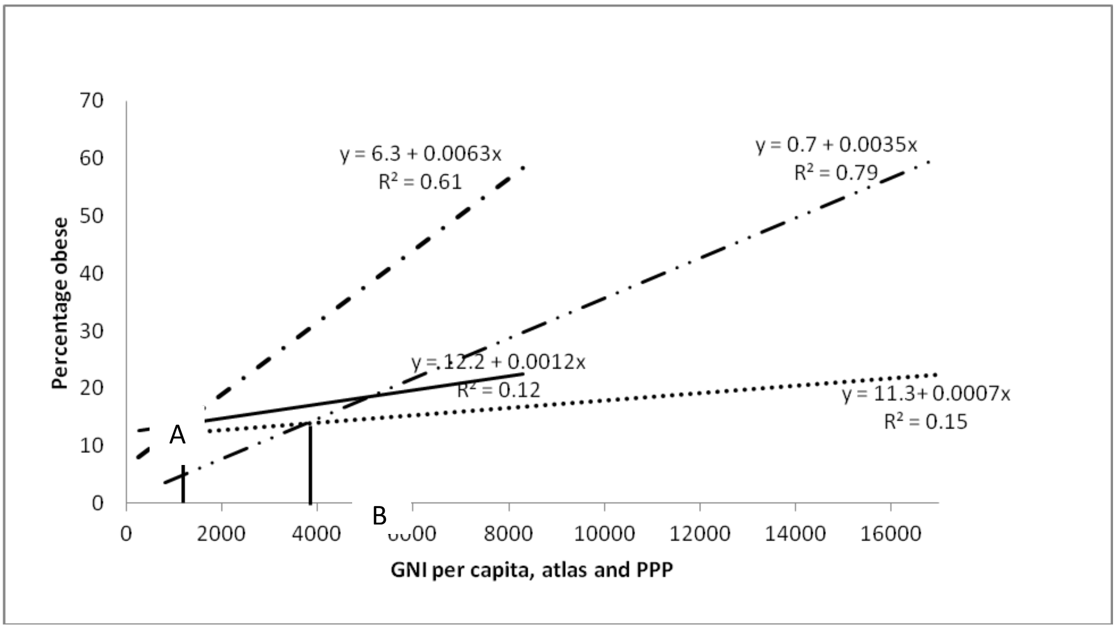
Legend: Black, studies with positive association; white, studies with negative association; grey, studies with no significant association.

HDI; Human Development Index

Association between SES and obesity by the countries' GNI per capita: Atlas versus PPP method

Figure 5 plots the association between obesity (in low and high SES women) and GNI per capita using GNI per capita generated by both the Atlas and the PPP methods for a sub-sample of 14 studies which reported a consistent relationship between SES and obesity irrespective of the SES indicators chosen, as well as the prevalence of obesity for low and high SES women. GNI per capita generated by the Atlas method shows the nominal value of goods and services produced while the one calculated in PPP adjusts for local purchasing power of this income. Figure 5 shows that the choice of GNI per capita (Atlas versus PPP) can affect both the slope of the association between obesity (by SES group) and GNI per capita, and the level of per capita income at which obesity starts shifting from higher to lower SES women (see notes to Figure 5). More specifically, this confirms the finding that the burden of obesity shifts from higher to lower SES women at a GNI per capita of about US$1,000 (using the Atlas method). On the other hand, using the GNI per capita generated by the PPP method, it is possible to observe that this shift occurs at a GNI per capita of just under US$4,000 in the sub-sample of studies (see Figure 5).

Figure 5 – Predicted level of obesity for women by SES and GNI per capita (Atlas versus PPP methods)



Legend:

Long dash dot, low-SES, Atlas method; Solid; Obesity among high-SES, Atlas method; Long dash dot dot, low-SES, PPP method; Round dot, high-SES, PPP method; PPP, Purchasing Power Parity; GNI, Gross National Income.

Notes to Figure 5:

1. With GNI per capita (Atlas method), obesity shifts from the higher to lower SES individuals at point A, which corresponds to a GNI per capita of about US$ 1,000. With the PPP method, however, this shift takes place at point B, which corresponds to a GNI per capita slightly lower than US$4,000.
2. The coefficients of GNI per capita using the Atlas method are higher than those of GNI with the PPP (0.0063 versus 0.0034 for low SES and 0.0012 versus 0.0007 for high SES), implying that the choice of GNI metric affects the strength of the relationship between obesity and income per capita.

Association between SES and obesity among children

The studies on children used different measures of obesity compared with those employed in the adult-related studies reported above. In addition to BMI, one study employed fat mass index (FMI), which measures fat tissue in kilogram divided by height in metres to the power of 4 (fat mass (kg)/height $(m)^4$) and lean mass index (LMI), which measures lean tissue divided by height in metres squared (lean tissue(kg)/height $(m)^2$), while three others used height-for-age and weight-for-age. Overall, obesity prevalence varied between 1% and 18% and it was higher among boys than girls. The prevalence of obesity appears to increase with income; India and Vietnam are among countries with low prevalence while Guatemala and Ukraine are among those with relatively high obesity prevalence. In all of the 11 studies reviewed here, a positive association was reported between SES and obesity for both boys and girls, regardless of age, the level of GNI per capita, the level of obesity, the SES indicator chosen or the measure of fatness employed (see Table 2).

3.4. Discussion

The purpose of this review was to evaluate the evidence on the socioeconomic inequalities in obesity in developing countries, an evidence base that has grown markedly since the last major review was published in 2004 (Monteiro, Moura et al. 2004). The key results of this review are as follows:

(1) Within low income countries, obesity is more prevalent among the higher SES groups (i.e. those with higher level of income or education) than in the lower groups.

(2) The pattern of socioeconomic inequalities in obesity is far more mixed in middle income countries, particularly among men.

(3) Among women, the shift in the burden of obesity from the rich to the poor occurs at a GNI per capita (calculated according to the Atlas method) of about US$1,000, and within the medium HDI range. The shift in men is considerably less discernible.

(4) Based on the few studies (N=11) that have examined specifically the association between SES and obesity in children, the evidence unanimously depicts child obesity as being more prevalent among the affluent groups in developing countries.

The first and second results are broadly in line with Monteiro et al. 2004, but they add value in that the conclusions of this study are based on a considerably greater number of studies from low income countries, particularly for women. (Monteiro et al. included two out of 14 studies from low income countries, while this study included four out of 17 specific country-based studies for men, and 12 out of 27 for women.) The fourth result is unique to this review as no previous review had focused on inequalities in child obesity in developing countries. Reviews of high income country studies have shown that there is generally an inverse association between SES (particularly education) and child obesity, suggesting that the shift of obesity from the rich to the poor occur at a higher level of economic development (Lamerz, Kuepper-Nybelen et al. 2005). Shrewsbury et al. reported a mixture of inverse or no association in 73% of the studies they reviewed (Shrewsbury and Wardle 2008). Similarly, Due, Damsgaard et al. 2009 found a higher prevalence of overweight adolescents from less affluent families in 21 out of 24 countries in Western Europe and North America (Due, Damsgaard et al. 2009). This demonstrates that unlike what is found for developing countries, child obesity is largely a problem of poverty in developed countries. The third finding qualifies previous review evidence, in that it implies that, among women, the burden of obesity shifts at a lower level of per capita income than previously thought, an issue that deserves further elaboration.

Monteiro et al. 2004 had suggested that the reversal of the obesity gradient for women takes place at about a GNI per capita of US$2,500. The results of this study, however, show that this switch-over may already occur at a considerably lower per capita income level (US$1,000). This threshold is remarkably close to the World Bank income cut-off point between low and middle income countries (i.e. US$1,005), using the Atlas method. It is not as clear for men, or at least it occurs more slowly than in women, as was found by Monteiro et al. Other recent reviews of socioeconomic inequalities in obesity have focused on high income countries (i.e. countries with a GNI per capita > US$12,275 or a HDI > 0.80), suggesting that as countries grow into this income category, obesity shifts to the poor within those countries, at least among women (Sobal and Stunkard 1989, Zhang and Wang 2004, McLaren 2007).

This study has shown that when assessing the relationship between overall economic wealth and socioeconomic inequalities in obesity, the type of metric of the per capita GNI indicator used can greatly affect both the switch-over income threshold, as well as the slope of the association between income and obesity prevalence of both the lower and the higher SES group. The GNI per capita Monteiro et al. employed appears to be the one generated using the Atlas method, although this is not explicitly mentioned in their study, which is also the metric the World Bank has adopted for its country classification. Using this metric, this study arrived at the lower switch-over per capita income than Monteiro et al. If, however, one employs GNI per capita data in purchasing power parity (PPP) terms, the income level at which this shift begins is significantly higher (about US$,4000) (see Figure 5).

Using GNI per capita based on the Atlas method versus that based on PPP appears to particularly affect the exact relationship between national economic wealth and socioeconomic inequalities in obesity in those countries, in which the differences between incomes generated using the two methods are larger. The Atlas method reports nominal income per capita without accounting for prices of goods and services. This method does not take into account the purchasing power of the nominal income in a country. This has a significant bearing on real income, particularly in poorer countries where many products, mainly food, tend to be cheaper. GNI per capita (PPP) addresses this issue by accounting for price differences among commodities, since the amount of food consumed depends not only on nominal income, but also on food prices. Under the PPP method, one US$ is considered to purchase the same quality and quantity of a commodity all over the world. Hence, using GNI per capita (PPP) for the study of obesity helps to compare differences in purchasing power or real income among countries.

Robustness of the findings

Several robustness checks were undertaken: (1) The study examined whether results differed by sample size in the underlying study but found no significant differences. (2) The study also tested whether the association between SES and obesity is affected by the type of SES indicator. The result showed that the choice of SES indicator (income/wealth versus education) matters in the association between SES and obesity in about 20-30% of the studies (three out 10 for men and four out of 16 for women). This is probably due to a weaker correlation between wealth and education in some developing countries, in which the under-developed nature of a competitive market may prevent educational investment to pay off in the labour market in the form of higher earnings and income. (3) The study explored whether the pattern of inequalities differed by measure of fatness employed. Despite the widely recognised limitations of BMI (Yusuf, Hawken et al. 2005, McCarthy, Cole et al. 2006), this study does not detect differences in the patterns observed in studies that used BMI vs. those using WC or WHR. This suggests that BMI may still provide a sufficiently reliable indication of the degree of socioeconomic inequalities in overweight/obesity in developing countries, in contrast to the finding from a US-focused study (Burkhauser and Cawley 2008), which showed that the precise measure of fatness did significantly alter the association between obesity and employment. (4) The study also tested whether using national versus sub-national data affects the findings of this study regarding the association between the level of GNI per capita and obesity. No significant difference was observed although it is important to caution against over generalising this conclusion, in light of the small sub-sample of studies using national data (10 for women and five for men). (5) The study also tested whether using GNI per capita versus HDI as a development indicator matters in the association between SES and obesity, finding no major difference in the association between SES and obesity in using either of them. (6) Finally, the study also tested whether the definition of GNI per capita matters in both the strength of the association between GNI per capita and obesity (by SES) and the level of GNI per capita where obesity starts to shift from the higher SES to lower SES individuals. As discussed above, the study observed that the definition of GNI per capita matters for both the level of income at which the switch-over takes place and the significance of the relationship between GNI per capita and obesity.

Explaining the findings

Why are the poor in low income countries "protected" against obesity, and why are the rich more susceptible to it? One potential explanation for the poor in low income countries being "protected" against obesity may lie in the existence of food scarcity in those countries, which implies low/moderate food intake among the poor. In addition, the poor tend to be engaged in manual work that requires higher energy expenditure. Conversely, the observation that the rich in poorer countries are particularly susceptible to obesity could be explained by their access to surplus/excess food and a lower level of engagement in manual labour-intensive occupations (World Health Organization 2003). In addition, in some low income countries, a larger body size might be considered as a positive status symbol (Rguibi and Belahsen 2006, Fernald 2009). Thus, in such communities, people in higher SES might prefer a larger body size (Holdsworth, Gartner et al. 2004, Rguibi and Belahsen 2006, Fernald 2009). A large body size preference and its correlation with actual body size were found, for instance, by studies in Morocco (Rguibi and Belahsen 2006, Lahmam, Baali et al. 2008) and Senegal (Holdsworth, Gartner et al. 2004).

By contrast, in many middle income countries (or in countries with medium HDI), the issue of food shortage no longer represents a common problem even for the poorest section of the population (Temple, Steyn et al. 2010). Instead, access to healthy food becomes the critical issue distinguishing the more from the less affluent. Low calorie food (e.g. whole-grain cereals, fruits and vegetables) are likely to be expensive for the poor, therefore leading to the consumption of a more energy dense diet (Drewnowski and Specter 2004, Drewnowski and Darmon 2005). For example, a recent study in rural South Africa reported that healthier diets compared with the most commonly consumed food items (e.g. whole-meal bread against white bread; brown rice against white rice; fat-free milk against full-cream milk and lean beef burger against high-fat beef burger) cost between 10-60% more. The authors also compared the extra cost of a recommended healthier diet to a typical South African menu and found that for an adult man, the healthier diet per day costs US$1.22 (69%) more. This study also estimated the extra cost of a healthier diet to equal US$140 per month for a household with five members, a cost that corresponds to more than 30% of the total household income for most of the population (Temple, Steyn et al. 2010).

In addition to food consumption, a higher degree of urbanisation and technological progress in these economies render occupations less laborious, resulting in less energy expenditure even among the poor. Obesity prevalence, due to a more sedentary lifestyle, is far higher among urban dwellers even in low-income countries (Ziraba, Fotso et al. 2009). Furthermore, the poor are more susceptible to the risk of obesity, given their lower levels of education and health awareness (Nyaruhucha, Achen et al. 2003). Then again, the elite in such countries are more likely to be health conscious and in a better position to invest in a healthy diet and exercise, in order to shield themselves from obesity (World Health Organization 2003).

Hence, the rich in poor countries would be able to afford and demand surplus food (which exposes them to obesity), while the rich in higher income countries would be more likely to be in a position to afford and demand a healthier diet and exercise (which helps prevent them from obesity). Conversely, the poor in lower income countries face food shortages (which prevents them from obesity), while the poor in higher income countries are particularly exposed to energy dense foods (which increases their odds of becoming obese) (Block, Scribner et al. 2004). This phenomenon may help explain the shift in the burden of obesity.

Why does the within-country shift of obesity from the rich to the poor occur faster and at earlier levels of development for women than for men? One tentative explanation for this intriguing question may be related to the finding from research in high income countries, suggesting there is a wage penalty associated with obesity for women (but not for men) in the labour market (Garcia Villar and Quintana-Domeque 2009). To the extent that as countries develop, women increasingly participate in the labour force, the female wage penalty can only begin to drive the inverse SES-obesity relationship after reaching a certain level of economic development. A further explanation relates to the evidence that women who were nutritionally deprived as children are significantly more likely to be obese, and still socioeconomically deprived as adults, while men who were deprived as children appear to face no greater obesity risk (Case and Menendez 2009).

Limitations

This review synthesised the directions of the association between SES and obesity, not the strengths of these associations. A meta-analysis of the strengths of these associations using studies employing similar methodologies could, in principle, provide useful information, although it is not obvious that the underlying data and methods used across country studies could indeed be comparable enough to allow for a quantitative meta-analysis. It is also important to caution against inferring overly strong conclusions from some of the findings due to the limited number of studies reviewed. These include the limited number of *nationally representative* studies (five for men and 10 for women), as opposed to the greater number of studies based on sub-national samples, which render the assignment of the relevant level of per capita income somewhat arbitrary. The number of studies on children was also quite limited (N=11). Moreover, it is important to bear in mind the caveat that the relationships between overweight/obesity and socioeconomic factors reported in the studies reviewed here reflect largely a simple correlation and do not allow inference about the causal nature of the possible bi-directional relationship.

3.5. Conclusions

The results of this study provide information on the global association between SES and obesity: obesity is a problem of the rich in low income countries for both men and women, while there is a mixed picture in middle income countries. Taken together, while on the basis of this study there is no immediate justification for a major focus on obesity prevention in low income countries, obesity warrants considerable attention in many middle income developing countries, both from an equity perspective as obesity in women is becoming disproportionately a problem of the poor, and due to the scale of the public health problem of the population as a whole.

Future research needs to focus on some of the key questions that remain unanswered, especially the understanding of the causal structure of the interrelationship between SES and obesity in developing countries. Furthermore, a better understanding as to why the shift in the burden of obesity from higher to lower SES occurs faster among women compared with men is important. More studies are also required to verify and explain the unanimously positive association between SES and child obesity in developing countries, which is very different from what is observed in developed countries. Perhaps most importantly, there is an urgent need to determine how the rising obesity levels among both the poor and the rich in developing countries can be prevented.

3.6. Summary

In summary, this chapter synthesised the recent evidence on the socioeconomic association of obesity in developing countries, and found that obesity prevalence is higher among people with higher socioeconomic status in low-income countries, while there is a mixed picture in middle-income economies. In addition to providing a good understanding of the socioeconomic inequalities in obesity in developing countries, this review also revealed areas where knowledge gaps exist. Prominent among these areas is limited analytical research on obesity in countries or regions with a high prevalence of obesity. Despite the fact that the MENA region has an obesity prevalence rate that is equivalent to, and sometimes higher than), many countries in the developed world, where obesity prevalence is often thought to be the highest, analytical research on the subject is limited. The next chapter seeks to fill some of the gaps in research by attempting to understand why obesity prevalence is high in the region.

Chapter 4 Socioeconomic inequalities and determinants of obesity in the Middle East and North Africa: is the region different from the rest of the world? A cross-national analysis

Abstract

Background: The Middle East and North Africa Region (MENA) bears one of the heaviest burdens of obesity among women world-wide. The prevalence of obesity among women in MENA is 31.6%, while the corresponding figure is 20.6% for other middle income countries and 16% for high income countries. Despite the significance of the obesity problem in the region, the literature on this topic remains limited. This study seeks to explore national-level socioeconomic factors contributing to the burden of obesity in MENA, focusing on the determinants of obesity and its socioeconomic inequalities.

Methods: The study investigates how MENA is different from other regions in terms of macro-level determinants of obesity among women, and how this difference makes the region more or less obese, using econometric analysis applied to cross-national data for 154 countries.

Results: MENA experienced the highest increase in calorie and sugar supply per capita during the last few decades. Calorie supply per capita and its increase as well as increased sugar supply during the last few decades are positively associated with higher prevalence of obesity in the region.

Conclusions: MENA is characterised by having a disproportionally high prevalence of obesity risk factors, which appear to be responsible for making the region an obesogenic environment, when compared with other regions of similar economic development.

4.1. Introduction

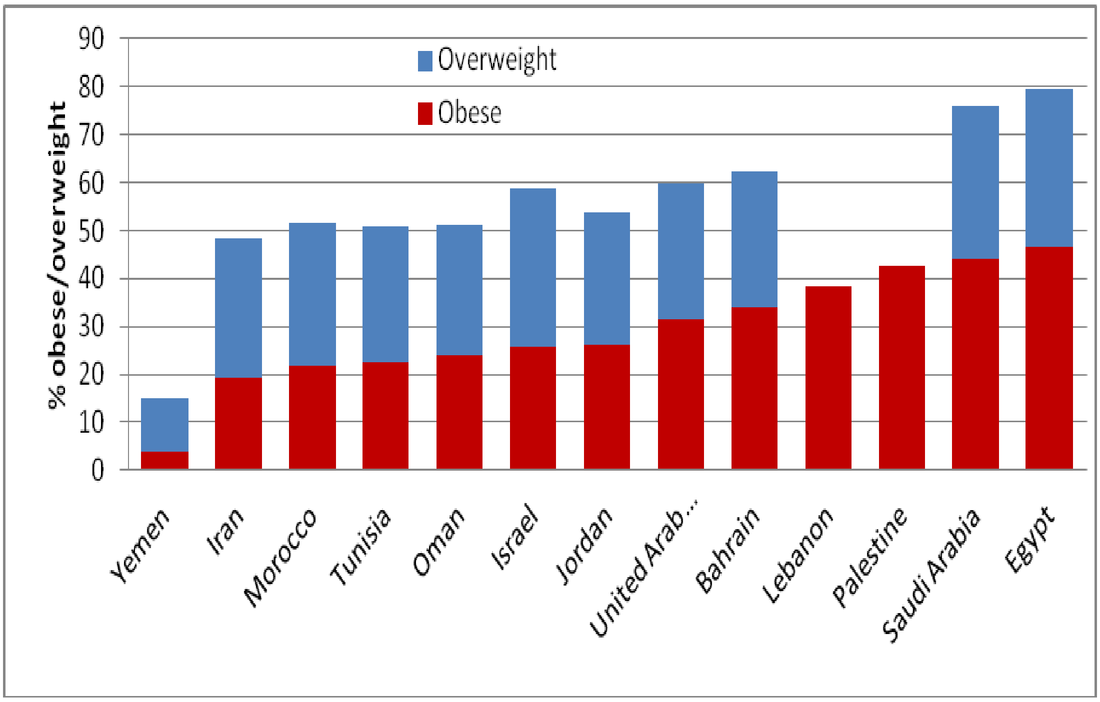
The Middle East and North Africa (MENA) region faces a significant problem of obesity. Nearly one out of every two women in MENA is either overweight or obese (see Figure 6), the highest rate in middle income and industrialised nations. For example, 79.8% of Egyptian women in 2005 and 75.8% of Saudi Arabian women in 1995-2000 were either overweight or obese. In contrast, the corresponding figures were 56.4% in the United Kingdom in 2007 and 61.8% in the United States in 2003-2004. With the exception of Yemen, the only low income country in the region and which has an obesity prevalence of just 4%, all other countries in the region have an obesity prevalence rate of 20% or more among women. The prevalence of obesity plus overweight ranges between 48% in Iran and 79.8% in Egypt, excluding Yemen, which has obesity and overweight prevalence rate of about 15%.

How different or similar is MENA? The majority of populations in MENA follow Islam, while less than 10% of the region's inhabitants are followers of Christianity or other religions. Religious and cultural differences between MENA and other regions might explain the differences in food culture as well as the role of women in the society. The traditional role of women in the society could determine how involved women are in food preparation or physical exercise. The region is also characterised by security problems and sporadic conflicts, which could limit the role of certain groups, particularly women, in the labour force or other activities outside the home. Nevertheless, analysing the implications of religious, cultural or geo-political differences between MENA and other regions on obesity is beyond the scope of this study.

With the exception of Yemen, the majority of countries in MENA are categorised as middle income according to the World Bank's income classification [1], although the region also includes oil-rich high income countries such as United Arab Emirates, Kuwait and Qatar. As shown in Table 3, even accounting for these differences in wealth, or daily calorie supply per capita, the MENA region is a global outlier for having the highest weight-to-GNI ratio or weight-to-calorie ratio, for women (Table 3).

[1] According to the latest World Bank income classification (see World Bank's website: data.worldbank.org) countries with Gross National Income (GNI) per capita <US$1,005 are categorised as low income, those with income per capita between US$1,006 and 3,975 as lower-middle income and those with income between US$3,976 and 12,275 as upper-middle income.

Figure 6: Prevalence of overweight and obesity among women in MENA, 1997-2005



Source: Author's computation using data sourced from International Obesity Taskforce

Table 3: Obesity prevalence among women by income classification and daily calorie supply

	Low-income (GNIPPC <US$1005)	Lower-middle-income (GNIPC US$1006-3975)	Upper-middle-income (GNIPC US$3976-12275)	High-income (GNIPC >US$12275)	MENA
% obese (women)	4.4	13.6	20.6	16.0	31.6
Daily calorie supply per capita	2,225	2,624	2,926	3,300	3,036
Average GNIPC, US$, atlas method	563	2,290	7,011	35,228	11,510
Number of countries	36	31	31	40	16

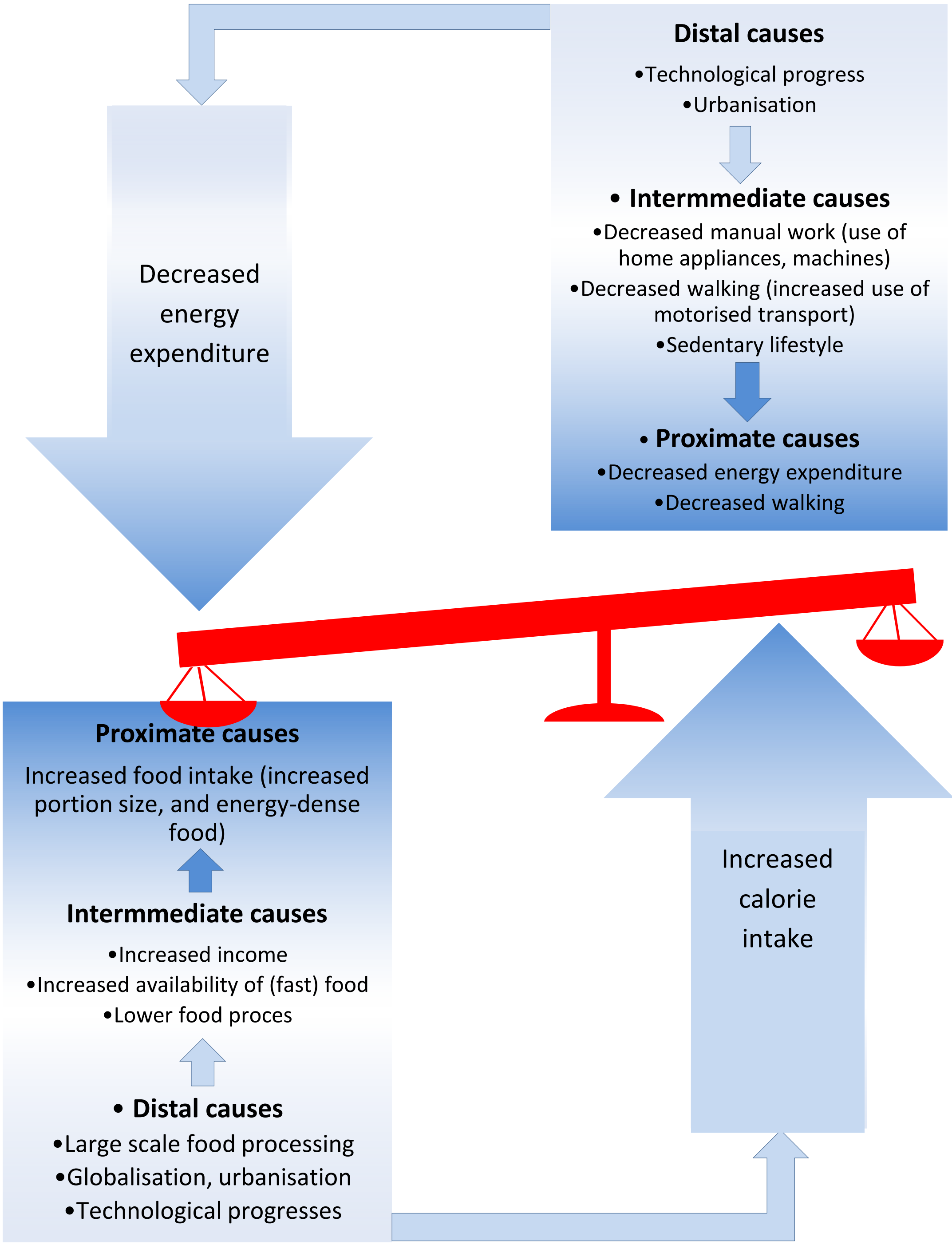
Sources: Gross national income per capita (GNIPC) from the World Bank database (data.worldbank.org); Daily Calorie supply per capita from World Food Organisation (www.faostat.org); and Obesity prevalence from World Health Organisation

Note: MENA countries are excluded from other comparators (i.e. low-, lower-middle-, upper-middle-, and high-income countries)

Why MENA bears such a high burden of obesity? At the most fundamental level, obesity reflects an imbalance between calories intake and energy expenditure (Cutler, Glaeser et al. 2003, Bleich, Cutler et al. 2008). While they may be less important compared with the effects of calories consumed or calories expended on obesity, metabolic and genetic effects are other factors linked to obesity (Mendez, Cooper et al. 2004). However, genes which do not change over the short term (Philipson and Posner 1999) are unlikely to be a major cause of the obesity epidemic observed in MENA, which occurred during the last few decades. While the imbalance between energy intake and energy expenditure is considered to be a proximate cause of change in body weight, other factors are likely to affect this imbalance. Figure 7 provides a brief conceptual framework on the interaction between key distal, intermediate and proximate determinants of energy intake and energy expenditure and obesity.

Figure 7 shows the distal, intermediate and proximate causes of obesity. The top panel of Figure 7 shows how technological progresses and urbanisation could result in reduced energy expenditure due to increased availability and utilisation of automated appliances (such as washing and cooking machines), as well as automated means of transportation which reduces walking. The lower panel of Figure 7 demonstrates how technological progresses, urbanisation and globalization may increase income, food production, and how they reduce food prices, resulting in increased food consumption. The model demonstrates how body weight increases when the distal and intermediate causes result in an increase in energy intake, reduction in energy expenditure or both.

Figure 7: A Conceptual framework on the distal, intermediate and proximate determinants of obesity



While the fundamental cause of obesity is known to be an imbalance between energy intake and energy expenditure (Cutler, Glaeser et al. 2003, Bleich, Cutler et al. 2008), there are factors that contribute to these proximate causes of obesity as indicated above, and some of these factors affect both energy intake as well as energy expenditure. For example, urbanisation is linked to high income and availability of fast foods which contribute to weight gain. More urbanised areas or countries are also more likely to have a higher level of motorized transportation systems and sedentary working conditions, which may reduce energy expenditure and increase weight. On the other hand, people living in high income urban areas are likely to have leisure time for exercising, which makes the association between urbanisation and obesity more complex. Similarly, the association between income and obesity differs from place to place (or from country to country) as evidenced from the systematic review in chapter three. This chapter seeks to identify which of the above key causes of increased body weight are responsible for the obesity epidemic among women in MENA.

Cross-national methods were used to test the hypothesis that MENA's high rate of obesity among women can be in part accounted for by their high caloric intake and relatively low energy expenditure, by exploring the nutritional determinants of caloric intake, sugar intake and other socioeconomic determinants of physical exercise on 154 countries (including 13 from MENA). Sugar energy is reported to raise insulin level in the body (Lustig, Schmidt et al. 2012, Basu, Yoffe et al. 2013) and consumption of sugar is correlated with a high prevalence of obesity and diabetes (Basu, McKee et al. 2013, Basu, Yoffe et al. 2013). The study also tests whether some of the key factors that are cited to reduce energy expenditure or physical exercise, such as urbanisation, car ownership and television watching frequency (Addo, Smeeth et al. 2009); (Colchero and Bishai 2008), are more prevalent in MENA compared with the rest of the world, and whether these factors have significant association with obesity in the region. In addition, the study also investigates the relationship between obesity and female employment (Aslan, Altin et al. 2009), which is linked to both calorie intake and physical exercise (see below). As such, some of these key variables are also interacted with MENA to test whether their effects on obesity are different in MENA compared with the rest of the world.

The rest of this chapter is structured as follows: The next section describes the data and methodology used in this chapter. Section three presents results of the econometric analyses on key macro-level determinants and obesity. Section four discusses the results of macro-level analyses and concludes.

4.2. Methods

The following multivariate model was employed to test the relationship between obesity and variables of interest mentioned above:

$$Y_i = \alpha_i + \beta_1 c_i + \beta_2 e_i + \beta_3 X_i + \varepsilon_i$$

Where Y_i stands for obesity rate in country i, c_i stands for calorie intake or factors that affect calorie intake in country i and e_i represents energy expenditure or factors that determine physical exercise in country i while X_i stands for other control variables such as primary school completion rate, GNI per capita and GNI per capita-squared in country i. Finally, β_1, β_2 and β_3 are coefficients while α_i is constant and ε_i is error term.

In addition to the above model, interactions between MENA and calorie intake or factors that affect calorie intake, as well as interactions between MENA and factors that affect energy expenditure, are also included in the model to test whether the effect of these interactions on obesity is different from the average effects for rest of the world.

Data on the prevalence of obesity were taken from the World Health Organisation (WHO) and from the International Obesity Task Force (IOTF)'s adult obesity database (for an additional 13 countries). The data sourced from both WHO and IOTF databases are generally similar while the IOTF data include more recent surveys and hence a few more countries. Countries for which obesity data were generated based on regional, rather than national surveys, were excluded to ensure the data used were nationally representative. While data for the low and middle income countries, including MENA, come mainly from surveys that measured height and weight, part of the obesity data for some high income countries (n=10) were self-reported, where typically some people tend to underreport their weight (Engstrom, Paterson et al. 2003, Dekkers, van Wier et al. 2008). However, the effect of this potential bias, if any, is negligible since obesity data on most of the middle income countries were generated from measured height and weight data. Moreover, a sensitivity test was undertaken excluding countries with self-reported data and this exclusion did not alter the results of the study.

Calorie intake is represented by daily calorie supply per capita collected from the Food and Agricultural Organisation of the United Nations (FAOSTAT) database (www.fao.org/faostat). The FAO daily calorie and sugar supply data measure availability of foods which reflects production and makes adjustments for exports, imports, waste and animal feed for each country. One obvious weakness of the calorie supply data is that it does not tell us what percentage of calorie supplied is actually consumed. It is expected that some of the calories supplied may not actually be consumed, but this is applicable to MENA as well as the other regions.

Reliable cross-national data on physical exercise or energy expenditure is not available. Hence, various indicators were employed to approximate energy expenditure. These included the share of women participating in the labour force, percentage of population living in urban areas (where physical activity tends to be lower while access to variety of diets is higher), number of passenger cars per 1000 people, ownership of television and frequency of television watching. Data on female labour force participation, urbanisation and passenger cars per 1000 people were taken from the World Bank's World Development Indicators (www.data.worldbank.org).

The World Bank database is widely used in development research focusing on multi-country studies since it covers a large number of countries. The World Bank data are also reliable since they are collected in close collaboration with respective countries. One weakness of the female employment data is that it does not take into account employment in informal sectors or unpaid in-house undertakings that are significant in some countries or regions (see discussion on employment in MENA). Similarly, the percentage of people living in urban areas may not tell the nature of the urban areas, for example, whether urban centres are convenient for walking or cycling or whether most of the people drive. Likewise, it does not disclose the density of fast food stores or restaurants in urban areas. Hence, data on the number of cars per 1000 people is included as proxy to the level of physical exercise. However, household car ownership may not necessarily imply that every member of the household drives or rides in the car, particularly in countries like MENA where the majority of women neither drive nor work outside of their homes (see more discussion below).

Data on television ownership was generated from the State University of New York's Cross National Time Series Archive, a database widely used in studies relating to media, energy, trade, health and education. Data on other control factors such as primary school completion rate and GDP per capita, variables that, in addition to accounting for the level of development of a country, may also affect obesity via knowledge and wealth/income respectively, were acquired from the World Bank's World Development Indicators. Primary school completion rate is commonly reported by governments and is widely used as an indicator of development. However, the quality of primary education may differ from country to country or region to region; as a result similar primary school completion rate may not necessarily reflect the same level of knowledge. Similarly, while GDP per capita is widely used to measure the level of economic development, it is often criticised for not reflecting the actual income distribution among residents of a country. For example, GDP per capita does not show the purchasing power of certain segment (such as the poorest quintile) of the population.

In addition to the survey-year level of the key covariates (daily calorie/sugar supply per capita, female labour force employment rate, urbanisation, motor vehicles per 1000 people and television per capita), changes in these variables between 1970s and 2000s were also considered as determining factors since it could take time for these factors to have an effect on obesity. It is possible that it is the changes in those factors, during the past few decades, that make countries more or less obese, rather than the current levels. Hence, the above model was modified as follows to incorporate changes in calorie/sugar supply as obesity determining factors:

$$Y_i = \alpha_i + \beta_1 \Delta c_i + \beta_2 \Delta e_i + \beta_3 \Delta X_i + \varepsilon_i$$

Where Y_i stands for the latest obesity rate[2] in country i, Δc_i is change in calorie intake or changes in factors that affect calorie intake in country i between 1970s and 2000s and Δe_i is changes in energy expenditure or changes in factors that determine energy expenditure in country i, while ΔX_i stands for changes in other control variables – primary school completion rate and GNI per capita between 1970s and 2000s. β_1, β_2 and β_3 are coefficients while α_i is constant and ε_i is an error term.

The positive association between caloric intake and obesity is well established (Drewnowski and Darmon 2005, Bleich, Cutler et al. 2008, Cecchini, Sassi et al. 2010, Custodio, Miguel A ngel Descalzo a et al. 2010) which is expected to be the same in this study. The existing literature, which mainly uses data from developed countries, suggests that female employment increases the time cost of cooking, which in turn increases fast

[2] Ideally, change in obesity prevalence between two periods should be compared against change in the key covariates. However, obesity data for most of the countries is available for only one year/survey. Hence, the effect of changes in explanatory variables is tested on the current or latest obesity prevalence rate.

food consumption (Chou, Grossman et al. 2004, Gomis-Porqueras, Mitnik et al. 2011) and hence obesity. Globally, however, the nature of the association between female labour force participation and obesity is less clear. In this study, this association is hypothesised to depend on the extent to which work place is more/less sedentary. As such, the association between female employment and obesity depends on the share of the labour force that is employed in sectors that are characterised by sedentary work conditions. The association between female employment (by type of occupation) and obesity is examined more closely in the individual-level analysis in Chapter 5. A higher level of urbanisation, a large number of passenger cars and more hours spent on watching television are expected to be associated with a lower level of physical exercise and hence an increased risk of obesity.

4.3. Results:

Table 2 shows that compared with other middle income or high income countries, MENA has experienced the biggest increase in daily calorie supply between 1970s and 2000s, namely 650 kcal per person, compared with 270 kcal per person in other upper-middle income countries and 215 kcal in high income countries. The increase in calorie supply occurred across all countries in the region but varied widely, ranging between 150 kcal in Yemen and 1,100kcal in Saudi Arabia.

The World Bank data shows that only 22% of women were employed in MENA compared with 42% in upper-middle income countries and 49% in high income economies. MENA has a lower level of urbanisation, fewer passenger cars per 1000 people, as well as fewer televisions per capita compared with high income countries, while the region has a higher level of these socioeconomic factors compared with other upper-middle income countries (see Table 4).

Table 4: Summary statistics

	MENA	Upper-middle-income countries	High-income countries
Obesity (%) – Women	31.6	20.6	16.0
Daily calorie supply per capita (kcal)	3,037	2906	3.237
Daily fat per capita (Fcal)	85	83	124
Daily sugar per capita (Scal)	316	345	397
Change in calorie supply per capita (kcal), 1970s – 2000s	660	212	238
Change in Fat supply (kcal) 1970s – 2000s	3.3	3.9	-5.0
Change in sugar supply (kcal), 1970s-2000s	58	-9.5	-3.8
Employment (% of ages 15-65) – Women	21.7	42	47
Men	69.3	64.3	67.4
Urbanisation (% living in urban areas)	72	53	74
Change in urbanisation (2000s - 1970s)	17.2	15.3	8.9
Motor vehicle per 1000 population	197	114	414
Televisions per capita	0.31	0.30	0.53
Change in television per capita	24	21	31
Gross National income per capita (US$,PPP)	11,510	7,147	35,228
Primary school completion rate – Women (%)	90.7	98	97.2

Source: obesity data come from World Health Organisation and IOTF (now World Obesity Federation

Notes: Data for all variables were generated from the year in which obesity survey took place or the closest year for which data are available; Data on change variables were calculated by taking the difference between average figures for the period of 2001 to 2010 and the period of 1971 to 1980; Obesity data generated from the WHO and IOTF reports published in 2012

The results of the cross-national models, testing alternative determinants of obesity trends and adjusting for potential confounding factors are shown in Table 5. Included in the models are daily calorie and sugar supply per capita, female labour force participation rate, percentage of population living in urban areas, number of passenger cars per 1000 people, televisions per capita, and interaction terms between these variables and MENA. The models also control for a number of confounding factors such as GDP per capita, GDP per capita-squared, primary school completion rate and regional dummies (Table 5). Column 2 uses daily calorie supply per capita and data from the year in which the obesity survey took place or the closest year for which data is available for each covariate. Column 3 uses changes in calorie supply per capita and changes in other covariates during the period between 1970s and 2000s where longitudinal data were available. Column 4 uses daily sugar supply per capita (instead of daily calorie supply per capita) for the year in which the obesity survey took place or the closest year for which data is available. Column 5 uses changes in daily sugar supply per capita and changes in other covariates between the 1970s and 2000s.

There was no significant association between obesity and daily calorie or daily sugar supply per capita or their changes for the whole sample (see row 1 of Table 5). Similarly, no significant association was found between obesity and the interaction term between MENA and daily calorie supply per capita or its change. On the other hand, a statistically significant positive association was observed between obesity and the interaction between MENA and daily sugar supply as well as its change over time (see columns 3 and 4). Similarly, the interaction between changes in urbanisation and MENA has a positive association with obesity (see columns 2 and 4). Likewise, when interacted with MENA, the number of passenger cars per 1000 people and the change in the number of passenger cars (between 1970s and 2000s) have a positive and statistically significant association with obesity.

The association between female employment and obesity is mixed, while neither female employment nor its change over time has a significant association with obesity when interacted with MENA. The existing literature suggests there is a positive association between female employment and obesity in developed countries (Philipson 2001, Finkelstein, Ruhm et al. 2005). Given the fact that work places are less sedentary in developing countries, this study hypothesises that the relationship between obesity and female labour force participation might be different in these countries from what is observed in developed countries (this hypothesis will be further tested by looking at the relationship between obesity and employment by sector in the individual-level analysis in Chapter 5). Finally, television ownership and obesity appear to have no significant association which will also be tested further in Chapter 5 using individual-level data.

Table 5: Ordinary Least Squares estimation of the relationship between socioeconomic factors and obesity

	2	3	4	5
Daily calorie supply per capita (or changes between 1970s and 2000s)	0.003	0.001		
	(0.002)	(0.002)		
Daily sugar supply or its change between 1970s and 2000s			0.009	-0.013
			(0.008)	(0.011)
Employment (% of women aged 15+)	-0.128**	0.083	-0.121**	0.094
	(0.043)	(0.142)	(0.044)	(0.136)
Urbanisation (or % change 1970 to 2000)	0.048	-0.021	0.060	-0.024
	(0.038)	(0.088)	(0.39)	(0.084)
Motor vehicle (per 1000 people)	0.011	0.012	0.012	0.015
	(0.007)	(0.003)	(0.007)	(0.008)
Television ownership	-1.768	-3.782	-2.981	-3.900
	(4.803)	(5.862)	(4.471)	(5.818)
MENA x Calorie supply (or % change)	0.021*	0.022***		
	(0.010)	(0.006)		
MENA x Sugar supply (or % change)			0.030	0. 109*
			(0.042)	(0.048)
MENA x Employment	-1.468	-1.627***	-0.762	- 1.651*
	(0.932)	(0.507)	(0.731)	(0.798)
MENA x Urbanisation (or % change)	-0.964	-0.523	-0.289	-0.527
	(0.554)	(0.285)	(0.487)	(0.310)
MENA x Cars per 1000 people	0.250*	0.046***	0.097	0.084* **
	(0.118)	(0.014)	(0.081)	(0.018)
MENA x Television ownership	27.334	-27.316	73.249	- 25.899
	(40.695)	(17.869)	(41.017)	(34.01 9)
MENA	-3.217	11.727	2.435	13.731
	(17.320)	[6.351)]	(28.598)	(10.79 0)
Constant	0.875	-2.132	4.162	-3.125
	(5.899)	(2.186)	(3.445)	(2.158)
Observations	118	95	115	96
Adjusted R-squared	0.76	0.78	0.76	0.77
Standard errors in brackets	="* p<0.05	** p<0.01	*** p<0.001	

Notes to Table 5: Column 2 tests the association between daily calorie supply per capita and all other covariates (using data from the year in which obesity survey took place, or the closest year for which data is available) and obesity.

Column 3 assesses the effect of change in calorie supply per capita, and changes in other covariates between 1970s and 2000s where longitudinal data were available, on obesity.

Column 4 tests the relationship between daily sugar supply per capita, for the year in which the obesity survey took place or the closest year, and obesity.

Column 5 assesses the effect of changes in daily sugar supply per capita and changes in other covariates between the 1970s and 2000s on obesity.

Note that the number of observations (countries) used in the analysis varied between 95 and 118, a reduction from 154, as a result of missing values. On the other hand, the overall fit of the models are good with Adjusted R-Squared = 0.76 or more.

4.4. Discussion

This chapter investigated cross-national covariates of obesity in MENA. The analysis of global cross-sectional data originating from 154 countries showed that daily calorie and sugar supply are positively associated with obesity in MENA, while female labour force participation and obesity have a negative association. Increased number of passenger cars during the last few decades is also positively associated with obesity in the region. Overall, the following key conclusions can be drawn based on the cross-national data analysis:

1. The Middle East and North Africa saw the largest increase in calorie supply per person between the 1970s and 2000s; and the average daily sugar supply per person and its increase during the last few decades have a consistently positive relationship with obesity among women in the region.
2. MENA is more urbanised compared with other regions and countries of similar socioeconomic status, and urban areas tend to be highly obesogenic compared with rural settings.
3. MENA has the largest number of passenger cars per 1000 people, another attribute positively linked to obesity.

4. Similarly, television ownership in MENA is twice as much as in other regions, and women in the region tend to watch television nearly three times as long as women in other regions of similar socioeconomic status (see chapter 5).

The explanation for the positive relationship between sugar calorie supply and obesity appears to be because weight increases with a higher calorie intake and MENA experienced the largest increase in sugar/calorie supply during the last few decades compared with other regions. While the reason behind this large increase in calorie supply requires a study of its own, one may speculate that the oil boom during the 1970s, which resulted in a seven-fold increase in income per capita in MENA over 10 years (from US$270 in 1970 to US$2042 in 1980) (Karl 1999), and food subsidies enacted in some countries in the region, may have played an important role (Asfaw 2006). Increased oil revenues are often linked to an increased short term consumption, and a low level of social welfare (including health) and a high prevalence of poverty (Karl 1997.).

The negative association between female employment and obesity is inconsistent with the existing literature. Nevertheless, the existing literature that reported a positive association between obesity and female employment depends largely on data generated from developed countries (Paeratakul, Ferdinand et al. 2003, Lakdawalla 2007, Gomis-Porqueras 2011). In contrast, the results of this study supports the finding of a micro-level study undertaken in Turkey, a similar environment to MENA (Aslan, Altin et al. 2009). In this particular study undertaken in Ankara among two groups of women (employed and homemakers) who had similar age and educational status, the group that was employed had a significantly lower level of obesity (6.6%) compared with the group that was homemakers (17.8%) (Aslan, Altin et al. 2009). An analysis of obesity by type of occupation was conducted and it was observed that women who were employed in agriculture or other occupations that require more manual labour were less likely to be obese. This implies that the large majority of women in MENA face a higher risk of obesity since just one out of five women in the region is employed.

A further investigation is required to assess how homemakers spend their time. Some studies point to the existence of a large informal sector in the region, and that the actual female employment is underreported since national surveys do not capture informal sectors (Moghadam 2009). Whether women in the region are employed in the informal sector or in-house, a further research is required to understand why the prevalence of obesity is higher among women who do not participate in the formal sector. One speculation is that women who stay at home are more likely to spend more time cooking which might induce more food consumption compared with women who spend more time outside their homes. For example, the study mentioned above (Aslan, Altin et al. 2009) found a significantly higher consumption of milk products and carbohydrates among women who stayed at home compared with women who were employed. Unemployed women were also more likely to frequently skip breakfast compared with working women. They also found that work place was associated with a less sedentary lifestyle compared with homes.

The literature that reports a positive association between obesity and female labour force participation is based on data generated from developed countries. The most frequent explanation provided for the positive association in these studies (Paeratakul, Ferdinand et al. 2003, Lakdawalla 2007) revolves around the notion that female employment increases time poverty which reduces time spent on cooking at home and, hence, increases consumption of fast/processed food. The opposite finding in this study is likely a reflection of differences in the nature of the work place, which is mainly automated in developed countries but mainly manual in developing economies. Increased employment is likely to increase body weight where occupations are mainly sedentary, while it is likely to result in lower body weight where occupations are mainly manual. Given the less automated work environment in poorer countries, female employment might help prevent weight gain. This is accompanied by a relatively limited access to fast food restaurants and processed foods in these settings compared with developed countries. Hence, it is plausible that the association between female employment and obesity is different in developing countries, where unhealthy foods are either more expensive or less accessible and/or where occupations are less sedentary.

Other factors such as culture and social norms that affect perception about one's body weight or risk assessment could also lead to weight gain. Previous studies have documented such a possibility even in MENA, where significant differences were reported between perceived and actual risks among women (Fernald 2009). For example, in Morocco women preferred to gain more weight, or showed no or little desire to lose weight, when they were already overweight (Rguibi and Belahsen 2004, Lahmam, Baali et al. 2008) or underestimated their weight (Nicolaou, Doak et al. 2008). Their rating of ideal body size was also significantly different from a healthy body size (Rguibi and Belahsen 2006). This may not entirely be due to low level of awareness; it could rather be because some cultures consider large body size as a symbol of positive social status which might encourage weight gain (Lahmam, Baali et al. 2008).

The reason why women who have a high level of education tend to have a lower probability of being obese, even when they possess other socioeconomic characteristics that are linked to weight gain in the region eg. car ownership, is likely that the knowledge effect of having these characteristics on obesity (which is usually negative) is stronger than the income/wealth effect (which is usually positive particularly in MENA). While understanding the working mechanism of this ‘protection’ requires further investigation, encouraging more women to have a higher level of education appears to be a good strategy to prevent obesity among women.

Finally, the estimates of the associations between socioeconomic status and obesity are mainly correlations rather than causations. A causality test is required to verify these relationships and to examine whether these socioeconomic factors are causing obesity or vice versa, or whether these socioeconomic factors as well as obesity are caused by some other unobserved factors. Nevertheless, the findings of this study could provide the foundation for such a study.

4.5. Conclusions

In conclusion, this study finds a disproportionally high prevalence of obesity risk factors among women in MENA, and that these factors made the region a more obesogenic environment compared with other regions of similar level of economic development. While a more in depth analysis is required to verify the association between these risk factors and obesity, as well as to better understand their working mechanisms, the current analysis already points at potential policies that can be pursued in the effort to reduce the burden of obesity in the region. These include awareness creation among communities where a larger body size is considered a positive social symbol, promoting education among women (since having a higher level of education is linked to a lower propensity of being obese even in the presence of other attributes that increase the risk of obesity), encouraging more women to work and exercise, interventions that have the potential to reduce the burden of obesity in the region.

4.6. Summary

This chapter attempted to explore macro-level factors behind the high prevalence rate of obesity in MENA, by assessing the difference between

MENA and other regions in terms of socioeconomic obesity risk factors, and analysing the association between these risk factors and obesity in the region. The study finds that MENA is endowed with several obesity risk factors compared with other countries of similar socioeconomic development. On the other hand, the analysis that uses macro-level data is likely to conceal important details about the associations between various socioeconomic factors and obesity. The next chapter seeks to resolve this limitation by using high quality individual-level data generated from surveys undertaken in MENA and other developing countries. The individual-level analysis is intended to supplement the macro-level analysis in creating a better understanding of factors behind the high prevalence of obesity in the region.

Chapter 5 Socioeconomic inequalities and determinants of obesity in the Middle East and North Africa: is the region different from the rest of the world? A micro-level analysis

Abstract

Background: The prevalence of obesity among women in the Middle East and North African Region (MENA) is one of the highest in the world. One out of every two women in the region is either obese or overweight, a figure significantly higher than the rate of obesity/overweight in developed countries. Despite the severity of the obesity problem in the region, limited analytical literature exists on this topic. This study seeks to explore individual-level socioeconomic factors contributing to the burden of obesity in MENA.

Methods: Focusing on the key socioeconomic determinants of obesity, and using a logit model and individual-level data on 833,274 observations drawn from 43 countries world-wide, the study analyses how MENA is different from other regions in terms of individual-level determinants of obesity, and how these differences increase/decrease the likelihood of obesity.

Results: Women in MENA are more likely to be homemakers compared with women in other regions, and homemakers have a higher likelihood of being obese compared with women in employment, which may account for the high prevalence of obesity among women in MENA. Compared with other middle income countries, the region is also endowed with a high level of urbanisation, car ownership and frequency of television watching, factors that are commonly linked to a higher propensity of obesity.

Conclusions: The disproportionally high prevalence of obesity risk factors among women in MENA is responsible for making the region a favourable environment for obesity, when compared with other regions of similar economic development. While more analysis is needed to verify the association between these socioeconomic risk factors and obesity in the region, the current analysis supports the need for policies aimed at reducing obesity level, such as promoting female education and employment.

5.1. Introduction

The previous chapter highlighted that the Middle East and North African (MENA) faces a significant problem of obesity, particularly among women. Using country-level data, the previous chapter attempted to understand macro-level factors that help explain why countries in MENA suffer from a significant burden of obesity compared with countries in other regions. However, country-level data is less effective in identifying individual-level attributes that might have contributed to the burden of obesity. In this chapter, individual-level data drawn from 144 surveys undertaken in 43 low and middle-income countries were analysed to compare individuals in the MENA region with those in other regions.

This chapter takes advantage of the availability of high quality data on car ownership, frequency of television watching, and place of residence, in testing whether these factors play a role in increasing obesity indirectly by reducing physical exercise. Unlike the previous chapter, where calorie supply was used for national level analysis, reliable data on calorie intake was not available for individuals included in this study and thus, the analysis in this chapter will be based on other correlates of obesity such as female employment (in agriculture, service or manual), place of residence (urban versus rural), car ownership, TV ownership and watching frequency and educational status. Other confounding factors such as age, age squared, regional dummies and time (year of survey) were also controlled for.

Data from 144 nationally representative Demographic and Health Surveys (DHS) that were undertaken between 1991 and 2011 in 43 middle and low income countries were analysed. Eleven of these surveys were undertaken in three MENA countries (Egypt, Jordan and Morocco) comprising 89,157 of the 833,274 observations included in the study, after excluding pregnant women and observations that did not have anthropometric data. Pregnant women were excluded from the analyses since pregnancy normally raises weight. Data from subsequent surveys were pooled resulting in a sample size of 16,340 observations per country ranging from 787 observations in Comoros islands to 71,156 in Egypt.

The objective of this chapter is to estimate how individual-level socioeconomic factors, such as, occupational status, car ownership, place of residence and educational status, affect obesity and whether these effects differ regionally. The level of education was categorised as no education, primary incomplete, primary complete, secondary incomplete, secondary complete and a higher education. On occupational status, women who engaged in an income generating occupation (agriculture, manual and service) were compared with those who were not working. DHS also collects data on place of residence (rural versus urban) which was used to observe whether people who live in urban settings have a higher or lower probabilities of becoming obese.

The remaining part of the chapter is organised as follows: The next section describes the nature of the data and methods used in the analysis. Section three presents results of the individual level analysis and section four discusses the results. Sections five and six present conclusions and summary respectively.

5.2. Methods

This chapter uses individual-level data on 833,274 observations generated from 144 DHS (including 89,159 observations or 11 surveys from MENA) undertaken in 43 low and middle income countries (LMIC) to test whether the effects of the above socioeconomic determinants of obesity (place of residence, car ownership, television ownership and watching frequency and occupational status) are different among women in MENA compared with women in other LMIC.

A logit model was used to estimate the probability that an individual with X_i socioeconomic characteristics is obese. The outcome variable Y_i is coded as 1 if an individual is obese (i.e. BMI $\geq$30) and 0 otherwise. Key explanatory variables, X_i, include occupational status (whether an individual is engaged in agriculture, service, manual labour or unemployed), place of residence (coded 1 if urban and 0 otherwise), television ownership (coded as 1 if there is a television in the household and 0 otherwise) and duration of television watching per day which is categorised into three periods; less than 1 hour, 1 to 3 hours, or greater than 3 hours per day. Since data on calorie supply is unavailable in the Demographic and Health Surveys, the individual-level analysis focuses on the other socioeconomic determinants of calorie in-take and/or physical exercise.

Other confounding factors controlled for are age, age squared, educational status (categorised as no education, primary incomplete, primary complete, secondary incomplete, secondary complete and a higher education). Since there is no time series data to undertake a panel data analysis, year of survey was categorised into three periods; 1990s, 1st half of 2000s, and 2nd half of 2000s to observe the effect of time on obesity. The logit model employed in the individual-level analysis has the following specification:

$$Y_i = \alpha_i + \beta_1 S_{i+} + \beta_2 X_i + \delta T + \varepsilon_i$$

Where Y_i represents the probability that an individual is obese given S_i individual socioeconomic characteristics of interest (including occupational status, place of residence, frequency of television watching and car ownership); X_i control variables such as age, number of children and educational status; and T time or year effects. β_i denotes coefficients while α_i stand for constant and ε_i is for error terms. To simplify interpretation and comparison, the logit regressions are run by region; estimates are shown in Table 3.

Data on individual-level variables was available on the Measure DHS website (http://dhsprogram.com/data/). Eleven of these surveys were undertaken in three MENA countries (Egypt, Jordan and Morocco). DHS are conducted typically every five years and the repeat waves are suitable for monitoring demographic, socioeconomic and health progress in multiple developing countries. These surveys have a large response rate (usually above 90%) and cover a wide range of subjects including health, demographic and socioeconomic conditions. Data from subsequent waves were pooled which resulted in a total sample size of 833, 274, and an average sample size of 16,340 per country.

Anthropometric data in DHS is collected by trained field workers. Height is measured with a skateboard while weight is measured with an electronic weighing scale. BMI was used as a measure of body weight, which is measured by weight in kilograms divided by height in metres squared (kg/m^2). While BMI is often criticised for being inefficient in accurately measuring 'fatness' (Burkhauser and Cawley 2008), it remains the most widely used indicator of body fat to date. The conventional cut-off point of BMI $\geq 30kg/m^2$ is used to define obesity.

5.3. Results

The key objective in this section was to identify individual-level determinants of obesity, and to observe whether these factors affect obesity in MENA differently, than in other regions. The same covariates used in cross-national analysis (in the previous section) are included here except calorie supply for which individual-level data is not available in the DHS. Hence, the key explanatory variables in the individual-level analysis are female employment or occupation (whether employed in agriculture, service, manual jobs or not employed), place of residence (urban or rural), car ownership, television ownership and television watching frequency.

Confounding factors controlled for include, age, age-squared, number of children, educational status and time (year of survey).

In the pooled regression, working is negatively associated obesity. However, the extent of this association depends on the type of occupation, which is likely dependent on the level of manual work required at the work place. For example, women who were employed in manual or agricultural jobs are less likely to be obese compared with women who were not working. On the other hand, women who were working in the service sector had no significantly lower risk of obesity than those who were not working. In MENA, however, even women who are employed in the service sector have a marginally lower probability of being obese compared with those who are not working. Hence, women who are employed in any of the employment sector in MENA have significantly lower probability of being obese compared with women who are not working (see Table 6). Note that the relationship between female employment and obesity varies from region to region, which may reflect, among other things, differences in the level of automation in the work place.

Table 6: Association between SES and Obesity: Logit Estimates

Variable	Pooled data	Middle East & North Africa	Europe	Asia	Latin America and Caribbean	SSA
Not employed (ref.):						
Agriculture	-0.763*** (0.017)	-0.280*** (0.045)	0.085 (0.066)	-1.379*** (0.082)	-0.415*** (0.047)	0.136 (0.033)
Manual	-0.642*** (0.021)	-0.245 *** (0.059)	-0.000 (0.072)	-0.626*** (0.067)	0.012 (0.037)	-0.101* (0.047)
Service	-0.333 (0.012)	-0.066 * (0.028)	-0.018 (0.046)	-0.372*** (0.044)	0.213*** (0.027)	0.180*** (0.029)
Urban	0.501*** (0.011)	0.177*** (0.019)	0.164*** (0.040)	0.802*** (0.040)	0.200*** (0.029)	1.460*** (0.027)
Car ownership	0.102*** (0.015)	-0.189 *** (0.028)	0.271*** (0.040)	0.300*** (0.053)	0.318*** (0.031)	0.425*** (0.035)
No tv viewing (ref.):						
TV. short viewing	1.319*** (0.019)	0.613*** (0.068)	-0.005 (0.137)	0.362*** (0.090)	0.285*** (0.055)	1.522*** (0.027)
TV. medium viewing	1.228*** (0.023)	0.497*** (0.054)	0.048 (0.128)	0.617** (0.079)	0.576*** (0.049)	1.075*** (0.43)
TV. Long viewing	1.801*** (0.020)	0.767*** (0.042)	0.267** (0.097)	1.015*** (0.066)	0.895*** (0.034)	1.060*** (0.032)
No education (ref.):						
Primary incomplete	0.915*** (0.014)	0.269*** (0.028)	0.449 (0.345)	0.092 (0.069)	0.404 (0.042)	2.220*** (0.029)
Primary complete	0. 584*** (0.021)	0.551*** (0.46)	-0.591 (0.519)	0.419*** (0.072)	0.527*** (0.051)	1.360*** (0.043)
Secondary incomplete	0.412*** (0.016)	0.306*** (0.031)	0.050 (0.243)	0.544*** (0.050)	0.417*** (0.051)	1.378*** (0.036)
Secondary complete	0.680*** (0.017)	0.592*** (0.027)	-0.057 (0.243)	0.595*** (0.072)	0.026 (0.055)	1.066*** (0.048)
Higher education	0.279*** (0.020)	0.262*** (0.037)	-0.293 (0.248)	0.539*** (0.063)	-0.432*** (0.060)	0.540*** (0.049)
Age	0.265*** (0.005)	0.264*** (0.009)	0.227*** (0.018)	0.377*** (0.017)	0.286*** (0.009)	0.167*** (0.009)
Age squared	-0.002*** (0.000)	-0.002*** (0.000)	-0.002*** (0.000)	-0.004*** (0.000)	-0.003*** (0.000)	-0.000*** (0.000)
Number of children	0.063*** (0.002)	0.010* (0.004)	0.122*** (0.015)	-0.030*** (0.011)	0.030*** (0.006)	0.013** (0.005)
Period 1 – 1990s (ref.):						
Period 2 – 1st half of 2000s	-0.023 (0.017)	-0.366*** (0.022)	0.249*** (0.051)	0.378*** (0.186)	0.634*** (0.053)	0.902*** (0.061)
Period 3 – 2nd half of 2000s	-0.728*** (0.016)	-0.234*** (0.025)	0.241*** (0.055)	0.670* (0.155)	0.627*** (0.053)	0.808*** (0.060)
Constant	-9.807*** (0.078)	--7. 421** (0.160)	-7.964*** (0.404)	-13.131*** (0.323)	-9.076*** (0.158)	-11.785*** (0.170)
Number of observation	723,270	71,813	26,370	141,669	74,442	408,776
Adjusted (Pseudo) R-squared	0.24	0.12	0.16	0.18	0.14	0.30

Legend: SSA, Sub Saharan Africa; *, $p<0.05$; **, $p<0.01$; ***, $p<0.001$; Standard errors in brackets.

With regards to occupation, MENA is different from other regions in two ways. Firstly, only 19% of women in MENA are working compared with 49.5% in other middle income countries and 50% in low income countries. The share of women employed in agriculture, the sector most likely to protect women from obesity given a relatively lower level of mechanisation, is smaller in MENA, 22% versus 41% in other middle income countries and 48% in low-income countries. Hence, only a small percentage of women participate in the labour force, and even a smaller percentage engages in the relatively physically ‘active’ occupation in the region. This implies that most of the women in MENA, approximately 80%, are not engaged in income generating activities, and most of those who are employed have a relatively sedentary occupation. Second, the relative risk of obesity among women who are not working is higher in MENA (1 to 0.92) compared with other regions (1 to 0.74). This implies that while both places of work and residence are more obesogenic in MENA compared with other regions, being a homemaker involves a higher risk of obesity in MENA. Hence, one explanation for the high prevalence of obesity among women in MENA, is probably a higher relative risk of obesity as a result of staying at home multiplied by a large share of homemakers.

Among other determinants of obesity, urbanisation increases the probability of being obese in the whole sample as well as in the MENA-specific sample, in agreement with current literature. The positive coefficient of urbanisation is likely to reflect the effect of both increased calorie intake (urbanisation being associated with higher-income and more food consumption), and that of a lower energy expenditure (urbanisation being associated with a higher level of automation and sedentary lifestyle) on obesity. The share of urban residents is relatively higher in MENA (51%) compared with the whole sample (36%) and middle income countries (38%). Although the coefficient of urbanisation for the MENA-specific sample is not larger than that of the whole sample, the fact that the relative risk of obesity among urban residents is generally higher compared with that of rural residents, plus the higher share of women living in urban areas in MENA, explains in part the higher burden of obesity in the region.

While the number of passenger cars per 1000 people in MENA is twice as high as in other countries, car ownership is positively associated with obesity in all regions except MENA, where the association is negative (Table 6). This could be due to the fact that women in some countries in the region are not allowed to drive a car, due to religious laws, and hence household car ownership may have little effect on weight of women.

Alternatively, it may also reflect that people who own cars might also possess some other socioeconomic attributes that, despite having cars, helps protect them from obesity. For example, a further analysis undertaken using MENA-specific data to understand why the association between car ownership and obesity was negative, revealed that there is a strong positive correlation between car ownership and having a higher level of education (which has an inverse association with obesity) in MENA in general and in Jordan in particular. In the MENA-specific regression (Table 7), car ownership and education were interacted to test this hypothesis. These results show that the interaction between car ownership and education is negatively linked with obesity, while both car ownership and education are independently positively related to obesity. In particular, having a higher education and having a car are strongly inversely linked to obesity (Table 7). Hence, car ownership is unlikely to reduce body weight on its own; rather, women who have a higher level of education are less likely to adhere to religious or cultural barriers/rules, and more likely to drive or own cars. As such, car ownership is a risk factor for obesity mainly for people who have no education or those with a lower level of education.

Finally, the length of television watching is positively associated with obesity in the whole sample as well as in the MENA-specific regressions.

Again, more households (86%) have televisions in MENA, compared with 55% and 36% of households that own a television in other middle income and in low income countries respectively. Moreover, 84% of women in MENA watch television for 3 hours or more per day, compared with 38% and 33% of observations who watch television for the same length of time per day in other middle income and low income countries respectively. Hence, another potential reason for the high prevalence of obesity in MENA could be the length of time the majority of women watch television.

Table 7: Association between SES and obesity in MENA – Random Effects Logistic estimates

Variables	Coefficients	Standard Errors
Occupation (no employment ref.:)		
Agriculture	-0.351***	(0.045)
Manual	-0.005	(0.062)
Service	-0.113**	(0.028)
Urban	0.351***	(0.019)
Car ownership	0.445*	(0.053)
Educational attainment	0.148***	(0.029)
TV-frequency	0.173***	(0.014)
Interaction between car ownership and secondary/higher education	-0.155***	(0.015)
Interaction between long TV watching and education	-0.096***	(0.029)
Age	0.232***	(0.009)
Age squared	-0.002***	(0.000)
Number of children	-0.018	(0.004)
Year of interview (ref.=1990s)		
1st half of 2000s	-0.013	(0.024)
2nd half of 2000s	-0.134***	(0.027)
Constant	7.116***	(0.420)
Number of observations	71813	
Wald Chi2	6746.9	
Standard errors in parentheses		
Legend: *, p<0.05	** p<0.01	*** p<0.001

Note: Once the interaction of car ownership and education are included in the model, the coefficient of car ownership becomes positive. The interaction of car ownership with education itself is inversely related to obesity while the coefficients of other variables remain about the same. A sensitivity test was made (not reported here) interacting both car ownership and television watching frequency with each educational category and the interaction between a lower level of education and car ownership has a positive association with obesity while coefficients of the other variables remained about the same. Similarly, the interaction between long tv. watching and lower level of education has a positive association with obesity while other coefficients remain about the same.

Length of television watching was also interacted with education, to test whether people with a higher level of education have a lower probability of being obese, despite watching television for long hours per day. In the MENA-specific regression (see Table 7), a negative association is observed between obesity and the interaction term between education and TV watching frequency, despite the positive associations observed between obesity and these two socioeconomic factors independently. It should be noted that the length of television watching is about the same between women with a high level of education and those with other educational categories in the region. While further study is required to understand the working mechanisms, this study finds that people with a higher level of education have a lower level of obesity despite having possessions/characteristics that are positively linked with obesity, arguably because the education effect is stronger than the effect of income (or other possessions) on obesity.

The negative association between obesity and the asset/wealth-education interactions, car ownership interacted with education, as well as length of TV watching interacted with education, has an important implication for the study of socioeconomic inequalities in obesity in MENA. Studies that looked at the socioeconomic association of obesity in the region often report a positive association between asset/wealth and obesity, while at the same time reporting negative association between education and obesity (Belahsen, Mziwira et al. 2004, Ajlouni, Khader et al. 2008, Khader, Batieha et al. 2008, Madanat, Troutman et al. 2008, Beltaifa, Traissac et al. 2009), raising the question of why the two socioeconomic indicators have opposite effects on obesity. The use of the interaction term helps to estimate the ‘independent’ effects of income/wealth and education on obesity, by taking away the combined effects of income/wealth and education on obesity.

5.4. Discussion

The individual-level data generated from 43 low and middle income countries was analysed and the results showed that employed women have a lower probability of being obese in MENA. This individual-level analysis also revealed that employed women in general, and those who are engaged in relatively less sedentary jobs, such as agriculture, in particular have a lower risk of obesity. Furthermore, the individual-level analysis revealed that the majority of women in MENA view television for the longest hours per day compared with other regions. Three key conclusions can be drawn from this investigation:

1. Working and obesity are inversely associated among women in MENA, however, only one out of five women in the region participates in an income-generating activity. Out of the 19% women who are working, a little over one fifth are engaged in employment that protects against obesity. Hence, the largest majority of women in the region are homemakers, an attribute linked to a higher probability of being obese, and the majority of those working are engaged in the relatively more sedentary occupations, such as in the service sector. The association between female employment and obesity is reported to be positive in studies undertaken in developed countries (Paeratakul, Ferdinand et al. 2003, Lakdawalla 2007, Gomis-Porqueras, Mitnik et al. 2011). The negative association between

obesity and female employment in this study may reflect the fact that occupations in developing countries, such as agriculture, are relatively less sedentary and require more physical labour, compared with those in developed countries.

2. Television watching frequency is positivity associated with obesity while car ownership was inversely related to obesity in MENA. However, the interaction between these factors and education revealed that women with a high level of education have a lower risk of obesity, despite having these attributes.
3. Among other socioeconomic determinants of obesity, the prevalence of obesity tends to be the highest among people with primary or secondary education within MENA, while having a secondary or higher education protects women from obesity even when they have other attributes that are risk factors for obesity, such as having a car or watching television for long hours a day.

5.5. Conclusions

In conclusion, MENA is endowed with several obesity risk factors that may be responsible for the high prevalence of obesity in the region. These include the highest percentage of women who are homemakers, the highest number of cars per 1000 people, the highest percentage of women who view television for long hours per day compared with other low and middle income countries. While further studies are required to verify these associations, obesity in MENA appears to be driven by the abundance of socioeconomic risk factors. Consequently, understanding the socioeconomic risk factors could be useful in designing obesity prevention interventions.

5.6. Summary

The cross-national and individual-level analyses in this and the previous chapters revealed that MENA is endowed with several socioeconomic attributes that are positively linked with prevalence of obesity. These include (1) the largest increase in daily calorie supply between the 1970s and 2000s compared with other low, middle and high income countries and a particularly significant positive association between sugar supply and obesity, (2) the largest share of homemakers (low female labour force participation compared with other low, middle and high income countries, (3) the smallest share of women employed in sectors that are linked to low sedentary work conditions compared with other countries of comparable economic development, (4) the largest share of population living in urban areas compared with other countries, (5) the largest number of passenger cars per 1000 people compared with other low and middle income countries, and (6) the largest share of households having television and the largest majority of women watching television for relatively long hours per day compared with other low and middle income countries. All of these socioeconomic factors have a positive and statistically significant relationship with obesity in the region.

The two-MENA-based studies discussed how this region differs from others in terms of the socioeconomic factors linked to obesity, and revealed the prevalence of, and the associations between, key socioeconomic factors and obesity in the region. The next chapter studies the link between obesity and migration, a topic rarely studied among the populations of developing countries migrating within or outside their countries. Migrating from a rural to urban setting or from a less developed to a more developed region/country entails changes in diet composition and lifestyle, which could affect body weight. The following chapter studies the effect of migrating from places where obesity risk factors are relatively scarce to an environment endowed with more socioeconomic risk factors of obesity. Taking advantage of the availability of high quality data, among migrants from South East Asia and Sub-Saharan Africa, the next chapter assesses whether immigrants from these regions to the UK have a higher level of body weight than if they had stayed in their countries of origin. This study contributes to improving our understanding of the effect of rural-urban migration or that of international migration from a less urbanised to a more developed country or region.

Chapter 6: Does Migrating from a Developing Country to the UK Increase Immigrants' Risk of Obesity?

Abstract

Background: A growing body of literature reports that migrating from developing to developed countries is associated with increased obesity. However, it is unknown whether this weight gain is the result of a change in the environment or because those susceptible to obesity are selected to migration. This study attempts to estimate the effect of migration on obesity after accounting for selection bias.

Methods: A comparative analysis of obesity among immigrants in the UK versus non-migrants remaining in their country of origin was undertaken using propensity score matching (PSM). UK immigrants (1,163 women originating in six developing countries, Bangladesh, Ghana, India, Kenya, Nigeria and Uganda and 565 men from India) were selected from the ethnic minority boost sample of Understanding Society survey. Non-migrants (173,012 women from six countries and 69,206 men from India) were drawn from Demographic and Health Surveys undertaken in the respective countries of origin. Each immigrant was matched with a similar non-migrant using common demographic and socioeconomic characteristics including country of origin, gender, age, marital status, number of children, religion, educational attainment and occupational status.

Results: The results show positive and statistically significant effects of migration on obesity, although considerably smaller than the existing ‘naïve’ estimates. Specifically, migration is estimated to increase the probability of being obese by approximately 3.3-5.0 percentage points among women and by 3.5-6.7 percentage points among (Indian) men, both significant at the 5% level or less.

Conclusions: While most of the differences in obesity between migrants and non-migrants are due to differences in demographic and socioeconomic factors (selection bias), exposure to the UK environment also increases obesity, reinforcing the need for specific obesity prevention initiatives for immigrants.

6.1. Introduction

Existing evidence indicates that migration, particularly from developing to developed countries, is strongly associated with increased obesity (Argeseanu Cunningham, Ruben et al. 2008, Cawley, Han et al. 2009). While selection may play a role, with those who are more prone to become obese being more likely to migrate, changes in diet as well as lifestyle are also important (Ayala, Baquero et al. 2008, Gilbert and Khokhar 2008, Mejean, Traissac et al. 2009). Migrants from developing countries face a calorie supply per capita that is usually higher in the host country (World Health Organization); they also tend to substitute home cooking with fast food consumption, among others, due to time constraints (Cutler, Glaeser et al. 2003); (Lakdawalla 2007). Moreover, the increased influence of technological progress (such as washer/dryer, dish washer, hover and other appliances) and sedentary occupations tend to reduce energy expenditure in the host country (Cutler, Glaeser et al. 2003, Finkelstein, Ruhm et al. 2005). If these factors are important, and selection is not, then migration from developing to developed countries can be used as a 'natural experiment' to test the effect of moving to an obesogenic environment.

The majority of the literature on the association between migration and obesity focuses on investigating the lower levels of obesity among immigrants upon arrival (the Healthy Migrant Hypothesis; (McDonald and Kennedy 2005, Park, Myers et al. 2009), and on how their obesity converges with that of the natives over time - the Assimilation Hypothesis;(Antecol and Bedard 2006, Hao and Kim 2009). While the comparison between immigrants and natives in the host countries is certainly important to understand inequalities in obesity among different groups in the host countries, existing analysis is insufficient to infer a causal effect of migration on obesity. This is the case because two issues play a critical role. Firstly, both the treated and control groups are exposed to the treatment, the obesogenic environment, and hence it is difficult to capture the effect of this environment. [3] Secondly, differences in obesity between immigrants and natives may also arise because of genetic factors (Dina, Meyre et al. 2007, Frayling, Timpson et al. 2007). Individuals with a similar genetic makeup also tend to have a similar BMI, even when subjects live in different environments (Maes, Neale et al. 1997).

[3] A small number of papers exploit the fact that treatment and control groups are exposed to the new environment for different time periods, but this is often unsatisfactory since we are unable to observe the immigrant or a comparable subject in the country of origin.

In order to overcome these problems, this study uses a control group that has never been exposed to the treatment (i.e. the obesogenic environment) but comes from the same population. This should strongly reduce the role of genetic differences. Using the Understanding Society's minority boost survey, six developing countries were identified that represent the main sources of the UK immigrants, and this data was pooled with high quality nationally representative data collected recently in these six countries.

Although the control group used in this study has never been exposed to the treatment and is drawn from the same population as the treatment group, selection bias still has to be addressed in order to establish causal effects of migration on obesity, since migrants are unlikely to be randomly selected biasing the estimated Average Treatment Effect (ATE). Migrants tend to be younger, better educated, possibly with smaller families, and often wealthier, or at least above a threshold level (Rienzo 2013). Some of these characteristics may be associated, either positively or negatively, with obesity, implying that migrants would be more or less likely to be obese even if they had not migrated. To address this challenge every immigrant is matched with a non-migrant who has the same socioeconomic and demographic characteristics, using those characteristics that are commonly identified in the literature to be associated with obesity (or its absence), namely age, gender, educational attainment, occupational status, marital status, number of children, and religion. The study also controls for country of origin (Kuntz and Lampert 2010); (McLaren 2007).

Addressing some of the key problems in the literature, the estimates obtained in this study have a better chance of reflecting the causal effects of migration on obesity. The reasons are threefold. First, this is the first study that seeks to compare a treatment group that has been exposed to an obesogenic environment with a control group that has never been exposed to the same environment. Second, rather than comparing immigrants with natives in the host country, which is the dominant approach in the literature (Kennedy, McDonald et al. 2006, Delavari, Sonderlund et al. 2013), this study compares migrants and non-migrants from the same country of origin, thereby strongly reducing potential genetic differences between the control and treatment groups, which have been found to be key drivers of obesity (Dina, Meyre et al. 2007, Frayling, Timpson et al. 2007). Third, taking into account key factors that drive migration, such as education and employment (Rienzo 2013), and assuming that selection into migration is primarily based on these observable characteristics, the approach of this study provides net estimates of the selection effect. Using propensity score matching, the treatment (migrant) and control (non-migrant) groups were matched prior to estimation, ensuring any difference in obesity due to these observed factors is accounted for. As a result, the estimated difference in obesity between the two groups can be attributed to the change in environment after migration.

The study also tests the robustness of the estimates. First, a post matching statistical test was run to ensure there is no statistically significant difference, in terms of the observed characteristics, between the treated and control groups. Second, results from five different matching methods were compared to determine whether the estimates are sensitive to the selection of the matching method. Third, while existing work mostly considers simple correlations between migration duration and obesity (Lv and Cason 2004, Ayala, Baquero et al. 2008, Delavari, Sonderlund et al. 2013), here migrants were divided into sub-groups based on duration of stay in the UK, and each sub-group was matched with people of similar socioeconomic characteristics remaining in the respective country of origin. This enabled this study to tease out the effect of the extent of exposure to the host environment (acculturation) on obesity.

The study is organised as follows. In the next section methods of analyses are outlined and the nature of the data is described. In the results section, first a descriptive analysis is undertaken and then the effect of migration on obesity is tested using different propensity score matching methods. In the discussion section the results are discussed and conclusions are made in the final section.

6.2. Methods and Nature of Data

Methods:

Propensity Score Matching (PSM) is commonly used to estimate causal effects. This method matchs the treatment group, immigrants in the UK in this case, with a suitable control group, defined as a group of individuals that is matched as closely as possible with the ones "exposed to the treatment". In this chapter, the PSM method is used by creating an innovative control group which takes advantage of the availability of high quality surveys in six developing countries from where about 60% of UK immigrants originate. These include two countries in Asia (Bangladesh and India) and four countries in Africa (Ghana, Kenya, Nigeria and Uganda); all data is from 2006 or more recent surveys. BMI and obesity (BMI >30) of immigrants originating from these six countries were compared with that of non-migrants remaining in the same six countries.

To describe the setup of the model more precisely, let M be the binary variable describing the migration status of individual i: specifically, $M_i=1$ if the subject is a UK immigrant from one of the six developing countries, and $M_i=0$ if the individual is a non-migrant remaining in the respective country. The main outcome of interest, a measure of obesity, is denoted by Y_i. More broadly, Y_i can be any possible transformation of BMI, i.e. a logarithmic or any other transformation into a discrete variable with conventional cut-off(s) to indicate an un(healthy) weight category - obesity in this case. The objective here is to test whether Y_i is affected by migration status or more specifically, whether migrants have a higher rate of obesity. The binary variable Y_{0i} and Y_{1i} denotes the potential outcome of interest according the migration status. In other words, Y_{0i} is obesity status of a non-migrant while Y_{1i} is that of a migrant individual. Initially the following basic model is estimated:

$$Y_i = \alpha + \beta_1 M_i + \beta_3 S_i + \beta_2 D_i + \varepsilon_i \qquad (1)$$

Where Y_i is the outcome variable (% change in BMI for OLS and probability of being obese in logit model), M_i is the immigration status (1 if immigrant and 0 otherwise), S_i is a vector reflecting socioeconomic status and containing variables like education, occupation, marital status and religion, D_i reflects demographic factors such as age, gender and number of children, α constant, βi are the respective coefficients and ε_i the error term.

This model is similar to others used in the literature (Averett, Argys et al. 2012), but the control group in this model is a non-migrant remaining in the countries of origin, instead of UK native. Hence, unlike previous studies where $M_i=0$ denotes natives in the host country, in this (PSM) analysis $M_i=0$ denotes non-migrants remaining in the country of origin.

The key question this chapter attempts to answer is whether Y_i is affected by migration status. The binary variables Y_{0i} and Y_{1i} denote the potential outcome of interest according the M - migration status.

In other words, Y_{0i} is the obesity status of an individual who never migrated while Y_{1i} is the individual's obesity status if he/she has migrated. In the real world, however, only one of these potential outcomes can be observed (i.e. the one corresponding to the actual status of the subject because an individual cannot be observed both as migrant and non-migrant at the same time), while the causal effect of interest for individual *i* is defined by their comparison: Y_1 -Y_0. The challenge here is the one commonly posed in the programme evaluation literature that causality test becomes a problem of inference with missing data. Specifically one needs to know the average effect of the treatment on the treated (ATT) i.e. the difference between *Y* for migrants (*M=1*) with respect to the counterfactual unobservable outcome:

$$E(Y_{1i}|M_i = 1) - E(Y_{0i}|M_i = 1) = E(Y_{1i} - Y_{0i}|M_i = 1) \qquad (2)$$

The term in equation (2) is the so-called *average treatment effect on the treated* (ATT). Unfortunately, the ATT cannot be observed directly. Instead, it can be inferred by subtracting the observed difference in average obesity between those with $M_i=1$ and those with $M_i=0$ (first term in the right hand side of equation (2) and a term called *selection bias* (second term in the right hand side of equation (2)). Following (Angrist and Pischke, 2009), equation (2) can be re-written formally as follows:

$$\begin{aligned} E(Y_{1i} - Y_{0i}|M = 1) = \\ &= [E(Y_i|M_i = 1) \\ &- E(Y_i|M_i = 0)] \\ &- [E(Y_{0i}|M_i = 1) \\ &- E(Y_{0i}|M_i = 0)] \end{aligned} \tag{3}$$

Since migrant sample is a non-random sample and because this is a non-experimental framework, a non-zero selection bias is expected. This term would measure the difference in average Y_{0i} between migrants and non-migrants: if migrants are more (less) likely than non-migrants to be obese, then the selection bias would be significantly positive (negative). The selection bias estimated in previous studies measured the difference between the obesity outcomes for migrants with respect to natives in the host country. In this setup, however, it would measure the difference between the obesity outcomes for migrants with respect to similar individuals who had not migrated. By adding and subtracting $E(Y_{0i})$ and assuming that $Y_{1i} - Y_{0i}$ is the same for everyone$(Y_{1i} - Y_{0i} = \beta)$, equation (3) can be re-written as follows which can managed in a standard-regression setup:

$$Y_i = \alpha + \beta M_i + \sigma_i \qquad (4)$$

where β measures the ATT, whereas it can be shown that the selection bias equates the correlation between the error term σ and the regressor M. If M is randomly assigned, then the selection bias would disappear since $Cov(M_i, \sigma_i) = 0$. To adjust for the selection mechanism a possible solution would be the addition of a set of observable characteristics X assumed to affect both M and Y. Problems arise because of the potential association between unobservable variables that might affect the potential outcome (Y_{0i}) and M when M=0, the latter being determined by observable and unobservable variables. A *strong ignorability assumption* (Rosenbaum and Rubin. 1983) is often evoked to solve the identification problem of the ATT. According to this assumption, conditional on observables (X), the mechanism which affects M is independent of Y_{0i}:

$$Y_{0i} \perp M \,|X \qquad (5)$$

The condition in (5) is the Conditional Independence Assumption (CIA) commonly employed in non-experimental studies (Todd 2008). Under CIA, equation (3) becomes:

$$\begin{aligned} &E(Y_{1i} - Y_{0i}|X_i) \\ &\qquad = [E(Y_i|X_i, M_i = 1) \\ &\qquad - E(Y_i|X_i, M_i = 0)] \end{aligned} \qquad (6)$$

Thus, the ATT under CIA can be estimated using regression modelling:

$$Y_i = \alpha + \beta M_i + \gamma X_i + \sigma_i \qquad (7)$$

or statistical matching. Although there are similarities between these two approaches (Angrist and Pischke 2009), the latter would be preferable in the presence of many covariates in the X vector (Ichino, Mealli et al. 2008) and because it allows more efficient checks on the extent of overlapping on values of all covariates X (common support) in both groups (for a discussion of common support in matching see Heckman et al.1998; Smith and Todd 2001). Furthermore and more pragmatically, one would like to compare Y observed among individuals that have the same values of X. Matching algorithms based on the Mahalanobis-metric distance (Rubin 1980) or propensity score ($p(X) = P(M = 1|X)$) allows an individual observed heterogeneity to be condensed to a single dimension $p(X)$ with an outcome value ranging between 0 and 1, $p(X) \in [0,1]$. Robustness checks were performed around estimates obtained using matching algorithms as implemented by Leuven and Sianesi (2003).

The validity of the CIA assumption cannot be verified without observing the missing data or without imposing some un-testable assumptions on the relationship between the selection process and the missing variables. As Ichino et al. (2008) pointed out, the plausibility of this assumption crucially relies on the quality and amount of information contained in X. The X vector used in this study included a set of observable socio-economic and demographic characteristics assumed to be related with *M* and *Y*. This study pursued this approach for arriving at results shown in Table 3.

However, this would not solve the selection bias completely if some unobservable factors, such as genetic differences between the two groups (g) are related with the outcome of interest, $[Y_i, \sigma_i(g, \varepsilon)] = 0$. One possible way around this problem is to observe an individual over two periods, pre- and post-migration. This requires a longitudinal data which is rarely available. In the absence of such longitudinal surveys, the alternative is to draw a control group of non-migrants (*M=0*) that, while sharing a similar socioeconomic and demographic profile as that of immigrants in the UK, has a similar, even if unobservable, genotype/genomic sequence or Mendelian inheritance. In that case, once accounting for key demographic and socioeconomic differences between M=0 and M=1, one may more safely assume that gene difference would play a similar effect in explaining obesity in both groups (migrants and non-migrants) and this can resolve the bias, $E(y|X, M, g) = E(y|X, M)$, a strategy followed in this study.

The above model does not include time since migration, which is used to test the other common hypothesis in the literature, the hypothesis which states that immigrants' health status converges with that of natives in the host country over time (in this study time after migration tests whether migrants' BMI diverges from that of non-migrants remaining in country of origin). Instead, immigrants are sub-divided into three groups with equal number of migrants based on duration of stay in the UK. Then PSM is undertaken for each group and the control group to test if the effect of migration on obesity is higher among those groups who stayed longer in the UK. In this way the study is able to test whether obesity among migrants increases with the length of exposure to the obesogenic environment. Finally, different matching methods were used to test whether the results are sensitive to the matching method employed.

Data

Migrant data is from the Understanding Society survey, an annual survey undertaken in the UK collecting data on more than 40,000 households. The 2009/10 wave contains a boost sample of the most populous minority ethnic groups. The minority boost sample has additional interviews which help to overcome the problem of small sample size which was faced by some of the earlier studies (Averett, Argys et al. 2012). By using self-reported answers to the question "where were you born?" around 3,000 immigrants were identified who were born in six developing countries, where the majority of the UK immigrants from the developing world originated. These include two countries in Asia (Bangladesh and India) and four countries in Africa (Ghana, Nigeria, Kenya and Uganda). Migrant men were excluded from the general immigrant sample, because of lack of a control group in the DHS, except for migrant men from India, where there is a control group in DHS (see below). After excluding pregnant (since pregnancy normally increases weight), the final analysis used 1,164 migrant women originating from these six countries, and 535 men from India for whom BMI data were available. The study uses the survey question "In what year did you first come to live in this country" to compute duration of immigrant status.

A weakness of the obesity data originating from the Understanding Society's minority boost survey is that BMI is calculated from self-reported[4] height and weight data. BMI data generated from self-reported weight and height data have been criticised for under-reporting the true BMI, particularly in developing countries. The effect of potential bias on the findings of this study has been discussed below. The Understanding Society survey also has a low response rate, about 65%, which could create bias if non-respondents have similar characteristics. For example, if the majority of them are obese, then the actual prevalence of obesity reported by the survey could be under-reported.

The control data was generated from Demographic and Health Surveys undertaken in the six developing countries mentioned above. This study focuses largely on women, since DHS collects mainly data on women, but the study includes Indian men since there is anthropometric data for men in the Indian DHS, which is used as a control group as explained below. DHS have large response rates, typically 90% or above, for both household and individual questionnaires, and employ standard measures of weight and height across all surveys, allowing for comparison across countries and surveys. These surveys are undertaken by trained fieldworkers who

[4] A potential bias arising from self-reported weight and height, and how this may affect our results, is discussed further in the text.

measure height with skateboards, and weight with electronic weighing scales. After excluding pregnant women (N=10,731) and a small number of observations for whom BMI data are not available, 173,012 women and 69,206 (Indian) men were included in the analysis for matching with the treatment group.

To estimate the propensity score matching, variables that have been identified in the literature as being important for migration and/or obesity and are readily available in both surveys (the Understanding Society and DHS) were used. These variables include age, sex (men and women were matched separately), religion, marital status, number of children, educational attainment, occupational status and country of origin. All variables employed for matching are similar in both DHS and Understanding Society except educational status. DHS collects the highest number of years of education while Understanding Society collects the highest level of qualification. The UK qualification indicators were converted into the equivalent number of years of education. Then, the number of years of education were categorised into seven categories in both surveys (see Tables 1 and 2 for these categories).

6.3. Results

a. *Descriptive analysis*

Overall, just 4% of women who did not migrate are obese compared with 16.8% of those who have migrated to the UK. Obesity among non-migrant women varies by the country of origin from 2.2% in Bangladesh to 8.3% in Ghana. Taken at face-value, obesity among migrants appears to be about four times higher than obesity among non-immigrants. This difference varies between 2.4 times in Kenya to 5.5 times in Bangladesh and Uganda. However, there are demographic and socioeconomic differences between migrants and non-migrants. Migrants tend to be older (41 versus 29) largely because DHS surveys women of reproductive age group (15-49) while the Understanding Society includes all age groups. Migrants are more educated while there is no significant difference in terms of employment (44% versus 47%) among migrants and non-migrants respectively. Overall, there are statistically significant socioeconomic and demographic differences between non-migrants and migrants (see columns two and three of Tables 8 and Table 9).

Table 8: Summary statistics – Women

	Pre-matching sample			Post-matching sample		
Variable	Migrant (Treated)	Non-migrant (Control)	Difference	Migrant (Treated)	Non-migrant (Control)	Difference
Age	41.346	29.315	12.031***	32.993	32.499	0.494
Married	0.862	0.748	0.113***	0.827	0.835	-0.007
Christian	0.286	0.15	0.137***	0.21	0.203	0.007
Hindu	0.235	0.588	- 0.353***	0.371	0.369	0.002
Muslim	0.354	0.2	0.153 ***	0.3	0.307	-0.007
Other religion	0.125	0.062	0.063***	0.118	0.121	-0.002
Post graduate degree	0.125	0.026	0.099***	0.151	0.156	-0.005
First degree	0.164	0.067	0.097***	0.22	0.222	-0.002
Diploma	0.104	0.109	-0.005	0.13	0.113	0.017
Senior secondary	0.22	0.163	0.056***	0.206	0.21	-0.005
Junior secondary	0.277	0.124	0.153***	0.17	0.182	-0.012
Primary	0.071	0.192	- 0.121***	0.092	0.08	0.012
No education	0.037	0.319	- 0.282***	0.028	0.035	-0.007
Employed	0.434	0.463	- 0.029***	0.466	0.47	-0.005
No child	0.195	0.301	- 0.106***	0.286	0.274	0.012
One child	0.155	0.117	0.038***	0.175	0.175	-
Two children	0.277	0.178	0.099***	0.3	0.317	-0.017
Three children	0.194	0.142	0.052***	0.149	0.142	0.007
Four children	0.093	0.096	- 0.003***	0.045	0.047	-0.002
Five or more children	0.086	0.166	- 0.080***	0.045	0.045	-
Bangladesh	0.268	0.047	0.221***	0.187	0.213	-0.026
Ghana	0.101	0.024	0.077***	0.038	0.045	-0.007
India	0.412	0.698	- 0.286***	0.6	0.596	0.005
Kenya	0.066	0.043	0.024***	0.054	0.026	0.028
Nigeria	0.108	0.173	- 0.065***	0.113	0.116	-0.002
Uganda	0.045	0.016	0.030***	0.007	0.005	0.002
Total observation	1,164	162,294				

Legend: *, $p<0.05$; **, $p<0.01$; *** $p<0.001$.

Note to Table 8: Before matching, there were statistically significant differences between the control and treatment groups in terms of all variables, except in senior secondary level education. After matching, however, there is no significant difference between the control and treatment groups (see the last column which shows no statistically significant difference between the two groups (in terms of the variables included). This indicates that the applied matching has successfully eliminated any underlying differences between the two groups.

Table 9: Descriptive statistic - Men

	Pre-matching sample			Post-matching sample		
Variable	Migrant	Non-migrant	Diff.	Migrant (Treated)	Non-migrant (Control)	Diff.
Age	42.432	30.959	11.473 ***	34.050	33.860	0.190
Married	0.729	0.621	0.108***	0.651	0.653	- 0.003
Christian	0.097	0.092	0.005	0.087	0.085	0.003
Hindu	0.458	0.738	- 0.280***	0.548	0.526	0.021
Muslim	0.148	0.123	0.024	0.127	0.148	- 0.021
Other religion	0.297	0.046	0.251***	0.238	0.241	- 0.003
Post graduate degree	0.295	0.041	0.254***	0.331	0.328	0.003
First degree	0.241	0.071	0.170***	0.272	0.272	-
Diploma	0.049	0.039	0.010	0.050	0.050	-
Senior Secondary	0.105	0.129	- 0.024	0.106	0.116	- 0.011
Junior secondary	0.079	0.382	- 0.304***	0.074	0.077	- 0.003
Primary	0.095	0.193	- 0.098***	0.087	0.095	- 0.008
No education	0.136	0.146	- 0.009	0.079	0.061	0.019
Employed	0.658	0.835	- 0.177***	0.831	0.825	0.005
Total observation	535	69181				

Legend: *, p<0.05; **, p<0.01; ***, p<0.001.

Note to Table 9: Differences in sample mean after propensity score matching (Caliper (0.00001), without replacement). None of the differences between the two groups are statistically significant after matching, a key indicator of the quality of matching.

Post matching test was undertaken in order to observe if the difference in socioeconomic status between the two groups persists after matching. The last columns of Table 8 and Table 9 show that PSM has eliminated the socioeconomic and demographic differences among the treated and control, and the test results show that there is no statistically significant difference between them. Now that the two groups have been matched, the average treatment effect (ATE) can be estimated.

Before presenting the ATE, it is of interest to begin with a ‘naïve’ estimation of the effect of migration on BMI/obesity, using OLS and logit models. The results (see Table 10) show that migration is positively associated with both BMI and obesity. The coefficients in Table 10 can be interpreted as reflecting the percentage change in BMI and the change in probability of being obese among migrants compared with non-migrants. For example, the coefficients in column 2 and 3 indicate that BMI among a migrant woman and man are higher approximately by 6.5% and 9.9% compared with that of a non-migrant woman and man respectively, after adjusting for confounding factors. These figures are equivalent to a weight increase of approximately 3.3 kg for a migrant woman with average height and 5.5 kg for an Indian male migrant with average height.

Table 10: BMI and Obesity among migrants versus non-migrants– Naïve estimates

	Log BMI		Obesity	
	Women	Men	Women	Men
	0.065***	0.099***	0.559***	0.878**
Migrant	(0.006)	(0.008)	(0.111)	(0.204)
Number of observations	162,438	69,575	162438	69,575
Adjusted (Pseudo) R-squared	0.19	0.19	0.13	0.08

Legend: *, p<0.05 ** p<0.01 *** p<0.001; Standard errors in brackets

Note: Coefficients show a unit change in BMI, and percentage change in obesity. The models control for age, educational status, employment status, marital status, country dummies as well as interaction between country dummies and duration of migrant status

The weight of a migrant is likely to be dependent on the extent to which the individual is exposed to the treatment, i.e. the length of stay in the UK. In order to test whether migrants who stayed longer have a higher BMI or a higher probability of being obese, migrants were categorised into three equal groups based on the length/duration of migration status (see Table 13 below). Then PSM was undertaken for each of these three sub groups separately.

b. Does migration increase BMI and obesity?: Propensity Score Matching Results

Having matched the two groups on observable demographic and socioeconomic characteristics that determine obesity (see Tables 8 & 9), and assuming genes are similar among the treatment and control groups (see above), the remaining differences in body weight can be attributable to migration, or the change in the environment (i.e. the effect of moving to the host country). Table 11 shows the ATE which were estimated separately for women and men using the Caliper matching without replacement method[5]. The PSM results for BMI and obesity show a positive effect of migration on BMI and obesity as was the case in the naïve estimate above. However, the PSM

[5] The selection of matching method depends largely on the size and nature of data (see: Dehejia, R. H. and Sadek Wahba (2002). "Propensity Score-Matching Methods for Nonexperimental Causal Studies " The Review of Economics and Statistics **84**(1): 151-161.) While all of the matching methods applied in this study showed postitive and statistically signficant effect of mgration on obesity, and therefore the selection of matching method has no effect on the results/conclusions, the results presented in Table 3 are generated using the Caliper matching without replacement method, the estimates of which are arguably more robust when there is a large control group to select from, which is the case in this study. Ibid.

coefficients for both BMI and obesity are lower (PSM coefficients for obesity are significantly lower) than the naive estimates, indicating the fact that PSM has helped in reducing migrant selection bias compared with the naive estimation method. More specifically, the PSM results show that migration increases BMI by approximately 5.8% for women and 8.7% for men, a figure close to the naïve estimate. On the other hand, the PSM results are significantly lower for obesity: For example, the probability of being obese among migrant women was reduced from 0.56 in the naïve estimate to 0.04 in PSM (compare results in Table 10 and 11). This implies that an average migrant would still have a higher level of BMI even if he/she had not migrated, whereas the probability that an average migrant would have been obese is significantly lower if he/she had not migrated. In other words, migration has a lower effect on increasing overall BMI, while it has a larger effect on obesity.

Table 11: BMI and Obesity among migrants versus non-migrants– PSM

	Log BMI		Obesity	
	Women	Men	Women	Men
ATE for Migrant	0.058*** (0.013)	0.087*** (0.012)	0.042*** (0.018)	0.039** (0.017)
Observations: Non-treated	161,727	59,114	161,651	59,114
Observations: Treated	1083	535	1082	535

Standard errors in brackets

Legend: "*, p<0.05; **, p<0.01; ***, p<0.001"

All estimations have standard bias less than 5%

PSM was also undertaken separately for each of the three groups created based on duration of stay in the UK. The results (shown in Table 11) show that the migrant group that lived the longest in the UK is more likely to have a higher level of BMI and a higher probability of being obese compared with those who lived for a shorter period of time. This is the result of acculturation, the longer immigrants live in the host environment, the more likely they are to adopt the host diet and lifestyle.

c. *Robustness checks*

In order to check the robustness of our estimates, Table 12 presents ATE generated using five different matching methods, including the one presented above (for discussion about different matching methods see Austin 2011). The methods used here are matching without replacement (above), matching with replacement, matching with (10) neighbourhood, Kernel matching, and Mahalanobis matching. The first method matches a treated individual with only one untreated individual with closest propensity score, while in the second method an untreated individual can be used more than once as a match. In order to avoid poor matching, a 'caliper' (maximum distance allowed for propensity score to match) is defined for each method. Post-matching tests are used for each method to adjust the caliper to ensure a good quality of matching. The third method allows using up to 10 closest neighbours. Kernel method matches each treated individual with a weighted average of the outcome of all the untreated people (those with scores closest to the treated individual take the highest weight). This is the least favoured method in this analysis since it considers all untreated individuals. The last method, Mahalanobis, is useful in finding close matches for all matching variables (Rubin 1980). Although there is no clear rule for determining which method is best, matching without replacement is the most preferred method as it is a one-to-one matching method

Table 12: Summary of robustness check using multiple PSM methods

Matching method	ATE (BMI)		ATE (Obesity)	
	Women	Men	Women	Men
Caliper (0.0001) with rep	0.066***	0.087***	0.042*	0.035*
	(0.012)	(0.015)	(0.020)	(0.019)
Caliper (0.001) No rep	0.058***	0.087***	0.042*	0.039*
	(0.012)	(0.012)	(0.019)	(0.016)
Caliper (0.0001) and	0.071***	0.084***	0.042**	0.042**
Neighbour (10)				
	(0.009)	(0.009)	(0.016)	(0.014)
Kernel common Bw(0.01)	0.066***	0.081***	0.043**	0.037**
	(0.008)	(0.008)	(0.014)	(0.013)
Mahalanebis (0.001)				0.035*
	0.068***	0.080***	0.048**	
	(0.01)	(0.014)	(0.018)	(0.019)
N = untreated	161,727	59,114	161,651	59,114
N = treated	1083	535	1082	535

Legend: *, p<0.05 ** p<0.01 *** p<0.001; Error terms in brackets

Note to Table 12: All matching methods show a positive effect of migration on obesity, and there are no major differences between most of the coefficients, which reflects the consistency of results across the most common matching methods.

For each matching method, post-matching tests were undertaken to ensure that there is no statistically significant difference or bias between the control and treatment groups for each of the variables included (see Table 8 and Table 9). All matching methods show a positive effect of migration on BMI/obesity for both men and women. More specifically, on average the BMI of an immigrant woman in the UK is higher by 5.8 to 7.1 percentage points compared with non-migrant woman of similar socioeconomic characteristics (see Table 12). Similarly, the probability of being obese for an immigrant woman is higher by 4.2 to 4.8 percentage points compared with a non-migrant woman with similar socioeconomic and demographic factors. The range of the coefficients implies the sensitivity of the different matching methods. All results are statistically significant including for those matching methods where a significant number of observations, up to 34% for women and 23% for men, were excluded from the treatment group. Each method successfully matched 740 or more immigrant women and 430 or more immigrant men with their non-immigrant counterparts.

Finally, propensity score matching was performed for the categories of sub-samples based on duration of stay in the UK. Tables 13 and 14 present the matching results for BMI and obesity respectively. Overall, both BMI and obesity increase with duration of stay in the UK for both men and women although the level of significance varies.

Table 13: Duration of migrant status and BMI – PSM

	Women - ATE				
	Caliper (0.00001) with rep	Caliper (0.00001) No rep	Caliper (0.00001) and Neighbour (10)	Kernel common Bw(0.01)	Mahalanebis (0.001)
≤9 years	0.061***	0.052**	0.056***	0.049***	0.050**
	(0.016)	(0.015)	(0.012)	(0.010)	(0.015)
10 - 26 years	0.063**	0.055**	0.071***	0.087***	0.065**
	(0.018)	(0.018)	(0.014)	(0.014)	(0.018)
>26 years	0.087**	0.086**	0.090**	0.099***	0.096***
	(0.038)	(0.038)	(0.031)	(0.017)	(0.023)

	(Indian) Men - ATE				
	Caliper (0.0001) with rep	Caliper (0.0001) No rep	Caliper (0.0001) and Neighbour (10)	Kernel common Bw(0.01)	Mahalanebis (0.001)
≤4 years	0.099***	0.080***	0.074***	0.069***	0.076***
	(0.021)	(0.018)	(0.014)	(0.013)	(0.020)
5-25 years	0.070**	0.080***	0.081***	0.078***	0.088***
	(0.019)	(0.016)	(0.012)	(0.011)	(0.019)
≥25 years	0.106**	0.116**	0.139***	0.136***	0.121***
	(0.034)	(0.031)	(0.0.22)	(0.020)	(0.030)

Table 14: Duration of migrant status and obesity - PSM

	Women - ATE				
Duration	Caliper (0.0001) with rep	Caliper (0.001) No rep	Caliper (0.0001) and Neighbour (10)	Kernel common Bw(0.01)	Mahalanebis (0.001)
≤9 years	0.016	0.012	0.013	0.003	0.012
	(0.024)	(0.022)	(0.019)	(0.017)	(0.023)
10 - 26 years	0.069*	0.059*	0.072**	0.099***	0.054*
	(0.031)	(0.031)	(0.027)	(0.023)	(0.032)
>26 years	0.146*	0.147*	0.105*	0.110**	0.140**
	(0.077)	(0.077)	(0.044)	(0.036)	(0.050)

		Men (India) - ATE			
Duration	Caliper (0.0001) with rep	Caliper (0.001) No rep	Caliper (0.0001) and Neighbour (10)	Kernel common Bw(0.01)	Mahalanebis (0.001)
≤4 years	0.025	0.031	0.032	0.029	0.037
	(0.026)	(0.022)	(0.019)	(0.018)	(0.023)
5-25 years	0.042	0.036	0.033	0.028	0.000
	(0.026)	(0.023)	(0.021)	(0.020)	(0.026)
≥25 years	0.104*	0.098*	0.094*	0.091*	0.115*
	(0.060)	(0.056)	(0.050)	(0.049)	(0.052)

* p<0.05 ** p<0.01 *** p<0.001

Note that, in most cases, coefficients increase as duration in the UK increases, which indicates that the effect of migration on BMI/obesity increases as the duration of exposure to the UK environment increases.

6.4. Discussion

The purpose of this study was to investigate whether migrating from developing countries to the UK has a causal effect on obesity. The existing literature is limited to analysing a simple correlation between migration and obesity. Such analyses are likely to suffer from immigrant selection bias. Furthermore, a common approach in the literature is a comparison of immigrants with natives in the host countries. After matching the migrants in the UK with a control group of non-migrants remaining in their countries of origin, a positive and statistically significant effect of migration on BMI and obesity was found. The effects of migration on obesity computed using PSM are much lower than the 'naïve' estimation, that would have been reported if PSM was not used. It was also observed that, in general, BMI and obesity among migrants tends to increase with the duration in migration which can be thought of as 'dissimilation' of migrants' BMI from that of non-migrants as duration of migration increases. In contrast with the assimilation of immigrants' health with natives referred to as "assimilation hypothesis" in the literature where the control group is natives in the host country (McDonald and Kennedy 2005);'(Kennedy, McDonald et al. 2006, Park, Myers et al. 2009) The increased risk of obesity faced by migrants may be related to changes in environmental factors such as increased unhealthy food consumption as well as sedentary lifestyle in the host country. Studies have shown that migrants tend to increasingly adopt the diet of the host countries as the length of migrant status time increases (Satia 2010) and that such acculturation is correlated with health deterioration including developing obesity (Gilbert and Khokhar 2008, Regev-Tobias, Reifen et al. 2012)

Several sensitivity tests were undertaken to check the robustness of the results. First, multiple matching methods were used, caliper matching without replacement, calliper matching with replacement, caliper matching with replacement and 10 neighbours, Karnel, and mahalanonis matching, to test the robustness of the estimates. While the size of the effects show limited variation based on the matching method employed, all of the estimates show a positive and statistically significant effect of migration on obesity. Second, Indian women (which constitutes over 40% of migrant women) were excluded and tested to check if the results are sensitive to this exclusion and no effect was observed. Matching was also performed separately for Africa and Asia to determine if there is regional variation in the coefficients, with similar results. Third, post-matching tests were undertaken for each matching method and variable (and for each category of variable) to ensure that there is no statistically significant difference between the treated and control group after matching. Fourth, separate matching was undertaken for three sub-sample categories created based on duration in migrant status to test the robustness of the time effect. Larger effects were found in general for migrants who lived longer in the UK, a common finding reported in the literature (Kennedy, McDonald et al. 2006, Park, Myers et al. 2009)

However, limitations remained. First, the analysis of men uses data only from India since DHS surveys focus on women and the study lacked a control group for immigrant men from other countries. Hence, the estimates for men is largely limited to immigrants from India and perhaps, by extension the Asian subcontinent. Second, while the Demographic and Health Surveys collect measured height and weight data, the Understanding Society's anthropometric data are self-reported, which could be a potential source of bias. People in developed countries tend to under-report their weight while they tend to over-report height (Engstrom, Paterson et al. 2003, Dekkers, van Wier et al. 2008), both having the potential to reduce actual BMI.

This means the effect of migration on obesity would be even larger if such reporting bias is true for immigrants in the UK. Finally, the causal effects estimated in this study are based on the assumption that selection into migration is based on observable factors which are controlled for. While the common observable socioeconomic characteristics of migrants are controlled for in this study (Rienzo 2013); (Borjas G 1994), one cannot exclude the role of unobserved factors.

6.5. Conclusions

A simple comparison of obesity among migrants versus non-migrants showed the existence of a significantly higher burden of obesity among migrants. Matching the treated and control groups (migrants and non-migrants) in terms of key demographic and socioeconomic factors substantially reduced the differences in obesity between migrants and non-migrants. The results of this study indicate that migrants bear a larger and more statistically significant burden of obesity than they would have if they had not migrated. Hence, migrating from developing countries to the UK increases the risk of obesity, which may imply the need for obesity prevention interventions among immigrants. There is some evidence that obesity and other chronic disease prevention interventions become more effective when they are tailored to specific target group, considering social and cultural context under which intervention occurs (Renzaho, Mellor et al. 2010, Tovar, Renzaho et al. 2014), while the implementation of such a tailored intervention could be difficult (Gucciardi, Demelo et al. 2007).

Having established a causal effect with higher confidence than was available in the current literature, the intriguing question remains as to which characteristics of the obesogenic environment make immigrants more or less likely to be obese. In addition, it would be interesting to evaluate how quickly or slowly immigrants adopt these key factors of their new environment, as this will also help to explain differences in obesity among immigrants.

Chapter 7: Discussion and Conclusions

This thesis examines socioeconomic inequalities in and determinants of obesity, focusing on populations living in or originating from developing countries. The four studies incorporated in this thesis provide a brief description of the extent of the problem of obesity and focus on identifying the risk factors or determinants of obesity. Evaluating the effectiveness of interventions, prevention or treatment, is beyond the scope of the thesis.

While the literature on the prevalence of obesity in developing countries is growing fast, only a limited number of studies exist that analyse the socioeconomic inequalities in and determinants of obesity in developing countries. The four free-standing studies included in this thesis focus on addressing some aspects of this limitation.

The challenge in studying obesity in developing countries in general and in analysing its determinant in particular, is lack of appropriate data. The majority of surveys undertaken in these countries are either limited to cities or main regions or fail to collect information on key socioeconomic factors that are critical for the study of obesity. Hence, studies that use these surveys are unable to generalise their findings nationally or internationally.

Likewise, they are unable to undertake robust analyses of the socioeconomic inequalities in and determinants of obesity due to lack of appropriate data on confounding factors.

The existence of the Demographic and Health Surveys (DHS) which collect measured weight and height data in several developing countries are useful for analysing socioeconomic inequalities in and possible determinants of obesity in these countries. Nevertheless, only a few recent studies have taken advantage of these surveys (Jones-Smith, Gordon-Larsen et al. 2011) (Ziraba, Fotso et al. 2009, Subramanian, Perkins et al. 2011). There is scope for using these nationally representative and high quality surveys for a deeper study of obesity in low and middle income countries. Three of the four studies included in this thesis use the DHS data in addition to more data generated from other sources. The findings of the systematic literature review and the three analytical papers that use DHS data improve our understanding of the socioeconomic inequalities in and determinants of obesity in developing countries and hence will inform public health policy interventions intended to prevent and control obesity.

7.1 Summary and Synthesis

The literature on the prevalence of obesity in developing countries is relatively large and growing. On the other hand, the socioeconomic inequalities in obesity in these countries are not adequately understood although the review of the recently published papers (Dinsa, Goryakin et al. 2012) showed that the number of studies focusing on this issue has markedly increased. Furthermore, studies undertaking the analyses of determinants of obesity in developing countries are rare, if any. This thesis presents a systematic review of the literature on the association between socioeconomic status and obesity published between 2004 and 2010, as well as three analytical studies on the socioeconomic inequalities in and determinants of obesity, using secondary survey data collected in selected developing countries.

With the systematic literature review the thesis adds knowledge by clarifying that the burden of obesity shifts from women with high SES to those with low SES at a lower level of socioeconomic development of a country than previously understood. In addition to validating some of the results of an earlier review (Monteiro, Moura et al. 2004), this systematic review also shows that obesity among children in developing countries appears to be largely a problem of affluence, irrespective of the level of socioeconomic development of a country (Dinsa, Goryakin et al. 2012).

While socioeconomic inequalities in and determinants of obesity vary even within the developing world itself, the analyses of the socioeconomic inequalities in obesity in MENA, a region where one out of every two women is either overweight or obese, is a useful contribution for understanding the socioeconomic inequalities in and determinants of obesity in a region with high obesity prevalence. Using cross-country and individual-level analyses, the thesis contributes new knowledge by identifying key macro- and micro-level drivers of obesity in the region. The findings show a high concentration of factors that increase food intake as well as a high concentration of factors that reduce physical exercise (a high level of urbanisation, passenger cars, television watching and sedentary lifestyle in general), to be responsible for the disproportionally high burden of obesity among women in MENA. In addition to identifying factors that drive obesity, the two MENA based studies found that having a higher level of education protects women from obesity even when other obesity risk factors exist among these women.

The MENA-based studies also reveal that female employment and obesity are inversely related. Obesity prevalence is lower among working women while only about 20% of women in the region are working (the lowest rate in the world) and the majority of those working are engaged in relatively sedentary occupations. The majority of women in MENA are homemakers and being a homemaker is associated with a higher risk of obesity. While the low rate of female employment might be due to cultural or religious reasons, the reason why homemakers have a higher risk of obesity requires further investigation.

Internal or international migration is now a common phenomenon with improved infrastructure that links the world and allows mobility. Migration entails changes in the environment such as change in diet, physical exercise or lifestyle in general. The effect of migration on obesity reflects the effect of change in the environment that is independent of genetic background. People commonly migrate from rural to urban areas, or from a less developed country/region to a more developed one, which may result in the consumption of processed or fast food and having a sedentary workplace (Philipson 2001, Lakdawalla and Philipson 2009), both of which are linked to an increased body weight.

However, people with high SES and those who are physically more active, are more likely to self-select in to migration. Hence some of the effect of migration on obesity is likely because people who are more/less likely to gain weight are the ones who self-selected into migration. The issue of self-selection poses a significant challenge in establishing causality in any study. Using innovative treatment and control groups, the fourth study in this thesis deals with the issue of self-selection and finds that migrating from developing countries to the UK increases the risk of obesity. Using data on UK immigrants originating from developing countries and making use of propensity score matching (PSM) to compare an innovative treatment group from the British Understanding Society survey with a control group from the DHS to address self-selection, this thesis provides new information by estimating the effect of migration from developing countries to a developed country on obesity.

7.2 Limitations

The review of the recently published literature synthesised the directions of the association between SES and obesity, not the strengths of these associations. A meta-analysis of the strengths of these associations using studies that employ similar methodologies could provide useful information, although the number of such studies is severely limited. Some of the findings of the systematic review were based on limited number of studies and it is important to caution against inferring overly strong conclusions from the limited number of studies reviewed. These include the limited number of *nationally representative* studies (five for men and 10 for women), as opposed to the greater number of studies based on sub-national samples, which render the assignment of the relevant level of per capita income somewhat arbitrary. The number of studies on children was also limited (N=11). Moreover, the relationships between overweight/obesity and socioeconomic factors reported in the review included in this thesis reflect a simple correlation and do not allow inference about the causal nature of the relationship.

The studies on socioeconomic inequalities and determinants of obesity in MENA identified key socioeconomic factors that drive obesity. However, the data used for these analysis were largely cross-sectional; it is important to use time-series data (when such data are made available) on both obesity and socioeconomic factors, which will facilitate undertaking a more rigorous analysis using panel data. Similarly, while efforts have been exerted to minimise biases, some of the data the studies used are not ideal for representing the variables of interest. For example, calories supplied may not be the same as calories consumed, since some of it might be wasted. Hence, using actual calorie consumption data provides a more accurate estimation of the relationship between calorie consumption and obesity. Finally, the estimates of the associations between the socioeconomic factors and obesity in MENA are mainly correlations rather than causations. A causality test is required to verify these relationships and to examine whether these socio-economic factors are causing obesity or vice versa, or whether these factors as well as obesity are caused by some other unobserved factors. Nevertheless, the findings of this study can be a springboard for such a study.

The study on the effect of migration on obesity addressed the issue of selection bias and found that migrating from developing countries to the UK increases the risk of obesity among immigrants. On the other hand, the study has few limitations that, if improved, will enhance our understanding of the effect of migration on obesity. First, the study lacked control groups for men in developing countries except India since DHS surveys mainly focus on women. Hence, the representativeness of the estimates for men is largely limited to immigrants from India and perhaps, the Asian subcontinent. Second, while the Demographic and Health Surveys collect measured height and weight data, the Understanding Society's anthropometric data are self-reported, which could be a potential source of bias. Since people in developed countries tend to under-report their weight and over-report height (Engstrom, Paterson et al. 2003, Dekkers, van Wier et al. 2008), the effect of these reporting biases have the potential to reduce actual BMI. If such reporting bias is true for immigrants in the UK, the effect of migration on obesity reported on this study would be even larger; however, this needs to be verified by studies that use measured anthropometric data for both groups. Finally, the causal effects estimated in this study are based on the assumption that selection into migration is based on observable factors which are controlled for in this study. While the common observable socioeconomic characteristics of migrants are controlled for in this study (Rienzo 2013) (Borjas G 1994), one cannot exclude that some unobserved factors play a role.

Overall, some of the data used in the analysis, particularly in the cross national analysis in Chapter 4, have missing values that might result in selection bias. Similarly, some of the data used in this chapter and chapter 6 were generated from different sources which may adopt different survey methodologies. These limitations could be overcome as more surveys or more indicators within each survey are made available.

7.3 Future Research

Further research is required even in the developed world where there have been many efforts to understand various aspects of obesity (Rodgers 2012). Future research should attempt to understand why the shift in the burden of obesity from higher to lower SES occurs faster among women compared with men (Monteiro, Moura et al. 2004). Similarly, potential research also needs to identify factors that determine the stage of socioeconomic development at which this shift occurs in a particular country. Furthermore, the positive association between SES and child obesity which is different from the relationship observed in developed countries (Shrewsbury and Wardle 2008, Due, Merlo et al. 2009), requires verification and explanation. Most importantly, a key task will be finding out how the growing burden of obesity, both among the poor and the rich, in developing countries can be prevented.

The studies on MENA described how the region differs from the rest of the world in terms of the key determinants of obesity and estimated the association between these factors and obesity in the region. Further research is required to verify these correlations. One of the striking findings of the MENA studies was that only one out of 5 women in the region participates in the labour force. An investigation is required to understand why the region is characterised with such a low female employment rate and how those who are not employed in the formal sector spend their time (Moghadam 2009). Further research is also required to verify and understand why being a homemaker is associated with a higher probability of being obese (Aslan, Altin et al. 2009).

The study of the effect of migration on obesity emphasises two future research avenues. Having established a causal effect with higher confidence than was available in the literature up to now, the critical research issue that remains to be addressed is the identification of the characteristics of the obesogenic environment which make immigrants more or less likely to be obese. Another important issue is to study how quickly or slowly immigrants in the UK adopt these key factors of their new environment, as this will also help to explain differences in obesity among immigrants.

7.4 Health policy implications

Obesity is increasing among the general population in developing countries. Current figures show that one third of the adult population of the developed world is either obese or overweight (World Health Organization 2015). As their incomes increase and the socioeconomic status of their populations change, developing countries may soon face a significant problem of chronic diseases related to weight increase. This is already reflected in the increasing prevalence in non-communicable diseases in these settings (Yach, Hawkes et al. 2004), which imply that the health systems of developing countries need to be equipped with resources required for preventing obesity as well as treating illnesses relating to the risk factor (Strong, Mathers et al. 2005). These countries bear the 'double burden' of both non-communicable as well as communicable diseases since the prevalence of communicable diseases is still high (Boutayeb 2006).

The fact that obesity is shifting from the rich towards the poor at a lower level of income per capita (Dinsa, Goryakin et al. 2012) than previously thought (Monteiro, Moura et al. 2004) implies that developing countries need to start preventing this shift from happening or protecting the poor from obesity at an early stage of economic development. Such an early intervention requires developing national policies for the prevention and treatment of non-communicable diseases (Holdsworth 2013), while the resources needed for the prevention and treatment of infectious diseases are still high.

Several obesity intervention strategies recommended in the literature (Khan 2009; Swinburn 2002), most of which focus on promotion of healthy diet and lifestyle, could be useful for obesity prevention in many developing countries. More importantly, since heavy weight is considered as a high social status symbol some cultures in developing countries and hence fattening foods are considered desirable, interventions that focus on modifying harmful cultural practices and norms are likely to have an effect on obesity prevention (Kumanyika and Obarzanek 2003, Caprio, Daniels et al. 2008). Also important is promoting attributes that are correlated with lower level of obesity, such as educating more women and increasing female employment, in many developing countries. Since causality is unlikely to go from obesity to educational status or to female labour force participation, interventions that promote increasing educational attainment of women and female employment are likely to help in reducing the risk of obesity among women.

Having established the causal effect of migrating from less to more developed country on obesity, the results of this study suggest that obesity prevention interventions tailored to immigrants are worthwhile in order to prevent chronic diseases that follow obesity. Such an intervention is suggested, for example, in a systematic review of studies that assessed intervention effectiveness on obesity and chronic diseases among US immigrants which revealed that culturally tailored interventions are more effective than generalised interventions although the review assessed only small number of studies (Renzaho, Mellor et al. 2010). This particular review also suggested that intervention content is more important than duration or venue of the intervention. While generic intervention among the whole population in the host country, such as taxes on calorie-dense foods and/or subsidies on fruits and vegetable, as well as physical exercise might be equally important for immigrants, interventions focusing on cultural and social context of immigrant communities could be more effective (Kumanyika and Obarzanek 2003).

7.5 Conclusions

The results of the systematic review provide valuable information regarding the association between SES and obesity in the developing world: obesity is a problem of the rich in low income countries for both men and women, while there is a mixed picture in middle income countries. The review also revealed that obesity is unanimously a problem of affluence among children in developing countries although this needs to be verified using a larger number of studies.

One of the analytical papers in this thesis showed that MENA has the highest prevalence of obesity in the world, particularly among women. The region is identified with a high caloric consumption from sugar and the largest proportion of women who stay at home (the lowest level of female labour force participation), both factors associated with the high prevalence of obesity. Within MENA, a low level of education is associated with obesity while wealth and obesity have a weaker correlation.

Migrating from developing countries to the UK increases the risk of obesity. Results of the PSM indicate that migrants bear a larger and statistically significant burden of obesity than they would have if they had not migrated.

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