Is the social gradient of female obesity in lower income settings reversing and why? An investigation into the association between wealth, education and obesity

by

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I, Amina Aitsi-Selmi confirm that the work presented in this thesis is my own. Help and contribution of others to this work is specified in the acknowledgement section. Where information has been derived from other sources, I confirm that this has been indicated in the thesis.

ABSTRACT

Female levels of obesity in low- and middle-income countries (LMICs) are rising. Obesity prevalence has been the greatest in high socio-economic status (SES) groups, but recent evidence suggests a changing pattern with the prevalence of obesity rising rapidly among lower SES groups and exceeding the former - a reversal of the social gradient of obesity. However, inconsistencies in the gradient by SES indicator have put the reversal into question. Using nationally representative surveys, the thesis: 1) examines the time variation in the SES-obesity association splitting SES into two components; and 2) tests the hypothesis that education protects against the obesogenic effects of improved material circumstances through cognitive skills and their influence on media exposure and dietary behaviour.

Egypt (~40% female obesity prevalence) is investigated using Demographic and Health Surveys data. Changes in the SES-obesity association over the period 1992-2008 are examined including the separate and joint effects of education and material circumstances on obesity. Then, Egypt is compared with countries of different levels of economic development: Benin, Nigeria, India, Jordan, Peru, Colombia (DHS data) and China (Four-Provinces survey data). Finally, literacy, TV exposure and sweet snack use are investigated as mediators. All estimates are adjusted for age group, area of residence, and number of children using multivariate logistic regression.

The findings showed variation over time and by country consistent with the reversal of the social gradient. Education significantly modified the association between material circumstances and obesity at middle levels of country income. There was evidence that literacy and TV exposure may mediate this inter-relationship but the study power limited inferences on dietary behaviour. The findings support the possibility that education drives the reversal of the social gradient of female obesity and that cognitive skills may be more important than material circumstances in preventing female obesity. Thus, investments in education could be viewed as preventive medicine.

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4-P study – The China Four-Provinces study

BMI – Body mass index

CEE/CIS – Central and Eastern Europe/Commonwealth of Independent States (the former refers to formerly Communist states in Europe; the latter refers to former Soviet Republics)

DHS – Demographic and Health Surveys

FDI – Foreign Direct Investment

GNIpc – Gross National Income per capita

GDPpc – Gross domestic product per capita

HICs - High income countries (GNI per capita>$12,195 in 2009)[1]

LMICs – Low and middle-income countries (GNI per capita<$12,195 in 2009)[1] – includes lower-income (LI), lower-middle income (LMI) and upper-middle-income (UMI) countries.

NCDs – Non-communicable diseases

SES – Socioeconomic status

TNCs – Transnational corporations

WC – Waist circumference

[1] World Bank income classification (Atlas method).
http://data.worldbank.org/about/country-classifications

1 CHAPTER 1: INTRODUCTION

1.1 GENES, BEHAVIOUR AND CONSCIOUSNESS

"Rien ne se perd, rien ne se crée, tout se transforme"[2]

(The law of energy conservation)

Antoine Lavoisier, 1789

It is said that the discovery of Leptin in 1992 changed the way we think about obesity[3] (Friedman and Halaas, 1998, Farooqi and O'Rahilly, 2009). Leptin replacement appeared to restore normal energy balance in obese mice mutants with a deregulated appetite. The identification of the *ob* gene as responsible for the expression of Leptin signalled the existence of a genetic cause, and shifted the blame for excess adiposity away from individuals to root it in our biological programming. Failing to lose weight through dieting was, therefore, no longer explained as a lack of will-power in lazy or intellectually inferior individuals, but as the result of a finely balanced homeostatic mechanism gone awry. The emphasis on appetite regulation rather than energy expenditure was justified through the law of energy conservation such that the energy consumed and expended by an organism balanced out, therefore obviating the need to focus on both at the same time. Leptin thus regulated food intake but also metabolism in general to control body weight (Friedman and Halaas, 1998).

This single discovery led to an explosion of research seeking to uncover the molecular basis of obesity and appetite regulation, and held the hope that obesity could be eradicated through the manipulation of the Leptin pathway to restore a normal appetite and a healthy energy balance (Chicurel, 2000). Other arguments supporting this flurry of activity in molecular biology included the high heritability of obesity calculated from twin studies as 0.7-0.9 - second only to height as a heritable trait; the fact that allelic selection could explain rapid morphological change in plants and insects; that individuals appeared to maintain relatively stable weights over long periods of time (a phenomenon also seen in overfed and food restricted

[2] Approximate translation: *It is neither lost, nor created, but transformed.*
[3] Defined in this thesis as a body mass index of 30 kg/m^2 or over unless otherwise stated.

animals) thereby suggesting an internal regulatory mechanism; and finally, that 10% of morbid obesity cases was thought to be explained by a mutation in the Leptin pathway (Friedman, 2012). While an effective weight loss drug still eludes science and industry today, clinical studies involving the more common variety of obesity (rather than the much rarer Leptin deficient form), show that recombinant Leptin appears to make some contribution to weight loss (Lonnqvist et al., 1999, Farooqi and O'Rahilly, 2009).

However, even the staunchest proponents of a genetic basis for obesity acknowledge that appetite regulation is a complex motivational behaviour and that a variety of afferent inputs to the brain are involved in appetite regulation alongside Leptin levels, including sight and smell but also emotion and volition, leading the search for the causes of obesity into the uncharted territories of consciousness (Friedman, 2012). The holy grail for the molecular science of appetite regulation has changed from identifying pharmacological intervention points along the Leptin pathway to locating the integratory centre of neuronal activity that brings together and translates the various signals to the brain into a yes/no answer to feeding (Cummings and Schwartz, 2003). In addition, the fact that the Leptin mutation contributes to only 10% of only the most severe obesity cases, and that the only common gene polymorphism of note (FTO) has a relatively small effect size (Wilding, 2012) has also put genetic determinism into question.

Furthermore, the heritability estimate of 0.7-0.9 is derived from simple studies of monozygotic twins (reared together/reared apart), whereas more complex segregation analyses can only explain 30% of the variability in BMI (Lonnqvist et al., 1999). Extensive genetic analyses of candidate genes known to be involved in susceptibility to obesity in Pima Indians of Arizona - who have very high rates of obesity and diabetes type 2 and are the most extensively studied population subgroup of this kind - have failed to provide support for a clear genetic susceptibility in this group (Leonhardt, 19 May 2009). This therefore raises doubts as to the heritability of obesity and the usefulness of emphasising genetic pathways in understanding obesogenesis in the real world where the causal web of obesity is more likely to resemble that in **Figure 1.1**.

Figure 1.1 The causal map of obesity – Foresight report on obesity, 2007 (McPherson et al., 2007).

Source: Foresight - Tackling obesities: future choices - http://www.foresight.gov.uk/Obesity/Obesity_final/Index.html

It stands to reason that the forces shaping emotions and volition in an individual, such as social structures, may be equally valid as a subject of investigation into the causes of obesity and that, just as individuals cannot be blamed for any genetic predisposition, individuals cannot be held responsible for the existence of these social factors. Other arguments for the existence of social factors influencing individual obesity levels include the significant increase in calorie availability and reduction in energy expenditure coinciding with the rise in obesity levels worldwide, the strong social patterning (particularly in women), and that this social patterning is dynamic and appears to change with economic development.

Of note, most reviews indicate the obesity epidemic is a gendered problem with women displaying higher rates than men especially in low-income countries (Wells et al., 2012, Finucane et al., 2011, Brooks and Maklakov, 2010). The gender differences in obesity are particularly stark in LMICs (see table in **Appendix A** for differences in prevalence by sex and country). Therefore, female obesity in LMICs presents a topic of particular research interest. It

also provides an opportunity to examine the association between socioeconomic factors and obesity in a different context and a way to gain new insights into aetiological pathways explaining health inequalities. Investigating key social determinants involved in the process of obesogenesis in women in lower income countries forms the subject of this thesis.

1.2 THE GLOBAL EPIDEMIC OF OBESITY: A BRIEF OVERVIEW

Obesity is not a modern phenomenon and cases are documented as far back as ancient Egyptian times (Haslam and Rigby, 2010). However, the epidemic itself was declared recently, in 1997, by the World Health Organisation (WHO) (Caballero, 2007). According to WHO figures, the proportion of people who are overweight or obese has more than doubled in the past few decades, and at least 1.3 billion adults are overweight or obese today based on a body mass index greater than 25 kg/m^2. The obesity epidemic is thought to have originated in the late 1970s in the US, where prevalence has risen from 13% in 1980 to 33% today, exceeding the obesity prevalence of all high income countries (HICs) (Cutler et al., 2003). In the UK, obesity levels are lower but the rate of increase was faster, more than tripling from 6-8% in 1980 to 24% today (Finucane et al., 2011).

1.2.1 LOW-AND-MIDDLE INCOME COUNTRIES

Epidemiological reports document an increase in obesity levels in low- and middle-income countries (LMICs) from the 1980s onwards (Martorell et al., 2000) (Finucane et al., 2011). This increase has been particularly notable in middle income countries (MICs) such as Brazil, Mexico, India, and China (Popkin, 1994, Finucane et al., 2011), but also in poorer countries in Latin America (Martorell et al., 1998) and urban areas of Sub-Saharan Africa (Ziraba et al., 2009). The South Pacific islands display the highest obesity rates in the world

followed by countries in the Middle-East and North Africa region as well as Mexico. Sub-Saharan Africa is the only region to be protected against the epidemic somewhat although increases in urban areas have been reported (Ziraba et al., 2009).

India and China, the two most populous countries in the world, have relatively low overall prevalence figures but display high rates of increase particularly in urban areas. They are predicted to become homes to the largest number of obesity cases and its correlate – type 2 diabetes - for which the top spot has been claimed now from India by China (Yang et al., 2010b). This is particularly alarming as Asian populations, particularly the Chinese, appear to have a higher susceptibility to central obesity at lower BMIs compared with Caucasians, and therefore a greater morbidity risk than Caucasians at equivalent BMIs (Stevens et al., 2008).

1.2.2 A GENDERED EPIDEMIC

There are relatively few published data on obesity rates early on in the epidemic for either sex, but the World Health Organisation estimates that obesity rates among men were approximately half those among women in the East Mediterranean, Africa, the Americas, and South East Asia (Martorell et al., 2000). The global age-standardised prevalence of obesity rose from 7.9 to 13.8% in women and 4.8 to 9.8% in men, between 1980 and 2008 (Finucane et al., 2011).

The causes of the observed divide are not known but may be a result of child-bearing and physiological factors related to fertility (Wells et al., 2012), but gender inequalities may also be implicated through their influence on women's social roles. In unequal (usually less affluent) societies women are often confined to the private sphere of social life where they contribute through their reproductive and caring roles, and their physical mobility outside the home may be restricted. Sexual maturation differences influenced by environmental factors have also been implicated (Schell et al., 2012, Schell et al., 2009), and where adjusted for,

appear to explain part of the sex differences in obesity (Wang, 2002). This may be the consequence of an extended growth period in boys resulting from delayed puberty which provides some protection against short adult stature and later obesity risk.

Unadjusted estimates for the association between country income category and the absolute difference between female and male obesity prevalence were calculated using a sample of 61 WHO countries for which recent data were available. These suggest that the difference between women and men declines with level of country income **Table 1.1** see **Appendix A** for the raw data).

Table 1.1 Linear regression coefficients for the relationship between country income level and female-male difference in obesity prevalence (WHO data).

N = 61	Coefficient for the relationship between country income and absolute difference in obesity prevalence (women-men) Coefficient (95% CI)[1]
World Bank country income category	
Low income	Ref
Lower middle-income	-4.61 (-11.2, 2.02)
Upper middle-income	-5.80 (-12.2, 0.64)
High income	-10.54 (-16.9, -4.13)

[1] Adjusted for country obesity prevalence in women. Going up one country income category reduces the absolute difference between women and men's obesity prevalence (see Appendix A for the data).

1.2.3 COUNTRY ESTIMATES OF FEMALE OBESITY: EGYPT IS AN OUTLIER

One of the first multi-country studies of obesity prevalence used survey data from 38 LMICs and the US (Martorell et al., 2000). It reported female obesity levels of 2.5% in Sub-Saharan Africa, 9.6% in Latin America and the Caribbean, 15.4% in the CEE/CIS region,

17.2% in the Middle East and North Africa, and 20% in the US. Obesity was not a significant public health problem in Sub-Saharan Africa (the prevalence ranging from 1% in Burkina Faso to 7.1% in Namibia), or many parts of Asia (4.3% in China - based on a definition of obesity as a BMI>27.3), or South Asia (0.6% in Bangladesh; 0.1% in Nepal).

The paper concluded that, at the time of the study, no region in the developing world - other than the Pacific Islands, Egypt and Kuwait - exhibited levels of obesity found in Europe and the US (22% and 20% respectively). Egypt had the highest rate of obesity (23.5%) of all countries included in the study (based on the 1992 Egyptian national survey), and was described as an outlier in terms of its obesity rate relative to its level of economic development measured by Gross National Income per capita (GNIpc).

This regional pattern, including the exceptionally high rates of female obesity in the Arab world, has persisted (Ng et al., 2011) and the findings have been reproduced in more recent surveys except that, today, obesity levels in Egypt and the Pacific Islands exceed those of the US and UK (Finucane et al., 2011). Egypt, an Arab country of just under 83 million people and a GNI per capita in 2009 of $1800, has one of the highest average body mass indices in the world. It is one of a handful of countries to have an average BMI over 30 among women alongside Kuwait and the Pacific Islands. Many lower income countries have double the obesity rates of the 1980s.

1.2.4 INEQUALITIES IN FEMALE OBESITY

Obesity and cardiovascular disease were thought to be diseases of affluence in the UK in the first part of the 20th century. In 1978, Marmot et al. showed that death from heart disease – which shares common risk factors with obesity - became more common in lower social classes (Marmot MG, 1978, Ferrie et al., 2002). Later studies examining obesity showed that women with lower education, occupational class or income have much higher odds of obesity

(Wardle et al., 2002, Zaninotto et al., 2009), findings that are corroborated in other high income countries (HICs) (Law et al., 2007, Norberg et al., 2010).

In LMICs, while obesity is increasingly recognised as a problem, the social distribution of obesity risk within these populations is disputed (Jones-Smith et al., 2011, Neuman et al., 2011) and recent analyses of lower income country data present conflicting reports as to whether the SES-adiposity association is positive or negative (Jones-Smith et al., 2011, Subramanian et al., 2011, Neuman et al., 2011). Different associations have been reported by SES indicator (education *vs*. income/wealth) in middle-income countries including Brazil, Philippines and the Peru (Monteiro et al., 2001, Dahly et al., 2010, Poterico et al., 2011). This potential differentiation of the SES-obesity association by SES indicator is an understated observation in the literature but an important one. It forms the basis of the puzzle addressed in this thesis and will be returned to below and expanded on in the next chapter.

1.2.5 THE HUMAN AND ECONOMIC COST OF OBESITY

Obesity has a significant human and economic cost. There is a well-documented link between excess adiposity and mortality - an estimated 2.6 million people die each year as a result of being overweight or obese (WHO, 2006) - as well as a life-long risk of several major chronic diseases including cardiovascular diseases, type 2 diabetes, selected cancers, gallbladder disease, asthma, osteoarthritis, chronic back pain (Guh et al., 2009) and lower cognitive function in the elderly (Zhou et al., 2010). Obesity is, therefore, a major risk factor behind the chronic diseases responsible for the majority of deaths worldwide, of which 80% occur in low- and middle-income countries.

Approximately 2-7% of all health care spending is accounted for by obesity in the developed world, alongside other human and economic costs affecting quality of life and worker productivity. Excess adiposity may soon rival tobacco as the world's leading cause of

preventable premature deaths, wiping out the gains in life expectancy achieved by the reduction in smoking rates in the US (Stewart et al., 2009). Arguably, obesity is now a greater global health concern than under-nutrition, and LMICs have to contend with a double burden of malnutrition whereby both under- and over-nutrition coexist (Lim et al., 2013, Lozano et al., 2012).

Worryingly, it has been suggested that the rise in obesity and related non-communicable diseases will widen the health gap between rich and poor countries: over the 2002-2030 period, the prevalence of non-communicable diseases is predicted to increase by 22% in poorer countries, compared with 15% in richer countries (Stuckler, 2008). The ensuing mortality crisis in poorer countries is expected to strike the working age population which would further impede their economic development.

1.3 AETIOLOGY

This section introduces the key aetiological questions guiding the research in this thesis. A more detailed and specific description of the aetiological pathways that might explain the changing association between SES and female obesity in LMICs is provided in the next chapter.

At the heart of it, obesity is simply the result of an energy imbalance where the energy input to the human body has exceeded its energy output over a length of time. However, this elegant but rather reductionist explanation eclipses the messy complexity of social living. Almost every scholarly discipline has laid claim to obesity as a research area, and all can contribute new knowledge.

There are numerous competing theories to explain differences observed between individuals and between groups as to why they may, or may not, be obese and a variety of

epidemiological frameworks. For example, ecological public health presents obesity as resulting from an obesogenic environment influencing four key dimensions of existence: the material, the physiological, the social and the cultural-cognitive (Rayner, 2009). This thesis will be couched in the social determinants of health approach which deals specifically with providing explanations for socio-economic inequalities in health and disease.

1.3.1 A SOCIAL DETERMINANTS OF HEALTH APPROACH

The social determinants of health are the conditions in which people are born, grow, live, work, and age and encompass educational attainment, occupation, income and material assets which are themselves determined by wider societal arrangements (economic, political, social and cultural) (Marmot et al., 2008). An important source of scientific evidence supporting the social determinants approach comes from the discipline of social epidemiology and the investigation of the social gradient of health. Using the Whitehall and Whitehall II cohorts, Marmot et al have consistently demonstrated a gradient of disease outcomes in which all members of the occupational hierarchy have measurably worse health and disease outcomes than those above them a level, with those at the very top being the healthiest (Stringhini et al., 2011, Ferrie et al., 2002).

The main advantage of the social determinants approach is its integration of individual level health outcomes with the wider structural determinants that define living conditions beyond individual control. The Whitehall II findings provide empirical support for a biological basis to social inequalities in health centred on the stress response to inequality. Inequality is experienced consciously or unconsciously, for example as high effort-reward imbalance or high demand-low control at work. This is translated into physiological changes in the hypothalamic-pituitary-adrenal axis which can manifest as increased inflammation resulting in a higher risk of pathology such as heart disease in those lower in the hierarchy. Other explanations complete

this view and include behavioural, material and neo-material theories of inequality (Bartley, 2004).

The wider or distal determinants of health are the living conditions shaped by global and national level political and economic arrangements such as trade agreements affecting food imports and exports, educational policy, labour market policy, and welfare policy which define both the level of inequality as well as how inequality is experienced within each stratum of the hierarchy. Measures of socioeconomic status (SES) can help measure inequality and provide a basis for its quantification.

In this thesis, SES indicators are examined not simply as measures of inequality but as variables with a causal role in a putative causal pathway between the global economy and obesity. The temporal element of economic change is incorporated in the thesis conceptual framework by integrating elements of the nutrition transition and globalisation frameworks within the social determinants of health framework. In addition, to flesh out the causal pathway between SES and obesity in LMICs, the thesis draws on the Foresight causal map of obesity (McPherson et al., 2007). This will be discussed in further detail in the next chapter.

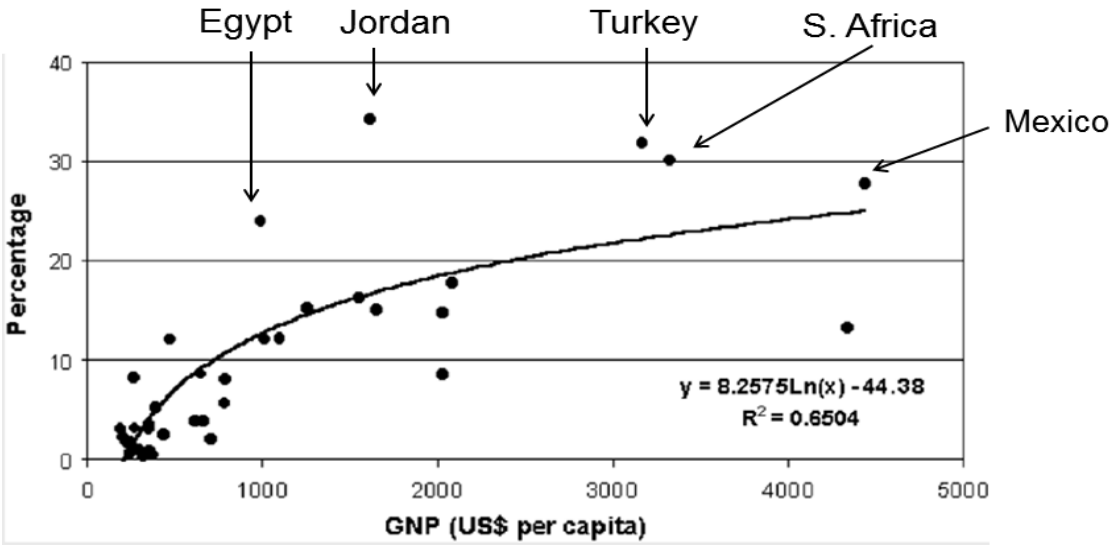
1.3.2 OBESITY: AN INEVITABLE CONSEQUENCE OF ECONOMIC DEVELOPMENT?

Logic would suggest that countries that are richer and more food secure will have higher rates of obesity and empirical evidence appears to support this. Monteiro et al. demonstrated a positive correlation between level of economic development and the prevalence of obesity in women, with Egypt and Jordan being significant outliers (Monteiro et al., 2004a) – see

Figure 1.2. Theorists suggest that obesity rates rise as a result of the nutrition transition which describes the set of changes in diet and physical activity that accompany economic development, namely moving from an agrarian economy based on physical labour to an economy based on services and industry (Prentice, 2006, Popkin et al., 2012, Monteiro et al., 2004b). This economic transition entails urbanisation and rural-urban migration, leading to the replacement of traditional low-fat diets that include locally grown foods, with diets that are high in fat and sugar and manufactured in factories, alongside a reduction in physical labour.

In the US and other advanced economies, economic data show that both rising calorie availability and declining physical activity levels have been correlated with rising obesity levels, however some models have favoured increased calorie intake as the dominant contributor, for example due to reduced food preparation time and female labour force participation (Cutler et al., 2003, Bleich et al., 2008). Higher levels of female formal education on the other hand, appear to be protective at country level (Loureiro and Nayga, 2005).

Figure 1.2 The correlation between economic development and female obesity prevalence (Monteiro et al., 2004a). *Percentage on the y-axis represents the age-adjusted prevalence of obesity.*



A conundrum facing epidemiology today is to explain why LMICs are displaying obesity levels comparable to those of HICs at much lower levels of economic development or, in other words, why the country prevalence of obesity today is not commensurate with baseline levels of national income: the US and UK were already advanced economies - post-industrial and high income - when obesity levels began to rise). While this is not the focus of the thesis, the analysis is informed by ideas that have been put forward to solve this conundrum.

Scholars have implicated global factors that facilitate the transmission of calorie-dense foods to hungry populations (Rayner et al., 2006, Hawkes, 2005, Stuckler, 2011). They explain the rise in non-communicable diseases (NCDs) including obesity in LMICs in terms of globalisation, foreign direct investment, an expanding role of multinational companies in the food supply, and the spread of corporate advertising as a tool to create value for business through its influence on the social valuation of food and dietary behaviour. The main argument put forward is that changes in consumption patterns leading to a higher risk of obesity are not simply the result of rational individual dietary preferences rooted in evolutionary biology, or amplified by technological developments in food production, but are heavily influenced by multinational corporations' business agendas in promoting energy-dense manufactured foods such as sugar-sweetened beverages. The implication is that LMICs may be vulnerable due to imbalances of power in trade and global economic arrangements and a lack of public infrastructure, which could be addressed by strengthening global and national economic governance and public health systems (Labonte and Schrecker, 2007).

1.3.3 IS THE SOCIAL GRADIENT OF FEMALE OBESITY REVERSING?

As described above, there is increasing evidence of time variation in the SES-obesity association. Although obesity may be a disease of affluence early in a society's development, it eventually affects disadvantaged groups as observed clearly in HICs (Sobal and Stunkard, 1989,

Martorell et al., 2000, Molarius et al., 2000, Monteiro et al., 2004a, McLaren, 2007, Jones-Smith et al., 2011, Dinsa et al., 2012).

In 1989, a review of the world literature on SES indicators (wealth/education/income) and obesity, incorporating studies published between 1933 and 1988 (130 in developed countries and 14 in developing countries) was the first to report that the social distribution of obesity at country level differed by level of economic development (Sobal and Stunkard, 1989). There was a positive association between SES and obesity in poorer countries, and a negative (inverse) association in richer countries. This led to the observation that a reversal in the association between SES and obesity as countries developed economically may be occurring, and that this relationship held true more consistently in women than in men.

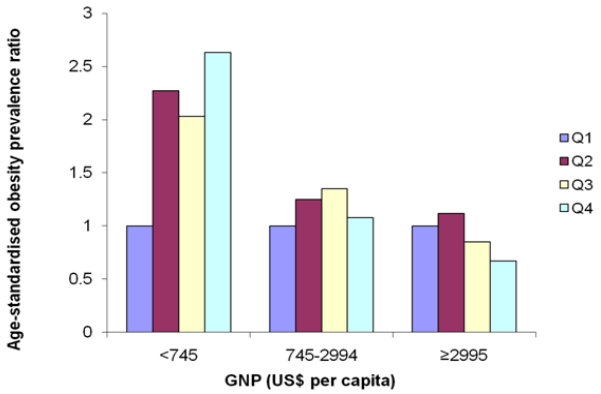
An update of this review was conducted in 2007 based on 333 studies from countries with diverse levels of development (McLaren, 2007). This showed that the associations appeared to have weakened - an observation explained through the globalisation of lifestyle patterns. The study had the advantage of greater discrimination between the SES indicators, and showed that the SES-obesity findings varied by SES indicator and, again, were most striking in women. For women living in countries with a high human development index (HDI – a measure of economic development incorporating human development indicators) education and occupation tended to have a weak or negative association with obesity (lower SES associated with increased obesity), while for women living in middle- and low- HDI countries, income and material possessions tended to show a positive association. Monteiro et al. illustrated the changing association using an ecological model based on cross-sectional surveys from 37 LMICs with a broad range of economic development levels ($500-5000 of GNIpc) (Monteiro et al., 2004a).

The results of the Monteiro study demonstrated the three stages of transition: a direct education-obesity association in low-income countries (Bolivia, Senegal, Namibia, etc); a flat association in middle-income countries (Colombia, Peru, etc); and an inverse association in the

relatively higher income countries (Brazil, Mexico, South Africa, etc) – see **Figure1.3**. Interaction tests showed that the level of economic development was a statistically significant modifier of the education-obesity association. The authors were able to quantify the point at which the association reversed - estimated as a GNIpc per capita of $745-2994 (Monteiro et al., 2004a).

Further evidence of the reversal came from individual regions including Europe (Molarius et al., 2000), Latin America (Martorell et al., 1998), and Sub-Saharan Africa in urban areas of Burkina Faso, Ghana, Kenya, Malawi, Niger, Senegal, Tanzania (Ziraba et al., 2009). For example, over a period of 13 years (1992-2005), the prevalence of overweight and obesity decreased by 10% in sub-Saharan women with secondary or higher education, while increasing by 46% among non-educated women (Ziraba et al., 2009). A recent study based on more recent national survey data of a similar cross-section of countries (Dinsa et al., 2012) proposed that the reversal occurs at even lower levels of GNIpc.

Figure1.3 The changing association between education and obesity among women (Monteiro et al, 2004). *Q1=highest education quartile.*



In summary, these studies support the existence of a dynamic, time-varying association between SES and female obesity in LMICs; and that the time variation of the association may differ by SES indicator. Some have taken the latter to mean that wealth is a

better indicator of SES than education and dismissed education altogether (Subramanian et al., 2011). However, there are many reasons to believe that these two indicators will operate differently as causal factors in female obesity, and an alternative possibility is that the weaker association with education represents the middle stage of a reversal process. Furthermore, better education may be the driving component behind the eventual full reversal of the SES-obesity gradient.

These hypotheses have not been duly explored, partly because of an underlying assumption in the field, informed mostly by studies in HICs, that the SES-obesity distribution is similar for different SES indicators, thus treating socioeconomic status as a single concept. However, the possibility that the measures that capture material circumstances and those that capture educational capital are differently associated with female obesity offers an opportunity to better understand the social epidemiology of health in societies undergoing economic growth, as well as contributing to a better universal understanding of the relationship between different dimensions of socioeconomic status and health.

1.3.4 WHY IS THE SOCIAL GRADIENT OF FEMALE OBESITY REVERSING?

If the reversal of the social gradient of obesity in women is occurring, the next task is to explain it. In theory, education should be protective for health regardless of the economic context, yet a positive association appears to be present between education and obesity in low income countries. Similarly, There are intuitive reasons for individuals to have a greater obesity risk as their incomes rise and countries develop including a mismatch between a biology programmed for scarcity and the sudden flood of cheap calories as markets open to the global food system (Prentice, 2009). Considering the different dimensions/indicators of SES within an evolving social and economic environment may afford new insights into these processes.

In an environment where food insecurity is a concern any resources are likely to be used to acquire food and, in this situation, the lack of material resources may be sufficient to explain the absence of an association between low household wealth and obesity. Here, lower SES groups with low material resources will have lower levels of obesity and *vice versa*. In other words the materialist model may largely explain the positive SES-obesity association in countries with chronic food insecurity.

By contrast, in an environment where food is relatively abundant, material resources alone cannot explain the rise in obesity in low SES groups and its decline among high SES groups. In this situation, the interplay between psychological, social and environmental factors may take on greater importance, and education may be a more relevant dimension of SES to consider. For example, education may begin to take on properties found in high income countries (HICs) and be used towards: 1) ensuring a healthy status; and 2) conforming with new forms of social distinction (thinness, healthy food consumption) as encapsulated in the cultural-behavioural model explaining health inequalities (Bartley, 2004). Education, may even allow individuals to modify their response to the changing environment through better decision-making, for instance, by modifying the relationship between improved material resources and food.

Little work has been done on this in LMICs, where the context is very different to HICs in that certain factors like food insecurity and the psychology of accumulation may have a much greater role to play. For example, in HICs, the cheap price of calories has been blamed for the rise of obesity among the disadvantaged, such that families on low income favour energy-dense[4] and nutrient-poor foods (Drewnowski and Darmon, 2005). In LMICs however, calorie rich foods are likely to be expensive compared with traditional diets, and available to the middle classes and elites rather than the poor. Furthermore, those with higher education but lower economic resources may be protected against the stress of lower status because of better cognitive skills.

[4] Energy density = calories per 100g of food.

Therefore, wider factors shaping the SES-obesity association will include the stage of the nutrition transition and of the cultural transition of the country. Media exposure may also have a key role in reinforcing or diluting cultural practices and behavioural norms in the rapidly evolving information economy, as will be discussed in the next chapter. Plausible pathways for the education/wealth-obesity association that are relevant to LMICs are discussed in more detail in the next chapter as well.

1.4 THE SOCIAL EPIDEMIOLOGY OF OBESITY IN LOW-AND-MIDDLE INCOME COUNTRIES: A PUZZLE AND AN OPPORTUNITY

In the field of molecular biology, obesity is sometimes referred to in the plural, as obesit*ies*, rather than in the singular to differentiate between the various genetic switches and metabolic pathways that can lead to an obese phenotype (Leibel et al., 1997). Similarly, it is conceivable that the social causes of obesity might vary depending on the country as argued above. Therefore, a conceptual shift is required to recognise that obesity afflicts different socioeconomic groups depending on the social and economic context of the country. In LMICs, analysing SES as a uni-dimensional concept may fail to elucidate the true relationships between SES and obesity or accurately identify vulnerable groups, leaving epidemiology with an important knowledge gap.

Research into the social causes of obesity therefore requires a context-appropriate theorisation of the associations between SES indicators and excess adiposity outcomes within a causal framework tailor-made for countries undergoing rapid economic transition. Otherwise, the price to pay for the excellence of epidemiological research in HICs would be a stunted research process in which models and explanations arising from HICs are applied to LMICs uncritically.

A distinctive feature of the social epidemiology of health in LMICs is the more complex sociology found in these countries by virtue of their undergoing rapid change. In HICs, a 'general law' of western industrialised societies might apply such that any marker of disadvantage whether material, cultural or educational is likely to predict poorer health behaviours and health outcomes (Jarvis and Wardle, 1998). However, in LMICs where the worlds of pre- and post-industrialisation are geographically and socially juxtaposed, detrimental health behaviours such as smoking or eating fast food, which are normally found in low SES groups in HICs, may be associated with images of glamour and western prosperity - images reinforced by media and advertising – and be found among the elites. As a result, health outcomes and associated aetiological factors may combine in unexpected ways, explaining why the social gradient of disease differs from that found in HICs.

Analytically, SES variables which are considered highly collinear in HICs, such as education and income, may be less collinear in LMICs and/or may be associated with disease in different ways even if they are collinear because of the different social and economic context. This is important, not just because it provides a different research context to that of HICs but, because it offers a window of opportunity into investigating the associations between the different dimensions of SES and disease that have up until now remained closed to scrutiny due to the high collinearity of these SES dimensions. Other settings where a similar opportunity has been identified and empirical research conducted include former Communist countries (Bobák et al., 2000).

1.4.1 CROSS-COUNTRY COMPARISONS: MODELLING PERIOD DIFFERENCES BY COMPARING COUNTRIES WITH DIFFERENT LEVELS OF ECONOMIC DEVELOPMENT

Multicountry studies have provided key insights into the social distribution of obesity in LMICs and how it evolves over time (Sobal and Stunkard, 1989, Molarius et al., 2000, McLaren, 2007, Monteiro et al., 2004a, Jones-Smith et al., 2011, Martorell et al., 2000,

Martorell et al., 1998, Dinsa et al., 2012). Most of the data documenting the transition are based on samples of low- and middle-income countries (LMICs) with a significant source of data being the Demographic and Health Surveys (Mukuria et al., 2005). This reflects the greater variation observed in the SES-obesity association in LMICs compared with HICs where the SES-obesity relationship is in its final stages of maturation with a negative association between SES and obesity apparent in women, regardless of the SES indicator (Molarius et al., 2000, Wardle et al., 2002). Cross-country comparisons of countries with different levels of economic development help address one of the shortcomings in this area of research: the limited availability of longitudinal data in LMICs. Therefore, they enable the modelling of period variation of the association that might be seen within a single country over time.

1.4.2 THE VALUE OF SINGLE COUNTRY STUDIES

However, cross-country studies are somewhat limited resulting in replication studies rather than truly innovative investigations. Arguably, this is linked to the methodological limitations of the study design in that, while the large sample sizes used in multi-country studies allow for greater generalisability of the findings, more complex patterns of association may be missed. These could be better observed at single country level. Single country studies taking individuals as the unit of analysis can allow for more detailed investigations by allowing for more sophisticated statistical analyses of the relationships between SES variables and a greater depth of understanding of the wider, country specific, context.

1.4.3 EGYPT AS A CRITICAL CASE STUDY IN UNDERSTANDING PERIOD DIFFERENCES IN THE SES-OBESITY ASSOCIATION

Egypt is used as the main case study for the thesis analysis. As mentioned above, by the early 1990s Egypt's prevalence of female obesity had already exceeded that of Europe and the USA (Martorell et al., 2000). At present, Egypt ranks not only among the countries with the

highest rates in the world for female obesity (WHO, 2012a) but it is also among the top fifteen countries for age-adjusted diabetes prevalence (15.2%) (Whiting et al., 2011).

Today's social and economic context in Egypt has been shaped by two waves of economic liberalisation which took place in the early 1990s and in 2004 (Hendy and Zaki, 2010). Egypt's economy experienced a rapid increase in its GNP from ~$600 in 1992 to $1801 in 2008 – the period of investigation covered in this thesis. Parallel social reform has also been successful to a degree. Egypt's educational reform increased access to schools such that reported primary school enrolment rates reached 100% by the early 1990s. However, the quality of education did not adequately meet the needs of the labour market resulting in the paradox of high unemployment in the most educated (Galal, March 2002). Improvements in life expectancy and child mortality also occurred over this period.

1.4.3.1 WHY IS THE PREVALENCE OF OBESITY IN EGYPT SO HIGH?

The excessively high overall prevalence of female obesity in Egypt relative to its level of economic development is currently unexplained. Egypt's economic reform through liberalisation and the impact of this on its food system is likely to have a role. During the period of economic liberalisation between 1990 and 2004, the food sector expanded by 425% (Hendy and Zaki, 2010).

As mentioned above, recent work in low- and middle-income countries (LMICs) has implicated large international corporations, suggesting they influence country diets through their significant investments in both the supply and marketing of processed foods resulting in the eventual replacement of more traditional diets. The intimate relationship between globalisation, liberalisation, and their impact on national diets has been called the 'dietary dependence framework' (Stuckler et al., 2012). Furthermore, media exposure may promote more Western and calorie-rich food consumption over traditional diets based on fruit and vegetables.

There is little research available in the academic literature on marketing in Egypt, but an illustration of advertising methods comes from the US commercial service webpage which provides the following advice to businesses seeking to market their products (USCS, , updated 2011):

"Strategically placed newspaper and magazine advertisements are good marketing tools in Egypt. Egyptians read newspapers voraciously, and all literate people will see or hear advertisements placed in the widely circulating Al Ahram daily. Television is watched by all Egyptians, and advertisements reach and influence wide audiences. TV advertising has continued to increase in sophistication and prominence. Two partially privatized pop radio stations have also been created and already have captured a large part of the youth market."

In addition, marketing strategies by corporations have demonstrated an extreme adaptability and responsiveness to current events and have not hesitated to use the Arab Spring as an opportunity for sales (Bradley, 17 June 2011). Media exposure and its influence on dietary behaviours are likely to vary by socioeconomic status. These concepts are incorporated within the social determinants of health framework to explore the different associations between education, wealth and female obesity in LMICs and discussed further in the conceptual chapter of the thesis (see **Chapter 3**).

Other investigations into obesity in Egypt have discussed the role of the food subsidy system which makes oil, sugar, and previously ghee available more cheaply (Asfaw, 2007, Galal, 2002) - see below. In addition, there may be a biology-environment interaction specific to countries where the nutrition transition (from a situation of calorie scarcity to one of high energy-dense food availability) has been rapid compared with Western countries (Prentice, 2009). The significant social and economic changes experienced within individual lifespans could have caused a mismatch between metabolic programming during early life conditions of scarcity and the conditions of calorie abundance in adulthood, with a consequent increase in the susceptibility to excess adiposity, as formulated in Gluckman's match-mismatch hypothesis

(Gluckman et al., 2008). The combination of urban living, an increasingly abundant food supply, the cultural preference for plumpness and cultural as well as physical barriers to physical activity is an additional plausible explanation for the overall high female obesity levels in Egypt.

1.4.3.1.1 THE EGYPTIAN SUBSIDY PROGRAM

The food subsidy program in Egypt provides bread (called *baladi* bread), sugar and cooking oil at subsidised prices. These constitute 31% of total calorie availability of Egyptian households but only 4% of expenditures. It is easy to see how such palatable foods available at a cheaper price can become a favoured source of calories, and it is possible that the food subsidy system may be the single most important factor in Egypt's outlier status in female obesity levels.

Using data from the Egyptian Integrated Household Survey from 1997 Asfaw (2006, 2007) showed that increased income increases the risk of obesity except in the very high income bracket (Asfaw, 2007, Asfaw, 2006). He also calculated that the risk of maternal obesity in Egypt was reduced if the price of *baladi* bread and sugar (subsidised items) was increased, and the price of fruit, eggs and milk reduced. The author concluded that a reduction in the relative price of healthy diets would be beneficial in reducing obesity risk in Egypt and argued that the purpose of the food subsidy program should be re-oriented from ensuring basic food items to basic healthy food items.

1.4.3.2 THE SOCIAL EPIDEMIOLOGY OF OBESITY IN EGYPT

Epidemiology has been crucial in documenting the social distribution of excess adiposity and related risk factors at the population level, as well as the associations between diet, physical activity, and excess adiposity. Few studies have been conducted to investigate Egypt's obesity epidemic in detail but a review by Galal (2002) of a wide range of studies provides some information. Data from Food Consumption Monitoring Survey data showed that

45% of urban and 20% of rural women were obese in 1998, and reports based on smaller scale studies showed that the SES-obesity gradient was positive in women - higher SES-higher obesity – while no associations were apparent in men. In terms of physical activity, the little data available revealed that >50% of rural adults and >70% of urban adults were sedentary. These figures paralleled rates of obesity and diabetes (Galal, 2002).

Improved food access, and the increased availability of manufactured, calorie-dense food is likely to be the key dietary pathway explaining the association between wealth and obesity, but the potential pathways involving education are more numerous, and include early life influences of parental education, improved access to and use of health knowledge as well as better impulse control and restrained time-preferences, as discussed in the conceptual chapter. In this thesis, education is postulated to influence the impact of media exposure through better cognitive skills as supported by the literature (M. and Lleras-Muney, 2006, Cutler and Lleras-Muney, 2010, Büchner et al., 2012).

1.4.4 CHINA AS AN ADDITIONAL CASE STUDY

China is examined as an additional critical case study for comparison with Egypt, as both countries have undergone economic transition to a more liberal economy and an increase in female obesity levels, while having very different cultures and levels of female obesity.

In 2002, China had very low levels of obesity according to the World Health Organisation Global Infobase (WHO, 2012b). It ranked lower than Japan which itself had one of the lowest rates of female obesity in the world, estimated by the WHO at 1.5% of the female population, a level comparable to that of poor sub-Saharan countries such as Malawi. In 2010 however, while Japan's total prevalence dropped to 1.1% (one of a handful of countries worldwide to reduce its female obesity rate), China had more than doubled its prevalence level reaching 3.6%. As a result, it ranked in the top ten countries in terms of rate of increase, one

caveat being that many Eastern European countries were missing data. Trends in overweight also show an increase: between 1992 and 2002, overweight increased from 14.6% to 21.8% (Wang et al., 2007). Moreover, China is home to a large proportion of the global population, and now outranks both India and the US in number of diabetes cases (Yang et al., 2010b).

While in relative terms China displays low total obesity prevalence, the rate of increase in the last two decades is significant and mirrors the rapidity of its economic development. China has undergone important economic changes over the past decade which brought unprecedented growth in national and individual incomes. However, economic reform began much sooner, in 1978, when the promotion of market-oriented economic policy set the stage for a large-scale shift in peasant households from subsistence agriculture to production for the market-place (Nee and Young, 1991). China overtook Egypt's GNI per capita between 2003 and 2006 (WB, 2012).

Epidemiological research on the association between socioeconomic status (SES) and female obesity in China describes an inverse gradient between education and excess weight (BMI≥25) even when the country was still a low-income economy in the late 1990s (Monteiro et al., 2004c, Wang et al., 2012), an observation replicated in later studies in which both education and either household income (Hou et al., 2008) or parental possessions were taken into account (Schooling et al., 2008). For example, when parental possessions were taken into account education displayed a protective association against metabolic syndrome (a composite outcome which included central obesity) in women over 50 years of age (Schooling et al., 2008).

1.5 WHY IS THE INVESTIGATION OF THE SOCIAL EPIDEMIOLOGY OF OBESITY IMPORTANT?

Unlike other major causes of preventable disability and death like infectious diseases, tobacco use and road traffic injuries, there are no known examples of populations in which the obesity epidemic has been reversed by public health measures (Swinburn et al., 2011). This makes obesity one of the most challenging health problems to face humanity, and its global scale calls for a global response. The 2011 UN High Level Summit gave global prominence to the growing problem of non-communicable diseases (NCDs) and their risk factors and governments have responded by committing to a 25% reduction in relative mortality from NCDs by 2025. Momentum is now gathering to incorporate NCDs as part of the 2015 Millenium Development Goals (Alleyne et al., 2013).

Yet the link between development and NCDs has been made mostly in terms of NCDs being a barrier to development due to their economic impact on the income and productivity of households and national economies (Beaglehole et al., 2011) and research into the problem has relied primarily on population averages (Di Cesare et al., 2013, Gakidou et al., 2007). Moving beyond population averages and examining inequalities in NCDs and related risk factors can not only help identify target groups for preventive interventions but it also begins to unravel the relationship between different dimensions of inequality and disease outcomes. Furthermore, examining social inequalities in NCDs may help inform development approaches by highlighting multiple dimensions of human wellbeing such as education and freedom alongside income (Alkire, 2008).

The shape of things to come in the domains of food systems, sustainable living environments, and therefore economic models of growth is intimately tied to the social evolution of the obesity epidemic and the social epidemiology of obesity, therefore, is a vital piece of the jigsaw.

1.6 SUMMARY OF THE RESEARCH DESIGN, DATA SOURCES AND LIMITATIONS

The research design involves a combination of period effect analysis and comparative country studies to model the time-variation in the SES-obesity association in LMICs while treating education and wealth as separate causal factors within a broader causal framework. Cross-sectional data are used to estimate prevalence levels of obesity by subgroup and to construct a multivariate logistic regression model. This model is further developed to examine mechanisms behind the association between education, wealth and obesity.

Much of our understanding on the dynamic of the SES-obesity association comes from the use of Demographic and Health Surveys data (Monteiro et al., 2004a, Jones-Smith et al., 2011, Neuman et al., 2011, Dinsa et al., 2012). These are repeated cross-sectional, nationally representative surveys of women and children. One of the features of these studies is the use of an asset-based wealth index to capture household's ability to spend money on healthcare. Income is not recorded as income is usually an unreliable measure in LMICs for a number of reasons (discussed further in the next chapters).

As the country with one of the highest female obesity rates in the world, Egypt was selected as the central case study. Demographic and Health surveys data were available for Egypt, and several waves of survey data were available covering the period 1992-2008. This provided the data needed for the examination of the SES-obesity association over time in Chapter 5. Egypt was then compared to other countries with different levels of economic development in Chapters 6 and 7. The additional country data were all taken from the DHS apart from the data for China. The main subset of comparison countries were selected based on their sample size (the countries with the largest datasets were selected). China was selected as an additional case for the reasons described in section 1.4.4.

Thus, an additional dataset was used for the Chinese analysis. This had the advantage of allowing the hypothesis to be tested in a different datasets. Since the Chinese analysis was based on a different datasets and presented different methodological advantages and limitations it is treated in a separate chapter (Chapter 7). Finally, the hypothesised mechanism based on media exposure and diet is tested using the Egyptian DHS data in Chapter 8. A summary discussion and conclusions based on the findings of the thesis constitutes the final chapter (Chapter 9).

In terms of strengths and limitations, unlike HICs where cohort data are an important source for epidemiological research, longitudinal data are scarce in lower income settings due to their cost and the paucity of administrative tracking systems. Therefore, one of the key limitations in this investigation is the use of cross-sectional data to model time variation and mechanisms. This will be taken into account in the interpretation of the findings.

2 CHAPTER 2: STUDY HYPOTHESIS, AIMS AND OBJECTIVES

2.1 AIM

The thesis aims to investigate the SES-obesity association in LMICs in greater detail than has been done previously, focusing in particular on the role of education and material circumstances as the literature suggests these may display different associations with obesity in low- and middle-income countries. The thesis therefore hopes to contribute a better understanding of the time variation in inequalities in obesity and the reversal of the social gradient of obesity among women and the mechanism behind this.

2.2 MAIN HYPOTHESIS

Based on the empirical observations and theoretical concepts to be reviewed in Chapter 3 the following hypothesis was formulated:

Material wealth is associated with higher odds of female obesity in low-and-middle income countries, but formal education can protect against this effect. Formal education might modify the association between material wealth and obesity through cognitive skills and their influence on a wealth-obesity pathway mediated by media exposure and dietary behaviour.

If this hypothesis is true, then education should attenuate the positive association between wealth and obesity and each education level will display a statistically different wealth-obesity association. Incorporating media exposure and dietary indicators into the model should further attenuate the wealth-obesity association. If these associations are found to be true, in combination with evidence of time-variation in the SES-obesity association that suggests that the education-obesity association reverses before the material circumstances-obesity association, a strong argument can be made for education to be the driving factor behind the reversal of the SES-obesity association.

2.3 OBJECTIVES

2.3.1 OBJECTIVE 1: TO MODEL THE REVERSAL OF THE SOCIAL GRADIENT OF FEMALE OBESITY BY SES INDICATOR (CHAPTERS 5,6, AND 7)

Most research on the SES-obesity association supports the hypothesis of a reversal of this association from positive to negative. The thesis splits SES into two components – education and material circumstances – and examines these individually and in relation to each other. The time variation in the SES-obesity association can be modelled as period effects within a single country (Egypt). It can also be modelled using a comparative approach of countries at different levels of economic development. This would therefore model the successive stages of economic development that would occur within one country over time.

The hypotheses tested in this section of the analysis are:

1. *The SES-obesity association reverses over time as countries undergo economic development*

2. *The SES-obesity reversal differs by SES indicator*

3. *Education protects against the obesogenic effects of improved material circumstances (education modifies the material circumstances-obesity association)*

2.3.1.1 OBJECTIVE 1A: TO EXAMINE PERIOD DIFFERENCES IN THE ASSOCIATION BETWEEN EACH OF EDUCATION AND MATERIAL CIRCUMSTANCES AND OBESITY (CHAPTER 5)

Within Egypt, the SES-obesity associations are examined at two different time points and the results examined against the expected associations consistent with the reversal of the social gradient of obesity and the Monteiro model which predicts the reversal tipping point to be

$2500 of GNIpc. If the model is consistent with the reversal of the social gradient, the SES-obesity association should be expected to move along the inverted-u shaped curve over time. For example, if the association is positive in one period, an attenuation should be observed such that the association is no longer present (OR=1) in the second period, or may even become inverted depending on the length of time and level of economic development.

If education is protective while better material circumstances are obesogenic, the pattern of association between each of education and material circumstances in relation to obesity will differ. For example the education-obesity association may become inverted while the wealth-obesity capacity remains positive. If the education-obesity association reverses before the material circumstances-obesity association, this would suggest that increasing levels of education in women may drive the overall SES-obesity reversal process.

2.3.1.2 OBJECTIVE 1B: TO EXAMINE DIFFERENCES BY LEVEL OF ECONOMIC DEVELOPMENT IN THE ASSOCIATION BETWEEN EACH OF EDUCATION AND MATERIAL CIRCUMSTANCES AND OBESITY (CHAPTERS 6 AND 7)

Another way to model the reversal of the SES-obesity association is to examine differences between countries at different levels of economic development. If the data are consistent with the reversal of the social gradient, then countries at successively higher levels of development will display a reversing SES-obesity association along an inverted-u shaped curve, with countries at lower levels of development displaying a positive SES-obesity association and richer countries displaying a shallower SES-obesity association, in a similar manner to that described in objective 1a. Again, education and material circumstances would show different patterns of reversal if education has a protective role against the effect of wealth.

2.3.2 OBJECTIVE 2: TO CONTRIBUTE TO KNOWLEDGE OF PLAUSIBLE PATHWAYS EXPLAINING THE PROTECTIVE ROLE OF EDUCATION AS A DRIVER OF THE REVERSAL OF THE SOCIAL GRADIENT OF FEMALE OBESITY THROUGH MEDIA EXPOSURE AND DIETARY BEHAVIOURS (CHAPTER 8)

Numerous factors can explain the association of higher education with lower obesity of which having better cognitive skills is a strong candidate. Better cognitive skills may reduce the effect of marketing messages on dietary behaviour by modifying the association between wealth and media exposure. This could occur if education modifies the frequency or type of media exposure associated with improved material circumstances; and/or if education modifies the odds of consuming high calorie, processed food resulting from media exposure. Evidence supporting the existence of these associations would therefore provide an explanation for the role of education as a driving factor in the reversal of the social gradient of obesity in women where economic transition is occurring.

The hypotheses tested in this section of the analysis are:

1. *Cognitive skills, media exposure and dietary behaviour are mediators on the pathway linking education, material circumstances and obesity and therefore:*

    a. *cognitive skills can substitute for education in the model examining the relationship between education and material circumstances*
    b. *education modifies the media exposure-dietary behaviour association*
    c. *education modifies the material circumstances-media exposure association*
    d. *including media exposure and dietary behaviour variables in the analytic model attenuates the material circumstances-obesity association.*

3 CHAPTER 3: CONCEPTUAL FRAMEWORK

3.1 INTRODUCTION

In this chapter, the conceptual framework of the thesis is described. It is based on the social determinants of health framework and focuses on specific pathways linking the different dimensions of SES (education and material circumstances) and obesity in low- and middle-income country (LMIC) settings. Empirical and theoretical material is used to explore these pathways, including the nutrition transition and the Foresight obesity causal framework to build a model informing the empirical analysis. One of the key aims of the model is to move beyond the interchangeable use of SES indicators in relation to obesity in LMICs, and develop an understanding of the separate and interrelated causal pathways that might link education and material circumstances to obesity.

First, the rationale for using the social determinants of health framework is explained. Next, the global and national level contexts in which the SES-obesity association is evolving are reviewed. Finally, the specific pathways investigated in the empirical chapters are described based on a review of the literature. A key aspect of the review is that the empirical evidence documenting the reversal of the social gradient of obesity – the progressive change from a high SES-high obesity association to a low SES-high obesity association as countries develop - is examined through a lens that splits SES into two components: education on the one hand and material circumstances on the other.

3.2 THE SOCIAL DETERMINANTS OF HEALTH FRAMEWORK: EXPLAINING DISEASE VARIATION BETWEEN SOCIO-ECONOMIC GROUPS

In the 19th Century, Edwin Chadwick pioneered the notion that good health flows from the population level to the individual rather than the other way round, and by the end of the Victorian era, this was taken to mean that noone, however materially or genetically advantaged,

could escape the impact of a negative collective experience that threatens poor health (Lang and Rayner, 2012). In the UK, a study combining Whitehall data and national mortality statistics indicated that a social shift occurred between 1950 and 1960 such that the diseases of the rich became the diseases of the poor (Marmot MG, 1978). Therefore, this process signalled a change in the collective experience of health and disease resulting from large scale societal change that improved sanitation, nutrition and general living conditions in the UK, as well as making modern lifestyles and consumption patterns more widely accessible. This is likely to coincide with the tipping point of the epidemiological transition, where non-communicable diseases started to become the dominant form of disease in the UK population rather than infectious diseases.

The social determinants of health approach (Marmot et al., 2008), provides a contemporary framework for a broad understanding of the causes of ill health, while recognising the importance of genetic and biological factors. In line with Chadwick's idea of the collective experience of health as well as Virchow's vision of "medicine as politics and politics as medicine on the grandest scale", it seeks to explain and address the health differences between socioeconomic groups rather than between individuals within those groups. It places the causal emphasis on the distribution of power, knowledge and wealth (the causes of the causes) that is captured empirically through health inequalities measured by indicators of socio-economic status including income, education and occupation.

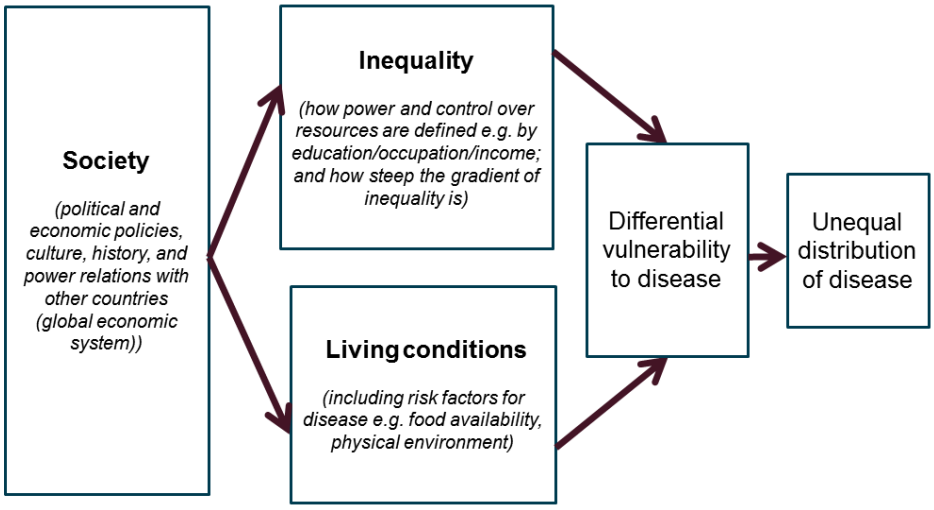
Broader societal and global factors such as national policies and globalisation can influence the distribution of power, knowledge, and wealth which, when unfair, can result in a "toxic combination of poor social policies, unfair economic arrangements, and bad politics" (Marmot et al., 2008). The existence of social inequality or a social hierarchy within this environment leads to unequal exposures to health-damaging experiences and consequently a socially graded disease distribution (health inequalities). In this sense, the context of societal arrangements - which change over time - shape the experience and distribution of disease. The social

determinants of health framework brings an understanding of these factors and individual level psychological, biological and genetic factors within a single causal model.

3.2.1 CONTEXTUAL EFFECTS ON THE SOCIAL DISTRIBUTION OF DISEASE

Global and country level determinants are thought to contribute to health inequalities between individuals of different SES through four mechanisms: social stratification, differential exposure (e.g. to the media), differential susceptibility, and differential consequences (Labonte and Schrecker, 2009) as shown in **Figure 3.1**.

Figure 3.1 The relationship between broader societal factors and the social gradient of disease.

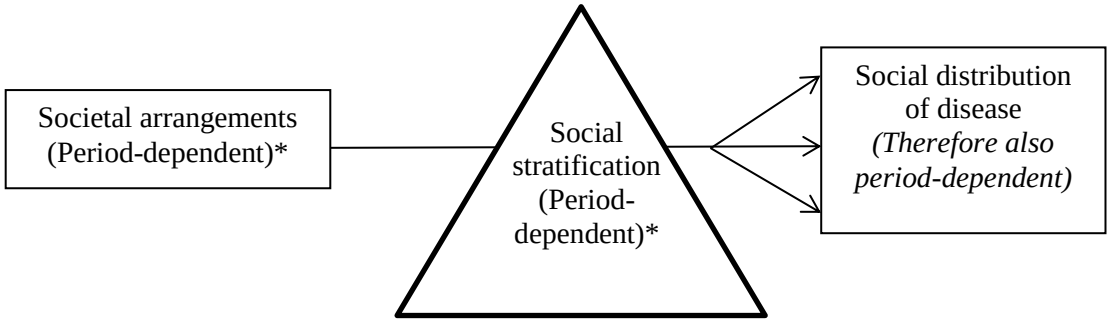


While unfair economic arrangements will always put the most disadvantaged at greater disease risk, and measures of life expectancy and mortality are likely to always be better among high SES groups, the nature of the disease risk will vary according to the societal or country context. In other words, the wider societal context will affect the type of health-damaging experience that dominates in a society at any given point in time resulting in period effects – see **Figure 3.2** for an illustration of this idea. Therefore, when it comes to evaluating the distribution of disease burden, there is an argument for separating between: 1) diseases

associated with absolute poverty and material deprivation which will always be found among the poorest and are much more threatening to life expectancy; from 2) the diseases of affluence which will be found among a) high SES groups when absolute poverty is still rife and material security is the preserve of a tiny group, as in lower income countries; and b) low SES groups in settings where absolute poverty is not so common and a minimum of material security exists for the majority of the population, as in high income countries.

The same logic can be applied to obesity specifically. For example, in terms of diet, higher SES groups may benefit from a more dynamic marketplace, while lower SES groups may continue to face inadequate diets in which food insecurity is replaced by poor quality obesogenic diets. In LMICs, individuals of lower SES or even of middle-class appear to be influenced over the long term by a convergence towards a global market, while the more affluent and educated move on to expensive health market niches (Labonte and Schrecker, 2009). Therefore, the concept of transition whether epidemiological, economic or otherwise becomes very relevant in defining the broader societal context and understanding the period effects shaping the nature of the SES-disease association at any particular point in time in LMICs. Key aspects of societal change linked to economic development that may impact on the SES-obesity association are discussed below.

Figure 3.2 Simplified diagram of the social determinants of health framework incorporating a temporal element.



* Both the social environment and the form of social stratification change over time thus changing the social distribution of disease. The social environment changes with economic transition from non-obesogenic to obesogenic. Social stratification is influenced by the transition from pre-industrial to post-industrial forms of social organisation.

3.3 CONTEXTUALISING THE SES-OBESITY ASSOCIATION IN LMICS

Obesity is a global health problem in that it falls in the category of "issues and concerns that transcend national boundaries, may be influenced by circumstances or experiences in other countries, and are best addressed by cooperative actions and solutions" (Labonte and Schrecker, 2009). Understanding obesity within this context can help explain the rapid spread of the epidemic. As mentioned in the introduction, the dramatic rise in obesity prevalence worldwide is a modern phenomenon located in time in the second half of the 20th century, and suggests that environmental factors are the primary cause while genetic and psychological factors influence individual susceptibility (Law et al., 2007). The following sections discuss the global obesity epidemic in relation to the phenomenon of globalisation and the spread of neo-liberal models of business and economic growth.

3.3.1 GLOBAL CONTEXT: OBESITY AS A CONSEQUENCE OF THE GLOBALISATION OF THE FREE-MARKET

Globalisation can be defined as "the increased interconnectedness of peoples and nations through technology, trade, and finance, reinforced by an increasing number of multilateral institutions and rules" and encompasses the existence of a global market place linked to the rise of trans-national corporations (TNCs) (Labonte, 2004). Clark (2011) describes how the last fifty years have been an era of cross-national health convergence associated with rapid economic growth for a number of LMICs and the liberalisation of foreign direct investment (Clark, 2011). For example, the average availability of calories per capita today is comparable across developed and developing countries and exceeds the average energy needs of a human being (NHSChoices) - except in sub-Saharan Africa (see **Table 3.1**). In light of this, it is not surprising that the obesity epidemic emerged. However, the process of globalisation is uneven, and middle income countries are experiencing faster rates of growth in food expenditure compared with lower or higher income countries as countries converge to a common level of food expenditure per capita (Euromonitor).

Globalisation can bring a variety of benefits to populations as well as new health risks (Labonte and Schrecker, 2009, Spiegel et al., 2004, Labonte, 2004). On the one hand, increased access to global markets and foreign direct investments may have a positive impact through increased availability of food and commodities that improve health and living standards. On the other hand, the abundance of new products that are heavily marketed in countries where public health institutions and regulatory bodies are ill-equipped to guide and protect consumers can have a negative health impact (Hawkes, 2005). Indeed, emerging markets have been identified as the main source of future profits by corporate strategists who frame the issue as a race to capture the emerging consuming classes in these countries (McKinsey, 2012).

Some have argued that income growth in LMICs is essential to US agricultural exports (Meade et al., 2011). Yet trade agreements seldom favour the interest of lower income countries showing the weakness of economic governance at global level (Thow and Hawkes, 2009, Labonte, 2004). An example of these effects can be seen most acutely in the microcosm of Pacific islands where obesity levels are the highest in the world: both Tonga and Fiji suffer from excesses of imported mutton flaps and chicken parts from the US and New Zealand (Evans et al., 2001) and there is currently little evidence in support of a genetic predisposition to obesity specific to these populations (Prentice, 2009). Therefore, global convergence in social norms and consumption patterns, but not in trading power or public health, governance and consumer protection systems can be seen as a global factor explaining the obesity epidemic in LMICs.

Table 3.1 Dietary composition by macronutrient and energy availability by economic development (FAO, 2010).

	Calories*	**Carbohydrates (%)**	**Protein (%)**	**Fat (%)**
World	2,780	63	11	26
Developed countries	3,420	53	12	34
Developing countries	2,630	67	11	23
Sub-Saharan Africa	2,240	72	10	19
Egypt	3,160	73	12	15

**Total number of calories available for consumption (kcal/capita/day)*

Source: FAO Statistics Division 2010, FOOD BALANCE SHEETS, *Food and Agriculture Organization of the United Nations, Rome, Italy, viewed 17th March, 2011, <http://faostat.fao.org/>. ChartsBin statistics collector team 2011, Dietary Macronutrient Composition per capita, ChartsBin.com, viewed 25th April, 2011, <http://chartsbin.com/view/1160>.*

3.3.2 COUNTRY LEVEL CONTEXT: OBESITY AS A RESULT OF THE INTERACTION BETWEEN THE GLOBAL AND THE LOCAL

The local impact of globalisation is shaped by a country's pre-existing endowments including its level of economic development and human capital as well as its natural resources (Spiegel et al., 2004). Sallis & Glanz (2009) call attention to the fact that policies are the primary mechanism for bringing about environmental changes; that policies can take the form of formal and informal rules, laws and regulations; and that both government and industry control these (Sallis and Glanz, 2009). Long-standing national policies in any particular country are therefore likely to be important in shaping the food environment at any particular point in time. For instance, the subsidy system in Egypt may explain Egypt's outlier status in terms of obesity levels (Asfaw, 2007, Asfaw, 2006), while Egypt's more recent economic liberalisation and increased food imports may have made a more recent contribution.

The process of economic liberalisation can have positive effects by fostering competition, the adoption of modern technology, an increased demand for highly skilled labour and an obligation on industries to confront their inefficiencies. Therefore, this can contribute to transforming the fabric of society and changing the societal arrangements and the type of social stratification that exists. As mentioned above, liberal economic policies can also increase market penetration of transnational corporations (TNCs) within a country which may have negative effects on health. Hawkes proposes three driving factors behind this process: 1) changes in terms of trade, for example in the agri-food sector, 2) increased foreign direct investment (FDI), and 3) marketing (Hawkes, 2006). Therefore, economic growth espousing liberalisation is likely to bring about change in the food environment; the information/cultural environment, as well as in the nature of social stratification. These three dimensions of societal change are discussed below.

3.3.2.1 SOCIAL TRANSITION: CHANGES IN SOCIAL STRATIFICATION

Inequalities in power, wealth, and status between categories of persons within a single social system (e.g. classes, castes, ethnic groups) are referred to as stratification and vary across

time and geographical location. It is thought that stratification arises as a result of increasingly complex social organisation required for the efficient use of commonly held resources through specialisation. Once stratification arises, it appears that elites are able to reproduce themselves (Bartley, 2004) and that stratified societies expand at the expense of egalitarian ones. Social mobility is possible but heavily dependent on social and economic policies. Income, education, and occupation are the main SES dimensions of stratification investigated in HICs. In LMICs, asset-based wealth indicators are often used in obesity research (Howe et al., 2012), while more traditional forms of social hierarchy are seldom used.

Individual income tends to increase as a country becomes richer, however the distribution can be segmented with large regional differences observed in LMICs. In advanced economies, the labour market specialisation and the transition to a service-based economy requiring higher skills can partly explain why better education generally correlates with better occupation and higher income and, therefore, display similar health gradients in HICs.

However, in LMICs, there appears to be a stage during which economic returns to education for individuals are poor. For instance, in the Middle East and North Africa region, unemployment is almost always highest among individuals with a higher level of education. This is because up until recently, a public sector post was practically a guarantee for someone with a higher education level regardless of the quality or content of their education, and many of these individuals find themselves unemployed now (Galal, March 2002, Nabli, 2007). Nevertheless, inequalities in education can be wide in poorer countries where infrastructure and investment in education can vary widely from region to region. As a result, a section of the population may be highly educated and another illiterate which has the potential to translate into large differences in health outcomes.

Gender is an important dimension of social inequality. For example, education levels rise with country income per capita but not equally among the sexes. Women tend to enter education much later than men and, even at middle levels of country income, women's

participation in the labour force may be relatively low. In addition, economic returns to education may be much slower for women even once they have attained higher education levels, because they are expected to continue occupying traditional female roles in society unless social reform has occurred (Bilton, 2002). However, education may confer other benefits by promoting women's social mobility through marriage.

3.3.2.2 DIETARY TRANSITION: CHANGES IN THE FOOD ENVIRONMENT

The obesogenic effect of modern economies has been pinpointed to an overall decline of the inflation adjusted price of calories in the last three decades, in parallel to a move towards more sedentary occupations (Philipson and Posner, 2003, Swinburn et al., 2011). The change in food supply from subsistence farming to industrial food production has been driven in part by technological progress pervading our food production, dietary habits and physical activity patterns. The Green Revolution (changes in farming methods involving machinery, fertilisers and pesticides) has led to an increase in food supply, the growth of food portion size and the production of processed foods convenient for snacking, while the use of labour-saving devices has reduced food preparation time. Physical activity patterns have been affected by the use of mechanised transport, the rise of sedentary entertainment such as computer games and television (TV) viewing. These features of modernity are captured under the umbrella of the nutrition transition (Popkin et al., 2012, Bleich et al., 2008, Besson et al., 2009, Hu, 2003, Hu et al., 2003, Popkin and Gordon-Larsen, 2004).

However, the nutrition transition in its original form does not provide a satisfactory account of the political economy of calorie availability and distribution. Recently, the nutrition transition concept has been used by scholars to refer specifically to shifts in food consumption towards *poor quality* diets dominated by highly processed foods and drink, particularly in LMICs (Prentice, 2006, Popkin et al., 2012) . This begins to raise questions around the role of the main suppliers in the food system - the trans-national corporations (TNCs).

Most of the world population depends on food supply from a food industry dominated by large TNCs and only subsistence farmers can be considered to be outside this global food supply system. Pearce and Witten (2010) define the food industry as a complex global network of businesses, including agribusinesses, food manufacturers, and retailers, with sufficient political influence to be considered a causal factor in the nutrition transition and changing dietary patterns (Pearce and Witten, 2010).

Increased foreign direct investment (FDI) associated with liberalisation leads to greater market penetration by TNCs in lower income countries leading, not only, to a rise in processed food production, but also an improvement in supply chains, and a consequent increase in food availability to individuals (Ács et al., 2007, Thow and Hawkes, 2009, Rayner et al., 2006, Hawkes, 2006, Hawkes, 2005). The last decade has witnessed an unprecedented increase in retail outlets such as supermarkets, convenience stores, and large discount stores in LMICs. In a case study of Central America, supermarkets have gone from accounting for 15-30% of national retail sales of food before 1980, to 50-70% in 2001, and similar trends are observed in Asia. In fact, food sales through supermarkets and fast food service outlets in middle-income countries are moving toward the levels found in HICs (Thow and Hawkes, 2009).

In principle, economic development conducted through liberalisation and market integration could reduce the burden of obesity by improving access to fresh fruit and vegetable. In addition, a growing economy may initially rely on mass manufactured, high energy density and/or processed foods as a means of increasing calorie availability and improving access to food in the early stages of economic development, since processed foods are easy to store and to transport (Pearce and Witten, 2010). However, a number of studies have argued that the current global market environment privileges obesogenic foods over healthy ones (Rayner et al., 2010, Popkin, 2002, Hawkes, 2006). For instance, economic data from the US indicate that the price of food does changes differentially over time for different food categories: fruit and vegetable become more expensive and sugars and fats become cheaper (both in absolute and relative

terms) (Leonhardt, 19 May 2009). **Figure 3.3** shows how liberalisation and the nutrition transition are linked.

Figure 3.3 The relationship between economic liberalisation and the nutrition transition. Adapted from Popkin 2002.

3.3.2.3 CULTURAL TRANSITION: CHANGES IN LIFESTYLE VALUES AND CONSUMPTION PATTERNS

The change in culture, knowledge and information availability in a country is arguably one of the most important aspects of economic development as individual decision-making is likely to be informed by this. This section describes how cultural factors and marketing might affect consumption patterns and obesity risk.

3.3.2.3.1 MARKETING AND THE CULTURE OF CONSUMPTION

As economies grow and move from traditional to modern forms of organisation, the business of living changes from meeting essential needs such as food and shelter to that of meeting perceived needs embodied in the culture of consumption (UNDP). Bourdieu argues that as societies move away from traditional values, there is room for merchants to claim cultural legitimacy and therefore shape the habits of potential consumers. This fosters competition between merchants for cultural legitimacy which, in Bourdieu's own words, *is also correlated with the constitution of an ever-growing, ever more diversified corps of producers and*

merchants of symbolic goods, who tend to reject all constraints apart from technical imperatives and credentials (Bourdieu, 1984b).

In terms of diet, as food provision is taken out of the hands of individuals and subsistence farmers and put into the hands of private suppliers in the business sector, the multitude of products that become available creates intense competition and drives companies to put a greater emphasis on advertising to shape individual preferences and gain a market advantage. Therefore, marketing becomes an important social force shaping the social valuation of food and individual dietary habits and a key strategy for businesses to ensure their success and healthy profit margins (Ács et al., 2007). TNCs are becoming increasingly sophisticated in their marketing strategies to capture the emerging middle-classes in LMICs (Eizenbergy and Salvoz, 2012), and a strong emphasis is placed on targeting children to create long-lasting brand loyalty (Harris and Graff, 2012). As transnational mass media corporations dominate the content and distribution of information on lifestyles and trends, they contribute to the production of a global form of dietary behaviour (Labonte and Schrecker, 2009).

LMICs are a particular target for TNCs today (Labonte and Schrecker, 2009). As a business textbook puts it, target markets have to be accessible, responsive, and (above all) viable (Hastings, 2012), criteria fulfilled by LMICs with their rapid economic growth and large populations with increasing incomes. As a result of the increased market penetration of Western companies in LMICs, local populations are increasingly exposed to their advertising power (Hawkes, 2005, Hawkes, 2006). For instance, in 1986 there were only three LMICs among the twenty biggest spenders in advertising while a decade later there were nine (UNDP). Rapid changes in dietary habits associated with increases in blood cholesterol have been linked to marketing of imported products among the pastoral Masai in Tanzania; and in West Africa, the marketing of imported wheat and rice has supplanted the consumption of local less-refined cereals (millet and sorghum) (Miranda et al., 2008).

While marketing can be useful in fostering a dynamic market place, the expansion of consumer choice has little significance if choices are based on wrong or misleading information and where there is little public action to protect consumer rights to offset the vastly imbalanced information flows dominated by commercial advertisements. Advertising is designed to create cognitive biases that favour one product over another without necessarily encouraging health-focused decision making. This effect can be worse in LMICs where the information environment can lack competitiveness such that large transnational corporations have a clear field for placing their products among poorly informed populations (James, 2006). For example, food and beverage advertising on television and other mass media, and the associated depictions of the West's overeating culture, are likely to influence food choices and reshape cultural norms around food, encouraging the consumption of unhealthier food types that originated in richer countries (Rayner et al., 2006, Hawkes, 2006). One particularly effective strategy has been to confer social prestige to eating in restaurants (Witowski, 2007, James, 2006).

3.3.2.3.2 SOCIAL NORMS OF BODY SHAPE

Local preferences for what constitutes an attractive body shape will vary over time. Bartley (2004) argues that alongside changes in the material realities of existence resulting from economic development, health behaviours (e.g. eating low-fat food and taking part in leisure exercise) can be used as a way of expressing social distinction as follows: 1) in poorer countries, where obtaining food is a priority, cognitive skills will be used towards addressing the lack of food, and social distinction will be expressed through the display of a well-fed body; whereas 2) in richer countries where cheap calories are abundant, cognitive skills will be used to self-regulate consumption and display a thinner body image as a form of social distinction (Bartley, 2004). Food sales may benefit from local preferences for plump, well-fed bodies, however, advertising and media exposure may also contribute to shaping new cultural preferences and social norms of body shape by promoting images of thin women. This may contribute to a cultural shift towards different body shape preferences that vary by age and SES.

Body image is particularly relevant for women as it is intimately tied with reproductive capacity and opportunities for upward social mobility albeit in different ways depending on the level of economic development of a country. Early in economic development, when food scarcity is a survival issue, and sexual reproduction a key role for women, plumpness is associated with abundance and fertility. Later in economic development, thinness is valued, perhaps as the result of a preference by men for younger sexual partners embodying youth rather than motherhood as a social trophy. In advanced societies, health consciousness and body shape norms that favour thinness have been put forward as factors explaining the low rates of obesity in high SES women (Salonen et al., 2009).

In summary, as individuals negotiate the new economy and information environment, they are driven to make different kinds of decision and change habits to optimise their desired outcomes within the evolving context. From the point these decisions are first made, they can become perpetuated through intergenerational mechanisms to become new norms, values and attitudes or cognitive social capital (Harpham et al., 2002). These are not socially neutral and represent a form of knowledge that increases power and advantage according to Bourdieu (Bourdieu, 1984a) **.** In addition, a non-competitive information environment where marketing power is unchecked, the links between consumption and benefits to a population of market liberalisation can be broken, thus exacerbating social inequalities and the epidemic of non-communicable diseases, including obesity (Wells et al., 2012).

3.3.2.4 A NOTE ON URBANISATION AND ENERGY EXPENDITURE

Urbanisation brings a reduction in physical activity as well as a greater availability of calories per capita. Manufactured food production can be concentrated in urban areas and food outlets more densely distributed in cities, leading to lower prices and an incentive to eat outside the home (Popkin, 1999). In LMICs, obesity is concentrated in urban environments, but the urban/rural divide in the prevalence of overweight and obesity is more obvious compared with

HICs where there is a smaller urban/rural difference in obesity prevalence (Pearce and Witten, 2010).

However, there are reports that while rural areas in LMICs have lower levels of overweight and obesity than urban areas, rural areas are experiencing a faster rise in overweight and obesity compared with urban areas (Wang et al., 2007, Austin et al., 2011). This may be a result of the spread of supermarkets to smaller towns and poorer areas, the increased ownership of consumer durables such as cars and refrigerators which facilitate shopping and storage, the desire to emulate Western culture resulting from media and advertising (manufactured foods, fast foods and soft drinks) and an increasing diversification of livelihoods beyond farming activities in LMICs leading to more sedentary lifestyles (Ellis, 1999).

The recent period of growing urbanisation globally coincides with a reduction in physical activity levels (Hallal et al., 2012). As countries move from an agrarian to an industrial and/or service-based economy, the structure of the labour market changes such that eventually the majority of people are employed in non-agricultural jobs. This implies a reduction in physical labour and daily energy expenditure per capita.

Therefore, including the place of residence in an analysis may be a reasonable way of taking environmental factors that affect obesity risk into account when examining the SES-obesity association in LMICs. In addition, controlling for occupation (agricultural or rural-based *vs.* urban-based) may be an important way of taking differences in energy expenditure into account.

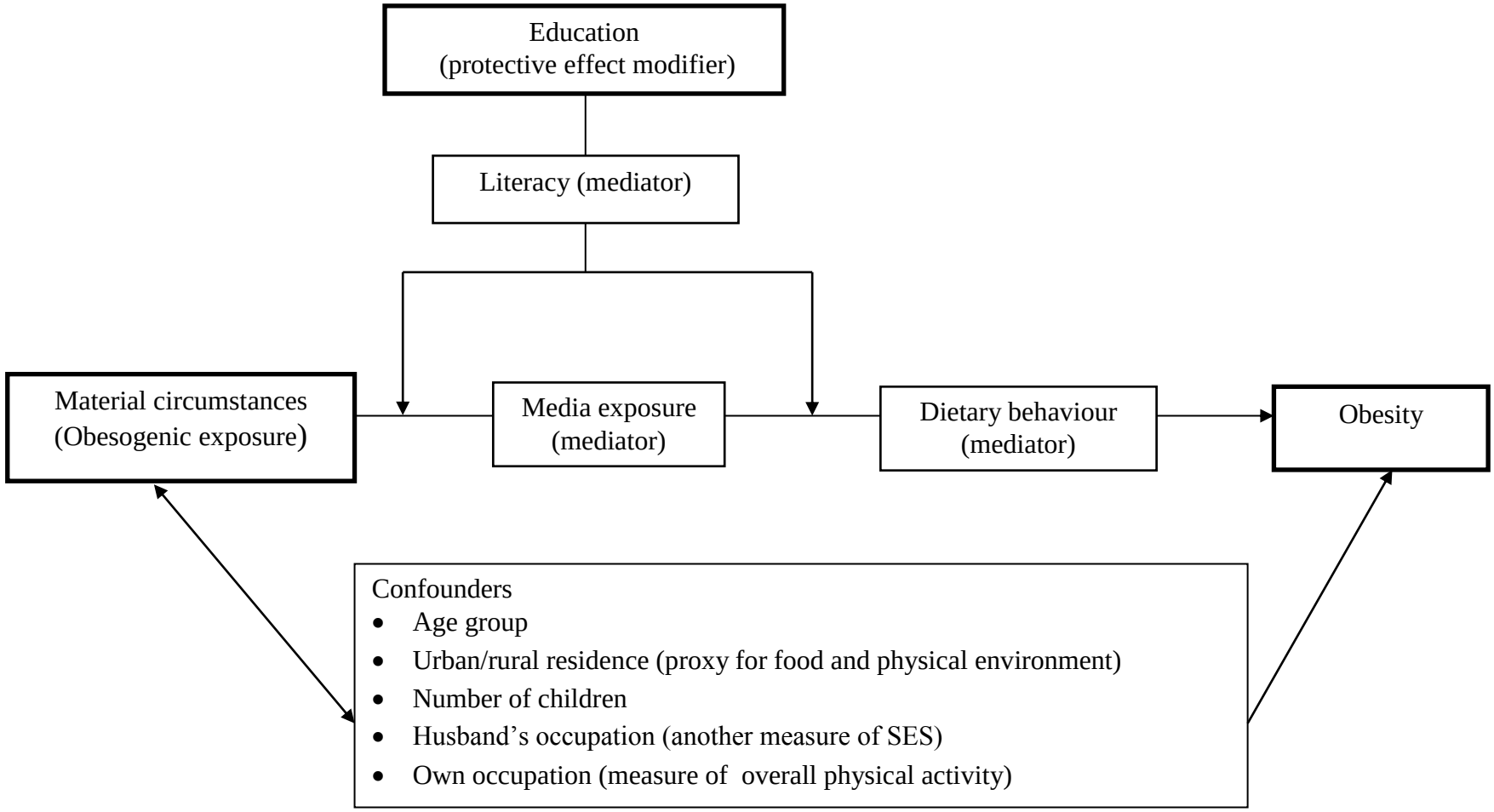
3.4 INVESTIGATING SPECIFIC PATHWAYS LINKING SOCIOECONOMIC STATUS AND OBESITY WITHIN THE SOCIAL DETERMINANTS OF HEALTH FRAMEWORK

Having described the wider societal context and patterns of change relevant to obesity as countries undergo economic development, this section will focus on the pathways between

the socioeconomic status indicators of interest (education and material circumstances) and obesity in women in low- and middle-income country settings. It fleshes out the potential pathways mediated by literacy, dietary behaviour and media exposure using theoretical and empirical material. **Figure 3.4** shows the conceptual diagram including the number of confounders taken into account in the regression model. The individual variables will be described more fully in **Chapter 4** (Data and methods).

Education and material circumstances are chosen as the indicators of interest for a number of reasons: a) an in depth investigation of indicators has to be limited in number; 2) education and material circumstances are the most commonly used indicators in the key studies examining the relationship between SES and obesity in LMICs; 3) they are more reliable indicators of SES in LMICs than occupation or income; 4) there are good reasons why they may differ in their associations with obesity as they capture different dimensions of SES; and 5) these indicators are systematically recorded in the Demographic and Health Surveys datasets. The putative pathways investigated were selected based on theory and empirical observations from the literature and draw on the social psychology cluster of the Foresight obesity framework (see below). Similarly to the SES indicators, the number of putative pathways and mediators (literacy, media exposure, diet) for investigation had to be restricted to limit the scope of the thesis and take into account the limitations in variables available in datasets from LMICs.

Figure 3.4 Causal diagram based on the conceptual framework.

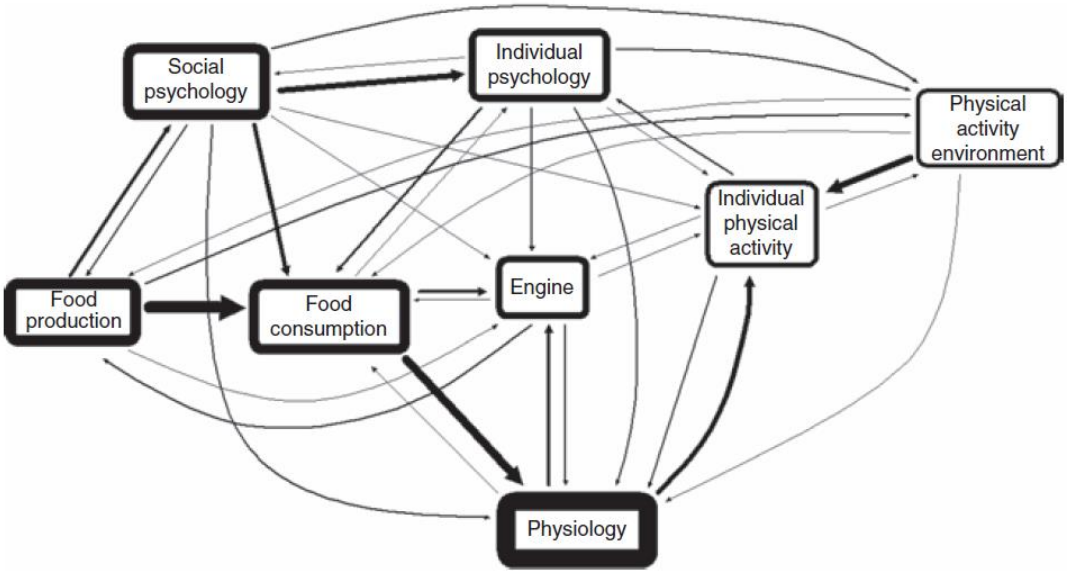


THE FORESIGHT CAUSAL MAP OF OBESITY

The Foresight map (McPherson et al., 2007) synthesises a large amount of information to identify causal pathways of obesity and integrates a wide-ranging set of biological and social factors. Using an ecological model of obesity and the notion of an obesogenic environment, it brings together clusters of factors, including a social psychology and an individual psychology cluster, around a core physiological engine of energy balance. The cluster that is most relevant to the thesis investigation was the social psychology cluster as this examined the relationship between each of education and purchasing capacity (for which material circumstances are a proxy in this thesis) and obesity. Education and purchasing capacity are treated as causal factors within the social psychology cluster. They represent two of five leverage points - as well as representing potential intervention points (McPherson et al., 2007).

Based on the evidence available, this cluster was considered by the Foresight experts to be most strongly connected to the food consumption cluster, whereas the physical activity cluster was strongly connected to the physiology cluster with no obvious suggestion of a connection to the social psychology cluster – see **Figure 3.5** for a simplified version of the Foresight map (Finegood et al., 2010). What this means is that physical activity may be less evidently patterned socially and weakly associated with education and purchasing capacity (see Foresight report, p.31). Furthermore, media exposure is placed at the centre of the social psychology cluster and identified as a key mediator between education and the social valuation of food. Based on this, the following sections expand on the association between each of education and wealth and obesity incorporating media exposure, dietary behaviour as well as literacy as mediators.

Figure 3.5 Simplified version of the Foresight obesity map (Finegood et al., 2010).



3.4.1 IMPROVED MATERIAL CIRCUMSTANCES AND OBESITY IN LMICS: AN OBESOGENIC PATHWAY

The increase in individual wages resulting from economic development is associated with increased life expectancy and decreased infant mortality in LMICs, and therefore considered a central mechanism for the improvement of human welfare. However, improvements in standards of living resulting from better economic resources may be offset by new types of unhealthy lifestyle where relevant health information is not widespread or individuals are not empowered to use it, as discussed above.

Global reviews conclude that there is a consistently positive association between wealth and obesity in women in LMICs (Sobal and Stunkard, 1989, McLaren, 2007). In studies that include both education and wealth in a logistic regression model, independent and opposite associations have been shown to exist with a positive association displayed between wealth and obesity and a negative association between education and obesity. This suggests that these indicators are less collinear in LMICs than in HICs offering an opportunity for the investigation of their separate and inter-related associations with obesity. Examples of this include Peru, the

Philippines, China and Brazil (Poterico et al., 2011, Dahly et al., 2010, Hou et al., 2008, Monteiro et al., 2001). The difference in the associations found between each of education and indicators of material circumstances (either wealth or income) and how these are affected by the level of economic development is illustrated with findings from Brazil which is one of very few LMICs for which long-term trends in obesity by income are published. Based on three successive national surveys in 1975, 1989, and 1997, Monteiro et al. observed a shift in women's obesity towards lower income groups in the economically more developed south-eastern region of Brazil (Monteiro et al., 2007). A later study controlling for education confirmed that there was an inverse income-obesity association in the richer South, but not in the poorer North (Monteiro et al., 2001). In the latter, income was positively associated with obesity in women, while the opposite was true for education.

But why is there a positive association between wealth/income as markers of material circumstances and obesity in LMICs when the opposite is observed in high income countries (HICs)? One explanation directly implicates diet and the difference in the availability and price of calories relative to fruit and vegetables. In HICs including the US, being in a lower income group is associated with the purchase of cheaper, lower quality food which are high in calories and low in nutrients (empty calories) (Drewnowski and Eichelsdoerfer, 2010, Drewnowski and Darmon, 2005), and poor Americans are reported to consume excessive amounts of dietary fat and sugar and not enough fruit, vegetables, and micronutrients relative to dietary recommendations. Drewnowski and Darmon (2005) argue that this is a matter of material deprivation because healthier diets are simply beyond the reach of many people due to cost, noting that on a per calorie basis, diets composed of whole grains, fish, and fresh vegetables and fruit are far more expensive than refined grains, added sugars and added fats (Drewnowski and Darmon, 2005). Conversely, higher incomes are associated with the consumption of a greater amount of fruit and vegetables and health foods that are nutrient rich relative to the amount of calories they contain.

However, consumption data from LMICs show that soft drinks and fast food are among the first purchases that individuals are making as their incomes increase and the middle classes expand. This corresponds to an overall rise in fat, refined sugars and protein content of national diets, as the consumption of fibre and starchy carbohydrates derived from traditional diets falls (Popkin et al., 2012, Popkin and Gordon-Larsen, 2004). Soft drinks and fast food are not necessarily low in cost in LMICs and may be considered a luxury rather than a cheap source of calories (McKinsey, 2012) suggesting that cost is not the only factor determining dietary behaviour and that the perception of these products may be important in LMICs.

Some nutrition transition scholars have proposed that longstanding conditions of food scarcity in LMICs may drive greater avidity for calories and therefore a higher risk of obesity among those who can afford them (Prentice, 2009). This may occur through three mechanisms: 1) genetic programming promoting fat deposition in times of plenty in preparation for times of scarcity; 2) metabolic/epigenetic programming promoting fat deposition following early-life exposure to scarcity; 3) cultural memes whereby prolonged food insecurity results in intergenerational transmission of behaviours that promote overeating and energy storage in times of plenty. Insecurity may also operate through psychosocial pathways involving stress (Marmot and Wilkinson, 2001) and leading to a physiology or a psychology that favours the consumption of energy-dense foods.

The latter is close conceptually to the idea of a ‘psychology of accumulation’ of calories or energy identified by the Foresight project as an important factor operating among low-income groups in HICs (McPherson et al., 2007) and may be presumed to operate on a more widespread scale in LMICs. This describes a psychological state whereby people remain locked in behavioural patterns dictated by short-term goals. They may find it difficult to put long term plans in place due to a dearth of financial resources, opportunities, information and awareness. As a result the force of dietary habits remains much stronger and the conscious control of accumulation much weaker (McPherson et al., 2007).

Therefore, food insecurity may have an impact on the perception of high-energy density goods and has been considered a key factor explaining why the poor in particular are susceptible to excess weight in the US (Smith et al., 2009). Whereas insecurity might drive the poor to consume large quantities of unhealthy, energy-dense and nutrient-poor foods in HICs, the relative scarcity of food in LMICs may not allow the poor access to large quantities of cheap calories. In LMICs only higher income groups would have access to enough calories to be susceptible to excess weight and their sensitivity to the wider food insecurity that exists in their country may shape their perception of food products accordingly.

In summary, improved material circumstances in LMICs may allow the alleviation of pre-programmed or psychosocial impulses shaped by a longstanding food insecure environment. These encourage the consumption of energy-dense foods at the expense of fruit and vegetables, a tendency enhanced by the marketing of energy-dense, manufactured products. However, improved material circumstances also lead to greater media exposure which, as proposed by the Foresight causal model, has a crucial role in shaping the social valuation of food. In the next section, the relationship between improved material circumstances and diet is further described, followed by a review of the role of media exposure as a mediator between material circumstances and dietary behaviour. The role of cognitive skills in potentially modifying and protecting against the tendency to consume energy-dense foods resulting from better material circumstances and greater media exposure in LMICs is discussed in the final section (the education pathway).

3.4.1.1 MATERIAL CIRCUMSTANCES AND DIETARY BEHAVIOUR

Cross-sectional studies, prospective cohort studies and randomised trials have shown an association between the intake of fats, snacks, sugar-rich foods, soft drinks and fast foods on the one hand and greater energy intake, higher body mass index (BMI) and obesity on the other (Powell and Chaloupka, 2009). Diets appear to be evolving globally towards a greater fat and sugar content and a lower fruit and vegetable content. For example, Chinese consumption and

nutritional data indicate that an increase in energy density (i.e. calories per 100g) in household diets has occurred in parallel to economic growth. (Du et al., 2004, Popkin and Gordon-Larsen, 2004). Popkin identifies soft drinks as a major contributor to this phenomenon and highlights the disappearance of water and milk from the diets of children in favour of sugar sweetened drinks (Popkin et al., 2012). Carbonated drinks are thought to be particularly problematic as they are calorie rich but liquid therefore bypassing the physical signals from the stomach for appetite suppression, as well as being devoid of any nutritional value (Wells, 2010).

Evidence of a detrimental effect of increased income and obesity risk in LMICs comes from experiments using cash transfers. These are poverty alleviation programmes aimed at breaking the intergenerational cycle of poverty (Lagarde et al., 2007). Cash payments to households are conditional on child school attendance, immunisation and so on. Data from the Mexican Conditional Cash Transfer program *Oportunidades* show that the cash component of the program was associated with higher body mass index in adults within households that received higher cumulative cash transfers over time (Fernald et al., 2008).

A study using consumption data from the Chinese Health and Nutrition Survey by Guo et al. (2000) shows how the dietary structure changed over time with rising incomes. Between 1989 and 1993, there was an increase in household incomes paralleled by a reduction in the consumption of low-fat, high-fibre foods including coarse grains and an increase in the consumption of oils, fats and meats. There was a positive association between household income and the latter types of food. More specifically, higher income households displayed the largest increases in pork consumption over time while the lower income households displayed the largest increases in edible fat consumption (Guo et al., 2000). This pattern was corroborated in a later study based on the same data and covering a longer period 1989-1997 (Du et al., 2004).

The Guo et al. (2000) study concluded that the rise in household incomes and food affordability could explain a part but not all of the change in dietary structure in China and proposed that the spread of mass media in China may have a role. If the psychology of accumulation linked to historical food insecurity still has a hold in these rapidly changing

environments while public health systems remain weak, marketing forces are likely to find fertile ground for the promotion energy-dense foods. Media exposure would therefore be expected to be a strong mediator of the association between wealth and obesity.

In the thesis, the intake of snacks and sugar-rich foods and the reduction in local fruit and vegetables consumption will be taken as hallmarks of a globalised diet. They will be incorporated as dietary behaviour variables in the analyses – see next chapter.

3.4.1.2 MATERIAL CIRCUMSTANCES, MEDIA EXPOSURE AND DIETARY BEHAVIOUR

Marketing messages reach individuals through a number of media platforms (e.g., print, broadcast (radio and TV), cable and internet). These may be used to advertise food, beverages, restaurants and fast food chains. The potential effects of television advertisements on knowledge, attitudes and behaviour have generated considerable concern among public health scholars. Part of this concern arises from the overall exposure of children to this medium (Byrd-Bredbenner and Grasso, 2000).

A review of studies examining the relationship between media exposure and obesity in children found that 63 out of 73 studies (86%) reported an increased rate of childhood obesity with increased media exposure, through effects on physical activity and diet (CSM, 2008). Children and young adolescents are thought to view 40,000 advertisements per year on television alone, and these influence children's food preferences, what children ask their parents to buy, and interestingly, what their parents eat themselves. Adults are also thought to be vulnerable to the obesogenic effects of television viewing time (Henderson and Kelly, 2005, Vioque et al., 2000), through its association with snacking on fast sugar foods (Francis et al., 2003, Gore et al., 2003) and reduced intake of fruit and vegetables (Lowry et al., 2002).

It is thought that young children are cognitively and psychologically vulnerable to advertising because they do not understand the notion of intent-to-sell and therefore often accept advertising claims at face value. In fact, in the late 1970s, the Federal Trade Commission

concluded that it was unfair and deceptive to advertise to children younger than six years (CC), and excessive advertising to children has been highlighted as a problem in Latin America as well (PAHO, 2012). By analogy, in a lower income society where advertising is a new phenomenon adults may be more susceptible to the effects of advertising compared with their less advertising-naïve Western counterparts, unless they are equipped with cognitive skills that enable them to acquire and interpret information in a more critical way.

The assumption in this thesis is that energy-dense and nutrient-poor manufactured foods such as sugar-sweetened beverages and sweet snacks (chocolate and biscuits) will be advertised through broadcast media, and that greater exposure time to television will increase the likelihood that calorie-rich, manufactured foods are consumed. However, the use and impact of different media may be socially patterned based on their cost and the user's literacy (Grabe et al., 2009). While improved material circumstances will lead to greater exposure to media messages, as a result of the acquisition of electrical goods including television and radio sets, cognitive skills may modify the media exposure effect on the social valuation of food. Since individuals with greater cognitive ability may grasp the intent-to-sell motive behind marketing more easily they may be less susceptible to its influence. They may also be more successful at filtering high volumes of information and extracting information for their health benefit.

3.4.2 EDUCATION AND OBESITY IN LMICS: A PROTECTIVE PATHWAY?

Findings based on the National Health and Nutrition Examination Survey data show that, in the US, an extra year of education lowers a person's BMI by 1-4%, and the probability of being obese by 2 to 4 percentage points with a stronger effect observed in women compared with men (Kemptner et al., 2011, Grabner, 2009). The association between low education and poor health has been consistently observed in high income countries including the UK, and multiple pathways proposed and examined.

A review based on research from high income countries (HICs) by Chandola et al. proposed a number of explanatory variables including cognitive ability, childhood SES, adult SES, health behaviours and a person's sense of control. Using data from the UK National Child Development Study they tested a model including all of these. They found that health behaviours and sense of control explained a large part of the association, while adult SES (measured using occupation) did not appear to contribute to the association in women but did in men (Chandola et al., 2006a). The authors acknowledged that the association between education and health may differ in other countries even if the mechanisms might be similar.

Other proposed pathways in the epidemiological, psychological and economics' literature for a protective role of education against disease include psychological capital (locus of control, self-esteem), better use of medical care, better health literacy, and time-preferences favouring longer term outcomes over immediate gratification (Leigh and Fries, 1994, Shaw, 2007). The latter is associated with impulse-control and is thought to be predicted by early life socioeconomic disadvantage and parental education level (Kaplan et al., 2001).

Recent empirical evidence suggests that cognitive advantages (unrelated to time-preference or personality characteristics) may be the key determinant (Loureiro and Nayga, 2005, M. and Lleras-Muney, 2006, Cutler and Lleras-Muney, 2010, Büchner et al., 2012). Cutler and Lleras-Muney investigated the link between education and health behaviours including dietary patterns and physical activity, using a variety of datasets from the UK and the US and incorporating a comprehensive set of mediating variables (Cutler and Lleras-Muney, 2010). They found that the positive effect of education remained after adjusting for income and that the education gradient cannot be accounted for by reverse causation nor health behaviours alone. The protective effect of education remained large and statistically significant after these factors had been taken into account. They reported that knowledge and cognitive ability were the single biggest factor accounting for the education gradient (30%), while other factors accounting for the education-health gradient included income, health insurance and family background (30% for the three factors combined), and social networks (10%). Behavioural

factors such as risk aversion, devaluing the future, or personality factors (such as sense of control) did not account for any part of the gradient.

Within a life course framework, education may capture early life circumstances shaped by parental education and reflect intellectual, material, social and other resources of the family of origin (Shaw, 2007). The importance of cognitive skills in adult life was demonstrated in a recent study using a large datasets combining a birth cohort and an income survey in the Netherlands. The authors showed that individual educational attainment and the mediating cognitive skills (measured by a mathematics test, a language performance test and an IQ test at age 12) were more important than personality in determining adult income, and accounted for 50% of income earnings; while neighbourhood social capital and parental cultural capital only accounted for 6%; with the remaining 44% ascribed to unobserved factors including personality and will-power (Büchner et al., 2012).

In LMICs, education has been shown to contribute to the reduction of child mortality and morbidity (Hatt and Waters, 2006, Gakidou et al., 2010). A study of the pathways between education to child mortality in India demonstrated that adjustment for caste, household wealth, and urbanisation does not fully attenuate the protective association between education and child mortality (Singh-Manoux et al., 2008). As described in the introduction, multi-country studies based on Demographic and Health Surveys data have demonstrated that an inverse association between education and female obesity appears in middle income countries and remains after adjustment for wealth and urban/rural residence (Dinsa et al., 2012, Monteiro et al., 2004a). The protective or inverse association between education and obesity is thought to appear gradually over time and this seems to occur more rapidly among women than men, suggesting that education may have a stronger effect on obesity in women. No studies were identified that specifically examined the causal relationship between education and obesity in LMICs.

From a theoretical perspective, education is widely used as a measure of SES but it also captures a number of dimensions related to cognitive skills including the knowledge based

assets of individuals (Shaw, 2007). Bartley describes how education has powerful relationships to health behaviours through culture as conceptualised by Bourdieu. Bourdieu's theory of *habitus* proposes that education equates with a healthier set of ideas, values and norms – the components of culture (Bartley, 2004) (p.70). As a result, the contribution of health behaviours to the education effect on health may be context specific such that they contribute to a greater extent in contexts where health behaviours are heavily socially patterned (see Stringhini for a comparison of the UK Whitehall data and French longitudinal data – (Stringhini et al., 2011)). Women in LMICs entering the educated elites may rapidly acquire the norms of Western elites as a form of social distinction in an environment where most women still seek to be plump.

From a theoretical perspective, Mirowsky and Ross (2003) have argued that the health effects of education operate primarily via the accumulation of productive skills and decision making abilities, and that these represent the bulk of the relationship between social status and health at least in the US (Mirowsky and Ross, 2003); that it is people's ability to communicate, solve problems, implement plans and complex strategies of thinking as well as having the confidence to do this (learned personal effectiveness) that gives the educated an advantage. Therefore, cognitive advantages may allow women in LMICs to make better health decisions and advocate for a better standard of living including better food. Cognitive skills may also enable women to negotiate the rapidly evolving information environment produced by mass marketing and optimise their interaction with media.

Empirical evidence suggesting that the health literacy component of formal education may mitigate the association of increased income with obesity comes from the Colombian Conditional Cash Transfer. Unlike the Mexican program, it incorporated an adult health education component and appears to have attenuated the obesogenic effect of the cash transfer on dietary choices. Compared with the Mexican program, the Colombian program had a smaller effect on increasing the purchase of fats and carbohydrates (Aitsi-Selmi et al.). This association is likely to be heavily influenced by the wider food environment and information environment including the effect of marketing campaigns and the intensity of media exposure. However,

knowledge related to medical care is unlikely to be important in obesity, and health literacy alone is unlikely to explain the whole picture.

In summary, there is empirical evidence and there are theoretical reasons to understand the association between education and obesity in LMICs to be mediated in a significant way through cognitive skills, and to potentially provide a protective pathway against the obesogenic effects of increased wealth.

3.5 CONCLUSION

This chapter reviewed theoretical and empirical research relevant to the association between socioeconomic status indicators -education and material circumstances- and obesity in low- and middle-income countries. The association was placed within a wider, global context that is changing rapidly and affecting the societal arrangements that determine the nature of social stratification, the food system and the cultural environment in LMICs. The review described a particular set of causal relationships within the broader social determinants of health framework showing how an obesogenic pathway resulting from improved material circumstances and increased media exposure may be modified through the cognitive skills captured by education. While, these may not be the only pathways linking SES to obesity, there is evidence to support their importance and focusing on them limits the investigation to a reasonable scope for the empirical analysis described in the following chapters.

4 CHAPTER 4: DATA AND METHODS

This chapter describes the analytic approach to the empirical investigation. The overall strategy, data sources and sampling, variables and statistical analysis are described in turn.

4.1 ANALYTIC STRATEGY

4.1.1 MODELLING PERIOD EFFECTS

Period effects will be examined in two ways: first, by examining the change in the association between SES indicators and obesity over time using data from the two different time periods in Egypt; and second, by examining the change in the association between SES indicators and obesity in different countries, whereby the time-variation will be modelled as levels of economic development.

4.1.2 MODELLING CAUSAL PATHWAYS

The thesis uses a hypothesis driven approach. The analytic strategy aims to test the proposed pathways and examines, at individual level, whether there is evidence to support the hypothesis that education protects against the obesogenic effects of material circumstances; and whether media exposure (a proxy for marketing exposure) is plausible in explaining the associations between SES and obesity through dietary behaviour. Any evidence that a mechanism exists through which education and material circumstances operate jointly but in different ways will support the possibility that they have different associations with obesity. Of note, for this hypothesis to be tested, the education and material circumstances variables must be adequately partitioned and have a sufficiently low correlation coefficient. This is where the unique opportunity offered by research on obesity in LMICs comes in to play.

4.2 STUDY POPULATION

The Demographic and Health Surveys (DHS representing a population of women between 15 and 49 years provide most of the data for the thesis. One section of the thesis is based on the Chinese Four Provinces (4-P) study representing an older population of women.

4.2.1 THE DEMOGRAPHIC AND HEALTH SURVEYS

As mentioned in the introduction, the Demographic and Health Surveys (DHS) are a key source of data for studies on obesity (Martorell et al., 2000, Puoane et al., 2002, Monteiro et al., 2004a, Ziraba et al., 2009, Neuman et al., 2011, Jones-Smith et al., 2011, Subramanian et al., 2011, Dinsa et al., 2012). The DHS are a worldwide project funded by the United States Agency for International Development aiming to provide data on demographics and health outcomes, mainly for women and young children. They are nationally representative household based cross-sectional surveys using a multistage stratified probabilistic sampling design.

4.2.1.1 DHS STUDY DESIGN

The primary population surveyed in the DHS is the universe of all ever-married women aged 15-49 years, although earlier versions of the DHS confined the collection of anthropometric data to women who had given birth in the five years prior to the survey. The DHS also collect detailed information on young children and implement a sampling policy of 1000 women per major domain of interest (contraceptive use and child mortality) to produce adequate estimates (USAID, 2012).

A three stage probability sample is used with the aim of securing a sufficient number of cases to reduce sampling error and provide estimates of adequate precision for the purposes of the survey. Therefore, each primary sampling unit and household has a defined probability of selection. The DHS ensure extensive interviewer training, use identical core questionnaires, standardised measurement tools and implement instrument pre-testing to ensure standardisation

across time and geographical locations (Zanati and Egypt, Mukuria et al., 2005) which facilitates comparison across time and countries.

As an example of the DHS sampling frame methodology, the Egyptian DHS are designed to represent the administrative regions that constitute the full geographical territory of Egypt. The latter is divided into 26 governorates, five of which are frontier governorates with relatively small populations. The 1992 and 1995 Egyptian DHS sampling frames are based on the 1986 national census; the 2005 DHS on the 1996 census; and the 2008 DHS on the 2006 census to ensure up to date information for the primary sampling units (PSUs). The first selection stage was the selection of the PSUs from a list of towns and villages; the second stage involved a number of steps including mapping to divide the PSUs into equally sized parts (~5000 persons per part in 2005 for example), followed by further division into equally sized segments, from which a systematic sample of households was selected in the third and final stage (Zanati and Egypt). Similar methodology based on local census data and geographical subdivisions is used in the design of DHS surveys for other countries.

4.2.2 THE CHINESE FOUR-PROVINCES STUDY

The study population for the Chinese analysis was derived from the Four-Provinces study of dementia which is described briefly below (Chen et al., 2011b, Chen et al., 2011a).

4.2.2.1 CHINESE FOUR-PROVINCES STUDY DESIGN

The study began in 2008-2009 by selecting one rural and one urban community from each of four provinces (Guangdong, Heilongjiang, Shanghai and Shanxi), with the aim of recruiting no fewer than 500 participants in each community. A randomised cluster sampling method was employed to choose residential communities from each of the four provinces. The target population consisted of those residents aged 60 years and over who had lived in the selected areas for at least five years. Based on the residency list of the committees of the village

and the district, a total of 4314 participants were recruited. The participants were interviewed at home by trained survey teams using locally validated instruments which included a general health and risk factor questionnaire.

4.3 STUDY SAMPLE

4.3.1 DHS STUDY SAMPLE

4.3.1.1 EGYPT

The Egyptian DHS are unique within the DHS as being one of a few countries to have conducted several survey waves. Four waves of data in two distinct time periods are used: 1992, 1995, 2005 and 2008. For the examination of period effects, the Egyptian DHS data were pooled from 1992 and 1995 to create time period 1 (1992/95), and from 2005 and 2008 to create time period 2 (2005/08). In the 1992 and 1995 surveys, anthropometric data were available only for ever-married women with children under five years for survey design reasons. Therefore, women who had never been married and had not given birth in the preceding five years (N=20386) were excluded from the 2005/2008 datasets period to ensure comparability of the data across the two time periods.[5]

The total population eligible for interview and measurement across the four datasets was 31808 women aged 15-49 years, although a small percentage of anthropometric data were not available for participants who were not at home (3% and <1% in time period 1 and 2 respectively). Women who were pregnant were excluded from both samples (N=3372), as well as 1207 women who had missing covariates, leaving a total of 27722 women in the final analytic sample (11628 in the 1992/95 sample and 16094 in the 2005/08 sample). More detailed

[5] A sensitivity analysis conducted on the Egypt data sets had shown that the interaction findings from the sample restricted to women with a young child extended to all ever-married women aged 15-49 whether they had children or not. Therefore, all interviewed women with data were included in the analyses in subsequent chapters using the more recent Egyptian DHS data (2005 and 2008) in order to maximise the study power.

sampling plans are available in Appendix B of the final DHS survey reports (Zanati and Egypt). Response rates were ≥99% across all survey waves.

For the exploration of causal pathways involving media exposure and dietary behaviours, only the 2008 Egyptian DHS datasets was used rather than the pooled 2005/2008 datasets used in Chapter 5, because this is the only Egyptian datasets to contain dietary data. The DHS 2008 datasets had a population eligible for interview and measurement of 16571 women aged 15-49 of which 99.7% responded. A small percentage of anthropometric data were not available for participants who were not at home (<1%) and 1577 pregnant women were excluded, resulting in an analytic sample of 14840 women. Less than 0.1% of the covariate data were missing resulting in a final analytic sample of 14795 women used in Chapter 8. The variable 'partner's occupation' was missing 4.5% of the data but this variable was not used until the final model and therefore had no impact on the rest of the analysis.

A smaller sample was used for the mediation analysis that incorporated dietary data in Chapter 8 of the thesis. A dietary diversity questionnaire was administered to a sub-sample of the full DHS 2008 survey sample. They were selected from the full sample of interviewees on the basis that the respondent's youngest child was under three years of age and lived with them. Dietary information regarding the respondent's child was also obtained from the women in this subsample. This resulted in approximately a third of the originally eligible women receiving the dietary questionnaire and represented 5363 women and children with full anthropometric data and dietary information.

4.3.1.2 COUNTRIES FOR COMPARISON WITH EGYPT

An arbitrary decision was made to select six countries with the aim of including a mix of low-income and middle-income countries for comparison with Egypt (a lower-middle-income country) based on the World Bank country income classification (WB, 2008). The

datasets were selected on the basis that data were available in the period matching that of the most recent Egyptian survey period (2005/08) examined in Chapter 5.

Therefore, all countries for which a DHS survey had been conducted since 2005 were eligible. This represented a crude adjustment for global period effects so that, under the global convergence assumption discussed in the conceptual chapter, there was some degree of similarity between the countries' exposure to global political, economic, and cultural factors. An additional sampling criterion was that at least one of the six countries should be from the Middle East & North Africa (MENA) region, to provide a more direct comparison with Egypt in terms of cultural and social factors. All DHS surveys were then listed according to their sample size using the DHS STATcompiler tool available on the DHS website (MeasureDHS, 2012). The first five surveys with the largest sample sizes were selected together with the largest sample from the MENA region. The five largest samples were from India, Colombia, Nigeria, Benin and Peru in descending order of size, and Jordan was selected as the largest sample from the MENA region after Egypt. Each country was analysed as a separate datasets.

As with the Egyptian DHS analyses statistical power was an important consideration in the analytic strategy. With this in mind, steps were taken to maximise the sample size in order to ensure enough participants were included in the subgroups, particularly in the group that was poor and had higher education. To this end, all ever-married women were included in the sample used in this country comparison analysis, as a sensitivity analysis conducted using the Egyptian datasets (Chapter 5) showed that the restricted sample of ever-married women 15-49 years with children and the full sample of all ever-married women 15-49 years displayed similar estimates. Educational attainment categories were combined where necessary to avoid cells with zero participants – see below for further details. Women who were pregnant were excluded from all samples.

4.3.2 CHINESE FOUR-PROVINCES STUDY SAMPLE

A total of 4314 participants were recruited in the 4-P study, corresponding to an overall response rate of 93.8%. Among the 4314 participants, 2465 were women of whom 94.4% had full anthropometric and covariate data, leaving 2327 women to constitute the final analytic sample.

4.4 OUTCOME AND COVARIATE DEFINITIONS

Figure 3.4 in Chapter 3 presents the causal model developed for the thesis.

4.4.1 OUTCOME

4.4.1.1 THE DEMOGRAPHIC AND HEALTH SURVEYS (DHS): GENERAL OBESITY

A body mass index (BMI) cutoff point is used to define obesity as a binary outcome. BMI remains the most widely available measure for studying weight status in populations, and there is a good correlation of BMI with cardiovascular mortality, dyslipidemia and hypertension and a weaker one (compared with central obesity) with diabetes (Huxley et al., 2010). Obesity is usually defined as a BMI $\geq$30 and calculated as (weight/height^2). In the DHS, women were weighed on a digital scale, and their weight recorded in kilograms, to the nearest 100 grams. Height was measured using an anthropometer with standard gradations, and recorded to the nearest millimetre (Mukuria et al., 2005).

4.4.1.2 CHINESE FOUR-PROVINCES (4-P) STUDY: CENTRAL OBESITY

In the Chinese 4-P study, the prevalence of obesity based on the definition of a BMI $\geq$30kg/m^2 was too low to allow the analysis to be conducted without resulting in cells with zero participants in the frequency tables. However, the prevalence of central obesity based on waist circumference was high and was therefore used as the obesity outcome of interest instead of BMI. This discrepancy between total and central obesity prevalence has been called "the paradox of low body mass index and high body fat percentage" and describes the considerably

higher percentage body fat present at sex and age equivalent BMIs in Asian populations compared with Caucasians (Deurenberg-Yap et al., 2000). Furthermore, Asian populations experience higher disease risk at lower waist circumference (WC) compared with Caucasians (Deurenberg-Yap et al., 2002, Snijder et al., 2006). In light of these differences in body composition and disease risk, the International Diabetes Federation recommends the use of lower WC cutoff points (compared with the World Health Organization cutoff points) in Asian populations. High risk central obesity in women is defined as a waist circumference ≥80cm (Alberti et al., 2006).

In the 4-P study weight, height and waist circumference (WC) were measured for all participants, according to standard procedures (Chen and Tunstall-Pedoe, 2005). Height was measured without shoes to the nearest 0.5 centimetre by portable stadiometer; weight was measured to the nearest 100 grams by digital scales, without heavy clothing; waist circumference was recorded to within 0.1 centimetre with a plastic tape-measure placed midway between the lowest rib and the iliac crest. Body mass index (BMI) was calculated as weight in kilograms divided by height in metres squared (kg/m^2).

4.4.2 COVARIATES

A summary of all the covariate details including definitions and coding is provided in **Table 4.1.**

4.4.2.1 DEMOGRAPHIC AND HEALTH SURVEYS (DHS)

4.4.2.1.1 MAIN EXPOSURES

Educational level

In the DHS, highest level of educational attainment was reported in four categories: 1=no education, 2=primary education, 3=secondary education, 4=higher education. The coding

of the education variable influences the gradient, and merging higher and secondary education groups together (Subramanian et al., 2011) has been shown to mask an inverse gradient in the US and may well mask the emergence of such a gradient in economies undergoing transition (Molarius et al., 2000, Martorell et al., 2000). Using finer gradations at the higher end of the education spectrum for a US population (in which 87% of women had secondary or higher education) revealed the expected inverse association between education and obesity, whereas this had been masked when a less finely graded coding similar to the one used for developing countries had been applied (Martorell et al., 2000). Therefore, educational level was recoded into three categories by collapsing no and primary education together.

For the country comparison analysis, the preliminary analyses showed that in the low-income country datasets, there were insufficient numbers of women in the subgroup that was poor but had higher education, which resulted in not being able to estimate the relevant interaction terms in the regression model. To deal with this, the secondary and higher education groups in these countries were combined to form a single group (secondary/higher). As a result, the education variable for the analyses of low-income country data was composed of two categories rather than three: 1) the no/primary education; and 2) the secondary/higher education. This was used on the assumption that these two groups would still be able to capture the variation in the odds of obesity attributable to a difference in educational level, since unlike in the US, having secondary education in a lower income country would represent a relatively high level of education compared to the average and would, therefore, capture the effect of better cognitive skills under investigation in this analysis. Finally, a sensitivity analysis was conducted to see if the difference in coding of the education variable affected the interaction results in an important way.

The wealth index

The wealth index was developed as an alternative economic measure to household income and household consumption expenditure for research into inequity in access to health

programs and other publicly or privately provided services. Income and consumption are more difficult to measure in LMICs due to the unreliability in reporting, seasonality of earnings and volatility of markets (Rutstein et al., 2004). Reasons for the unreliability include the difficulty in recording alternative sources of household income that may be important to a household's economic capital. For example, the informal sector represents two thirds of the country's Gross Domestic Product (GDP) in India's, while remittances represent half of the Phillipine's GDP.

The original aim of the asset-based wealth index was to measure the ability to pay for health services and the distribution of services among the poor. Now, it is also used as a general indicator of material circumstances and there is evidence that it performs well as a measure of consumption expenditure (Howe et al., 2012). The philosophy underlying the wealth index recognises that education and wealth may have different effects on health and that the former may offset the latter.

In the DHS, the wealth index captures general material circumstances through data collected in each survey on the ownership of durable assets such as electrical equipment (TV, radio, computer), basic amenities (sanitation facilities and drinking water supply) and housing characteristics (floor material, etc) - see **Appendix B** of the thesis for a full list of recorded amenities by survey year for Egypt. The wealth index score is generated using principal components analysis based on the Filmer & Pritchett method (Filmer and Pritchett, 2001, Rutstein et al., 2004) which is a data reduction technique. The correlations between the full set of asset indicators are used to generate a set of principal components and derive a score for each household. Only the first principal component - the one that explains most of the variance of the indicator variables - is used. Usually, it explains only a small proportion of the total variance in the asset indicators (<20%), but there is evidence that the other components are not correlated with consumption expenditure and are therefore less useful (Howe et al., 2012).

Although the technique applied is the same, the wealth index is generated separately for each survey year. As a result, there is some variation in the set of indicators included in the

calculation of the wealth index - depending on period and country - that reflects variation in living conditions. More specifically, ownership of modern electronic goods, a bank account and furniture were recorded in the later years but were not in the earlier years (see **Appendix B**). For instance, the more recent DHS datasets, like the Egyptian DHS of 2005 and 2008, incorporate assets that reflect the availability of new consumer products on the market including mobile phones and personal computers. The Indian DHS but not the Egyptian DHS record whether a servant is present in the household. This does not harm the comparability of the wealth index score across years and countries but may enhance it since it enables better discrimination along an underlying – time and place appropriate - scale of economic status (Rutstein et al., 2004).

The asset index can sometimes suffer from an urban bias but the fact that the wealth index used in the thesis analysis also includes rural-type assets (land ownership, livestock ownership) addresses this issue to a large extent. Furthermore, the variation in the indicators included in the wealth index score was not considered to interfere with the internal or external validity of the study, as the objective of this analysis was not to examine between country variation in obesity prevalence by wealth quintile but to examine the inter-relationship between wealth and education in relation to obesity and identify the presence or absence of an interaction between the two in each country.

A limitation of the household wealth index is that it does not take into account an individual's position in the household hierarchy. A young woman may have a lower level of control over household resources and, therefore, less access to food than a man or an older matriarch. However, the index will capture some of the variation between women living in different households and therefore the overall availability and type of food available to a household. In addition, the principal interest in this thesis is to examine the relationship between education and female obesity in contrast to the consistently positive wealth-obesity relationship in women in LMICs.

The wealth index was divided into quintiles (1=poorest; 5=richest). To simplify the presentation of subgroup frequencies in the tables, wealth quintiles were combined to create a poorer group (quintiles 1 and 2) and a richer group (quintiles 4 and 5) with quintile 3 coded as missing so that only the top two and bottom two quintiles are presented in this section. This did not affect the overall pattern observed when all quintiles were used.

4.4.2.1.2 MEDIATORS

Literacy

This reflects skills obtained through education (reading and numerical) which may be measured by direct assessment of the ability to read a page or through self-reporting, although the latter tends to overestimate ability (Howe et al., 2012). In the DHS, the literacy variable is provided as whether the respondent could read 'easily', 'with difficulty' or 'not at all'. This coding was retained for the purposes of the thesis analysis.

Media exposure

Three different media exposure variables were available in the DHS and examined separately. These were frequency of watching television (TV), frequency of newspaper reading, and frequency of radio listening. These were all coded in the original datasets as 'not at all', 'less than once a week', 'at least once a week', 'every day' and recoded into two categories for the purposes of the analysis (<once a week; ≥once a week). The main interest was in TV exposure as this was likely to be the most widespread and effective source of marketing messages for new food products. Newspaper reading and radio listening were examined in addition, as a secondary test of the hypothesised mechanism.

Dietary variables

Two different types of dietary behaviour data were used: 1) the foods that the respondent reported to have consumed themselves in the 24 hours prior to the survey, and 2) the foods which they reported feeding their youngest child. The latter variable was used as an

indicator of the mother's dietary behaviour on the assumption that this might be a sensitive indicator of the mother's overall dietary behaviour and nutritional knowledge. Dietary data were based on a validated individual dietary diversity 24 hour recall questionnaire (see **Appendix C**). The dietary diversity questionnaire for children was based on the one used for adults and the information recorded from the child's mother. The questions put to the respondents were "Did you consume food X in the last 24 hours?" for information on their own diet; and "Did you give your child food X in the last 24 hours?" for information on their child's diet.

The different dietary indicators were examined as separate variables rather than as a dietary score because the interest was in dietary behaviour rather than the type of diet itself. Dietary variables were selected to represent consumption or use of the main food groups: bread, locally grown fruit and vegetables, food rich in fat/oil/butter, meat and fish (protein), and calorie-rich manufactured sweet snacks (chocolate, sweets, biscuits). The meat and fish variables were combined as were the fruit and vegetable variables. Two food groups were of particular interest in this analysis: the consumption of locally grown fruit and vegetables and the consumption of calorie-rich sweet snacks (chocolates, sweets). The reasoning was that the proportion of dietary intake represented by the latter is likely to be sensitive to media exposure and likely to increase, while the former may be consumed less.

4.4.2.1.3 CONFOUNDERS

Confounding factors were incorporated in the regression in accordance with the conceptual model (see **Figure 3.4** in **Chapter 3**). Of note, one of the main challenges of this analysis was to isolate an effect specific to each of education and wealth separately, that is distinct from a general SES effect.

Age group

Age was incorporated as a categorical variable (age groups) in ten year age bands, on account of its biological association with obesity but also account for differences in educational attainment by age group who will have experienced different levels of access to and quality of education.

Parity (number of children)

This is believed to be an important factor related to obesity in LMICs, as women with a greater number of children are more susceptible to excess weight and LMICs have much higher fertility rates than in HICs (Brooks and Maklakov, 2010). This was included in three sub-categories.

Area of residence

This was included as a simple adjustment for environmental exposures and included two categories: urban and rural which were defined according to administrative criteria used in the DHS sampling strategy (Zanati and Egypt).

Respondent's own occupation

The importance of controlling for occupation when examining the effect of education on health outcomes is well-recognised although less important in women compared with men (Bartley, 2004). As women enter the labour force they may rely more heavily on processed or ready-made foods to feed the family and children, and visit restaurants or other prepared food outlets more often, particularly if they live in an urban area. This can lead to an increase in the consumption of energy-dense and nutrient poor foods among the household members. But most of the research on SES and health is conducted in HICs. In LMICs, where formal employment is less widespread among women and where occupational hierarchies are less well defined for research purposes, adjusting for occupation is less important if not methodologically unfeasible

(Howe et al., 2012). In the Egyptian DHS for example, the percentage of women reporting being in work was low in the sample in both periods (<22%) and so it was not included in the main model, but was added in the final analysis for completeness (Chapter 8).

Partner's occupation

In the final part of the analysis (**Chapter 8)**, partner's occupation was also included to account for additional SES effects deemed to be unrelated to the effects of education and wealth under examination in this thesis. The assumption was that a woman with higher education may marry a man with a higher occupational status thereby affording her a higher position in society.

4.3.1.1.1. OTHER VARIABLES

Time period

For the analysis of the SES-obesity association in the two different periods, a variable called 'year' was created to represent the two time periods (1992/95=1; 2005/08=2).

Country level indicators

For the purposes of the country comparison, a number of indicators were compiled mainly from the World Bank development indicators' database (WB, 2012) to frame the discussion of the country comparison analysis. These were selected as markers of the stage of transition in various domains. They included calorie per capita availability (reflecting the nutrition transition stage), health and nutritional outcomes (life expectancy, stunting in children), the availability of advanced electronic goods like mobile phones and services such as the internet (reflecting the increase in information availability and of media exposure), general information about the country (population size, urbanisation), the economy (GNI per capita), as well as indicators that have been linked to population levels of obesity such as foreign direct investment per capita (FDIpc) (Stuckler, 2008, Hawkes, 2005) and socio-economic inequality

(Offer et al., 2010). The indicators were selected from the period 2000-2010 and the most recent figure available used.

4.4.2.2 CHINESE FOUR-PROVINCES (4-P) STUDY

The health and risk factors questionnaire recorded participants' educational level, main occupation, and annual income (Chen et al., 2011b) but household assets were not available in the 4-P study. The variables were originally coded in the same manner as for the DHS analysis, however it became apparent that there were insufficient numbers in the more educated groups resulting in empty table cells for the subgroups. In addition, the preliminary analysis showed that income level had little effect on obesity (and later analysis confirmed that this was the case before and after imputation of missing data). There was no association between income and waist circumference, income had little impact on the estimates, and likelihood ratio testing showed that the model fit was not improved by the addition of this variable.

As a result, an alternative to the income and wealth measures were considered. It has been argued that occupation can be a better indicator of material circumstances than income (Davey Smith et al., 1998) which, as discussed above, is considered unreliable in LMICs (Howe et al., 2012). Therefore, occupation may arguably be more closely correlated with the wealth indicator used in the DHS. Furthermore, the use of occupational category as an indicator presented an opportunity to model an important aspect of the economic transition in China from an agricultural to a non-agricultural based economy. The analysis controlled for urban/rural residence, which is likely to be highly correlated with occupation, and examined the impact of this on the estimates.

Changes in material circumstances resulting from the transition could be captured at individual level in a relevant manner by examining differences between those working in agriculture as peasants and those working in non-agricultural (factory- and service-based) occupations, since many people in China have moved from peasant work to jobs in the

manufacturing and service sectors (Schooling et al., 2010, Wang et al., 2007, Nee and Young, 1991). Therefore, occupation category was chosen as an alternative measure of material circumstances and a proxy for the capacity to purchase and consume obesogenic foods for the analysis of the Four-Provinces data.

Education level

The education variable was simplified to two levels as a result of the large number of women with no education and the relatively small number of women with primary, secondary or higher education: no education=0, any education=1, as discussed above (see education variable description under the DHS section).

Occupational status

Occupational status was based on the participants' longest employment and divided into: agricultural=0; non-agricultural=1 (including manual worker, official, teacher and business person). A total of N=399 women whose occupation was housewife were removed from the sample as it was not possible to classify them within the agricultural/non-agricultural categories.

Confounders

Age was categorised into ten year age bands (60-69yrs=1; 70-79yrs=2; 80+=3). **Area of residence** was based on the administrative definition used to design the sample frame (urban/rural) and number of children or **parity** was divided into 0, 1-3 and 4+. As in the analyses of the DHS data, area of residence was used as a crude indication of the contribution of environmental factors to the association between individual level occupation and central obesity. This would not necessarily result in over-adjustment of the estimates for the occupation-obesity association, since a proportion of the participants recorded as currently residing in urban areas had also reported 'peasant' as their longest occupation.

4.5.1 INTERACTION ANALYSIS

To examine the main hypothesis of whether education level modified the association between wealth and obesity, interaction terms between education and wealth were fitted in a logistic regression model. Both the unadjusted odds ratio (OR) between each SES indicator and obesity outcome, as well as the OR adjusted for age group, parity and area of residence were estimated in each time period and each country in the thesis analysis, to examine how the associations have changed over time and by country level of economic development. Frequency tables to illustrate the participant characteristics and the prevalence of obesity by characteristic are presented as part of the data exploration.

The interaction term was examined for significance using Likelihood Ratio (LR) tests, comparing the model without an interaction term nested within the model with the interaction term. In the initial analyses, it became apparent that the time period variable was a strong effect modifier of the SES–obesity relationship, supporting the hypothesis that the associations between each of education and wealth and obesity differed by time period: the *P*-values for the tests of interaction between each of education level and wealth quintile and the time period variable were highly significant ($P<0.0001$ - unadjusted and adjusted estimates). On this basis, all the analyses were performed separately for each of the two time periods. For the country comparison the country-specific results are compared with each other and with Egypt, and compiled in the tables according to their level of GNI per capita (GNIpc). The prevalence of obesity in each country was plotted against its GNIpc to examine the correlation between the two.

The interaction results were compiled based on recommendations by Knol et al., to present both the separate and joint effects of the two interacting factors (Knol et al., 2011). First, the wealth trend (effect on the odds of obesity associated with each one quintile increase in wealth) was estimated in the no/primary education group using the wealth quintile variable in its

continuous form. Then, using the interaction terms for wealth by education, the wealth trend in the group(s) with a higher level of education was calculated to test the hypothesis that education level modifies the effect of wealth. Similarly, using the China 4-P data, the model including the occupation by education interaction term was used to estimate the effect of occupation (non-agricultural *vs.* agricultural) in the group with no education. Then, using the interaction term, the effect of occupation was calculated for the group with education, thus describing how education modifies the association between occupation and central obesity.

4.5.2 MEDIATION ANALYSIS

Mediation of the postulated education and wealth effects on obesity was assessed using an analytic strategy devised within the limitations of the data to test the model shown in **Figure 3.4**. First, literacy was examined as an indicator of cognitive skills and a mediator of the education effect. Second, media exposure and dietary behaviour were incorporated in the regression model including the education by wealth interaction term, and the impact of this on the joint effect estimates of wealth and education level on obesity assessed.

4.5.2.1 LITERACY AS A MEDIATOR

As a test of the hypothesis that education has a protective effect against obesity through cognitive skills, literacy was expected to be a mediator of the modifying effect of education. Therefore, it would be expected that it should interact with wealth in a similar manner to education and that substituting the literacy variable for education in the main model including the wealth by education interaction would result in a similar pattern of results. The relationship between education and literacy was also examined through a cross-tabulation of these two variables.

4.5.2.2 MEDIA EXPOSURE AS A MEDIATOR OF THE WEALTH BY EDUCATION INTERACTION ON OBESITY

TV viewing was the main media exposure of interest and it was expected that the estimates for the association between wealth and TV exposure would be attenuated with higher education levels. In addition, the modifying role of education on the wealth-media association was examined with the expectation that education may have different modifying effects (either augmentation or attenuation) depending on the media exposure.

If a statistically significant interaction term was found between education and TV exposure, it was incorporated into the main interaction model (wealth by education on obesity). Changes in the magnitude of the joint effect estimates for wealth by education level on obesity following the incorporation of this additional term were examined and the two models compared using likelihood ratio (LR) testing.

4.5.2.3 DIETARY BEHAVIOUR AS A MEDIATOR OF THE WEALTH BY EDUCATION INTERACTION ON OBESITY

The use of sweet snacks and consumption of fruit and vegetables in response to TV exposure were the main relationships of interest. It was expected that the estimates for the TV-sweet snack consumption association would be attenuated with higher education while the TV-fruit and vegetable consumption association would be augmented with higher education.

In the examination of the dietary variables, less attention was paid to *P*-values of the LR test and more to the effect estimates, in view of the much lower power available in this smaller dietary sample. As above, any statistically significant interaction term was incorporated into the main interaction model (wealth by education on obesity) and changes in the magnitude of the joint effect estimates for wealth by education level on obesity following the incorporation of additional terms examined.

4.5.2.4 FULL MODEL FOR THE INTERACTION BETWEEN EDUCATION AND WEALTH INCORPORATING MEDIA EXPOSURE AND DIETARY BEHAVIOUR

A final model was run incorporating all statistically significant interaction terms found in the above two analysis stages into the original interaction model (wealth by education on obesity). Changes in the magnitude of the association between wealth and obesity by education level were examined and models compared using likelihood ratio (LR) tests.

As the subsample for the dietary questionnaire was smaller, the final models described were run again in this subsample to assess differences with the findings from the larger sample. In this model, the absence of statistical significance for an interaction between education and wealth was expected due to the small sample size, however the interaction term was retained in the model on the basis that this absence was a power issue only. In addition, due to the smaller dietary sample, it was expected that the estimates would lack precision and, therefore, that the impact of the addition of the mediator variables would not be detectable in terms of statistical significance. However, the estimates in this smaller sample were expected to have a similar magnitude to those seen with the larger sample.

Finally, the impact of the respondent's occupation and partner's occupation as confounders was examined by adding these variables to the final mediation model in the dietary subsample only.

4.5.3 POST-ESTIMATION USING OBSERVED ODDS

The observed odds were used to illustrate the interaction fully in a graph where an interaction was identified. The graph plots the observed log odds of obesity calculated for each combination of education level and wealth quintile using the category 'education level=none/primary and wealth quintile=poorest' as the referent. This estimation was performed using logistic regression by fitting a dummy variable for all the different combinations of education level and wealth quintile, to produce the log ORs adjusted for age group, parity and area of residence. Potential multicollinearity between the covariates used in the multivariate

regression model for the first model (Egyptian DHS) was assessed using variance inflation factors. Similarly, with the Chinese 4-P data, the odds of central obesity were calculated for each combination of education level and occupation relative to the odds in the referent category ‘education level=none and occupation=agricultural using a dummy variable created by combining the different levels to create the four different combinations of educational and occupational level.

4.5.4 USE OF SURVEY WEIGHTS

The DHS are based on a complex design and requires the use of sample weights provided with the datasets to obtain nationally representative estimates. The application of the weights accounts for the oversampling used to fulfil the purposes of the survey in providing reliable estimates in core health domains and the unequal probability of household selection in the sample (DHS, 2003, 1996). The weights are provided with the survey data and their calculation described in the DHS manuals as follows below.

The weights are standardised by dividing each weight by the average of the initial weights. This is equal to the sum of the initial weights divided by the sum of the number of cases. As a result, the sum of the normalised/standardised weights is equal to the sum of the cases over the entire sample. The entire set of household/individual sample weights is multiplied by a constant, and therefore, the total weighted number of households/individuals is equal to the total unweighted number of households/individuals at the national level (DHS, 2012). As the estimates of interest in this thesis are at individual level, the individual weight variable for women (v005) was used. The weights are not adjusted for non-response or post-stratification.

Appropriate methods for complex survey data analysis were used in accordance with up to date statistical knowledge derived from Heeringa et al.'s approach (Heeringa et al., 2010). It is generally accepted, that survey weights should be applied in all frequency tabulations to reduce bias in the estimates. There is lower consensus over the application of weights to the analysis of associations using regression techniques. This is because both the design-based approach (the application of weights) and the model-based approach (specifying regression model variables to best explain the outcome variance) have advantages and disadvantages.

It is considered acceptable to compare both approaches during the preliminary analysis and to compare estimates for the standard errors and the magnitude of the estimates. If the magnitude of the main estimates is similar for the two methods, and particularly if standard errors are comparable then the regression model is considered to be well specified and can be used without the application of survey weights (Heeringa et al., 2010). The latter was the case in the thesis analyses and, therefore, a combination of a design-based approach for the frequencies' tabulation and a model-based approach for the logistic regression was used in all DHS analyses in this thesis.

The STATA 12 SE® survey commands (svy) were used to compute frequencies that take the complex design effect into account including the effect of clustering and of unequal weights. For the analysis over two time periods in Egypt, sampling characteristics and the prevalence of obesity by subgroup were estimated in both periods, and a chi-squared-based test, that takes the design effect into account, used to compare the differences between the two periods (Heeringa et al., 2010).

4.5.5 MISSING DATA AND IMPUTATION

The sample size obtained from the Chinese Four-Provinces study was relatively small compared with the DHS datasets and there was a concern over the power of the sample to

examine interactions. Therefore, data missingness in the 4-P study was investigated, comparing the sample of women who were complete cases with and without anthropometric data (N=1928 *vs* N=79 respectively). Chi-squared tests showed statistically significant differences for almost all the covariates to be included in the regression model. Thus, a decision was made to impute the missing data.

The STATA 12SE® chained equations command was used. The imputation procedure was performed using all the variables to be incorporated in the final model including education, occupation, age group, parity, area of residence and waist circumference (WC) group. A marital status variable available in the datasets was investigated as an auxiliary variable in the imputation, but was discarded as there was no correlation with central obesity in a multivariate model with missing/non-missing WC data as the outcome. All analyses were conducted comparing both the original and the imputed dataset.

4.6 ETHICAL REVIEW

The use of the DHS data for the analyses in this thesis is approved by Measure DHS. The use of the Four-Provinces data was approved by Dr Ruoling Chen who holds the datasets at King's College London. The research in this thesis was considered exempt from full review by University College London because the study is based on an anonymous, public-use datasets with no identifiable information on the survey participants. Demographic and Health Surveys (DHS) data collection procedures are approved by Measure DHS (Demographic and Health Surveys) (Calverton, MC) Institutional Review Board. Both the DHS and the Chinese Four-Provinces study are approved by the national bodies that approves research studies on human studies in the respective countries, and written consent was obtained by the interviewers from each participant.

Table 4.1 Summary of the variables used in the analysis.

Concept	Dimension measured	Variable	Category	Coding
Material circumstances	Ability to spend and consume	Wealth (asset based score; divided into quintiles)	Main exposure	1=poorest; 2=poorer; 3=middle; 4=richer; 5=richest (DHS)
Material circumstances	Ability to spend and consume	Occupation	Main exposure	1=agricultural; 2=non-agricultural (4-P)
Media exposure	Exposure to advertising for consumer products (energy-dense foods). May also be a source of health information and reduce energy expenditure through prolonged sitting)	Media exposure (TV, newspaper, radio)	Mediator	Binary (<once a week=1; ≥once a week=2) for TV watching; newspaper reading; radio listening; and a combined variable using all three
Area of residence	Environmental factors (food availability, opportunities for physical activity)	Area of residence	Confounder of SES-obesity association	1=urban; 2=rural
Age group	Age related obesity risk (risk increases with age)	Age group	Confounder of SES-obesity association	1=15-24; 2=25-34; 3=35-49yrs (DHS); 1=60-69; 2=70-79; 3=80+ yrs (4-P);
Number of children	Parity related risk of obesity (risk increases with the number of children	Number of children	Confounder of SES-obesity association	1=none; 2=1-3; 3=4+ children (DHS); 1=0; 2=1-3; 3=4+ children (4-P):
Education	Cognitive skills and the ability to make decisions that promote own health	Educational level	Effect modifier	1=none/primary; 2=secondary; 3=higher
Dietary behaviour (1)	Dietary behaviour of mother	Food consumed by respondent in last 24 hours	Mediator of wealth-obesity association	Binary (1=no; 2=yes)
Dietary behaviour (2)	Dietary behaviour of mother (through child)	Food given to youngest child under 3 years in the last 24 hours	Mediator of wealth-obesity association	Binary (1=no; 2=yes)
Literacy	Measure of ability to absorb and interpret information to one's health benefit	literacy	Mediator of education	1=can't read; 2=can read with difficulty; 3=can read easily
Physical activity	Measure of physical energy expenditure	Own occupation (crude proxy)	Confounder of media-obesity association	1=agricultural; 2=non-agricultural (service/sales/skilled manual/professional); 3=unemployed
SES	Measure of a woman's status in society	Husband's occupation	Confounder of wealth/education-obesity association	1=agricultural; 2=manual 3=non-manual (services/sales/clerical/professional)

5 CHAPTER 5: THE ASSOCIATION BETWEEN EDUCATION, WEALTH AND OBESITY - PERIOD DIFFERENCES IN EGYPT

The analysis presented in this chapter addresses the first set of objectives and particularly objective 1a - to examine period differences in the association between each of education and material circumstances and obesity. Using repeat cross-sectional data for women over a period of rapid economic growth in Egypt (1992-2008), the analysis begins to investigate the reversal of the social gradient of female obesity including the relationship between two of its components. The hypotheses set out under objective 1a are tested including (1) that the SES-obesity association reverses over time as countries undergo economic development; (2) that the reversal differs by SES indicator are tested; and (3) that if wealth has an obesogenic effect, education might protect against this or, in other words, that education level might modify the association between wealth and obesity.

5.1 RESULTS

Table 5.1 shows details of the sample selection process and how the final analytic sample used in the regression models was derived, as described in the Data and Methods chapter. The overall prevalence of obesity was 21.5% (S.E.: 0.8) in the 1992/95 sample and 32.0% (S.E.:0.9) in the 2005/08 sample (see **Table 5.2**). Over 90% of the women in the sample were married.

Table 5.1 Details of the sample selection from the total number of women eligible for interview. Egyptian DHS 1992/95 and 2005/08.

Number of women	**1992/95**	**2005/08**
Total survey sample		
Eligible for interview	24857	39304
Interviewed (response rate)	24643 (99%)	38442 (>99%)
Anthropometry sample		
Eligible (ever-married + birth in previous 5yrs)	13752	18056
Full anthropometry (% missing)	13223 (<4%)	17878 (<1%)
Removed because pregnant	1588	1784
Removed because of missing covariates	7	0
Final analytic sample	*11628*	*16094*

5.1.1 SOCIODEMOGRAPHIC CHARACTERISTICS AND OBESITY PREVALENCE

Table 5.2 shows that the age group distribution was comparable in both periods but the sample was generally younger in the 2005/08 period. Women in the 2005/08 sample were more educated and had lower parity, but similar proportions resided in urban and rural areas in both time periods. The distribution of wealth by education group also remained very similar over time with wealth being concentrated in the more highly educated. Spearman rank correlation coefficients between education and wealth were 0.56 and 0.57 in the 1992/95 sample and the 2005/08 sample respectively.

5.1.1 TRENDS IN OBESITY PREVALENCE

Table 5.3 shows the prevalence trends in obesity across the socio-demographic characteristics. The prevalence of obesity was significantly greater in most of the subgroups in the 2005/08 sample. The largest absolute increase in prevalence over time occurred in those who were less educated, poorer and living in rural areas.

The absolute increase in prevalence percentage points was 10.9 in women with no/primary education, 13.4 in the poorest wealth quintile, and 14.6 among rural residents respectively ($p<0.001$ for all three estimates). There was an appreciably lower increase in those who were more educated, richer and urban dwelling: the absolute increase was of 4.7, 3.8 and 5.6 percentage points in the highest educated, richest, and urban dwelling respectively. The largest period difference in obesity prevalence was observed in those with the highest parity (≥7 children) with an absolute difference of 17.9 percentage points (S.E.: 2.4) between the two time periods in this group. For the 1992/95 time period, there were only three women with higher education who were in the two poorest wealth quintiles, therefore no prevalence calculation was made for two poorest quintiles.

Table 5.2 Participant characteristics – Egyptian DHS 1992/95 and 2005/08.

	1992/95		2005/08		Absolute difference[1]	
	N=11628		N=16094			
	Total N	% (SE)	Total	% (SE)	% (SE)[2]	P-value[3]
BMI (kg/m^2)						
Non-obese (BMI<30)	9178	78.3 (0.8)	11179	68.0 (0.6)	-10.5 (0.9)	<0.001
Obese BMI (≥30)	2450	21.5 (0.8)	4915	32.0 (0.6)	10.5 (0.9)	<0.001
Education						
None/primary	8007	68.5 (1.1)	6726	40.0 (0.8)	-28.5 (1.3)	<0.001
Secondary	3057	26.1 (0.8)	7658	48.3 (0.7)	22.2 (1.1)	<0.001
Higher	564	5.3 (0.5)	1710	11.6 (0.5)	6.3 (0.6)	<0.001
Area of residence						
Urban	4688	41.7 (2.2)	6132	38.3 (1.5)	-3.4 (2.3)	0.2
Rural	6940	58.3 (2.2)	9962	61.7 (1.5)	3.4 (2.3)	0.2
Age group (years)						
15-24	2663	23.1 (0.6)	4212	26.3 (0.4)	3.2 (0.7)	<0.001
25-34	5912	51.4 (0.6)	8515	53.4 (0.5)	2.0 (0.8)	0.01
35-49	3053	25.5 (0.5)	3367	20.3 (0.4)	-5.1 (0.6)	<0.001
Parity						
1-3	6058	54.0 (0.8)	11330	72.7 (0.5)	18.7 (0.9)	<0.001
4-6	3602	30.7 (0.5)	3836	22.6 (0.4)	-8.1 (0.7)	<0.001
7+	1968	15.4 (0.5)	928	4.7 (0.2)	-10.6 (0.6)	<0.001
Wealth by education level						
None/primary						
Poorer 40%	5208	78.9 (1.5)	4804	83.0 (1.0)	4.1 (0.2)	0.02
Richer 40%	1211	21.1 (1.5)	761	17.0 (1.0)	-4.1 (0.2)	0.02
Secondary						
Poorer 40%	487	20.8 (1.7)	2098	33.7 (1.2)	12.9 (2.0)	<0.001
Richer 40%	1849	79.1 (1.7)	3628	66.3 (1.2)	-12.9 (2.0)	<0.001
Higher						
Poorer 40%	3	0.3 (0.2)	74	4.2 (0.7)	3.9 (0.7)	<0.001
Richer 40%	521	99.7 (0.2)	1481	95.6 (0.7)	-3.9 (0.7)	<0.001

[1] Difference in prevalence between the two time periods ($prevalence_{(2005/08)} - prevalence_{(1992/95)}$).
[2] Taylor-Linearised SE estimated taking the design effect into account
[3] P-value based on chi-squared test taking design effect into account

Table 5.3 Prevalence of obesity by socio-demographic subgroup, Egyptian DHS 1992/95 and 2005/08.

	1992/95		2005/08		Absolute difference[1]	
	N=11628		N=16094			
	N obese	% (SE)	N obese	% (SE)	% (SE)[2]	P-value[3]
Education						
None/primary	1472	18.8 (0.8)	1857	29.7 (0.9)	10.9 (1.1)	<0.001
Secondary	796	26.4 (1.2)	2445	32.8 (0.8)	6.4 (1.4)	<0.001
Higher	182	32.1 (2.3)	613	36.8 (1.6)	4.7 (2.8)	0.09
Wealth quintile						
Poorest 20%	225	7.6 (0.6)	722	21.0 (1.0)	13.4 (1.1)	<0.001
Poorer 20%	403	14.2(0.9)	872	26.6 (1.0)	12.4 (1.3)	<0.001
Middle 20%	502	22.2 (1.0)	1054	33.5 (1.1)	11.4 (1.5)	<0.001
Richer 20%	647	33.8 (1.4)	1149	38.2 (1.2)	4.4 (1.8)	0.02
Richest 20%	673	40.4 (1.6)	1162	40.8 (1.3)	3.8 (2.0)	0.9
Area of residence						
Urban	3238	32.4 (1.1)	2303	38.0 (0.9)	5.6 (1.4)	<0.001
Rural	1377	13.8 (0.7)	2612	28.3 (0.8)	14.6 (1.0)	<0.001
Age group (years)						
15-24	260	10.4 (0.9)	750	18.4 (0.8)	8.0 (1.2)	<0.001
25-34	1248	21.6 (0.9)	2668	32.5 (0.8)	10.9 (1.1)	<0.001
35-49	942	31.5 (1.3)	1541	48.4 (1.1)	16.9 (1.6)	<0.001
Parity						
1-3	1124	19.4 (0.9)	3119	29.0 (0.7)	9.6 (1.1)	<0.001
4-6	875	24.5 (1.1)	1438	40.1 (1.1)	15.2 (1.5)	<0.001
7+	451	22.4 (1.3)	358	40.3 (2.0)	17.9 (2.4)	<0.001
Wealth by education level						
None/primary						
Poorer 40%	577	10.8 (0.6)	1124	24.8 (0.9)	14.0 (1.0)	<0.001
Richer 40%	516	42.1 (1.7)	332	44.4 (2.1)	2.3 (2.8)	0.4
Secondary						
Poorer 40%	51	11.0 (1.8)	433	21.4 (1.1)	10.5 (2.1)	<0.001
Richer 40%	633	34.6 (1.5)	1420	39.3 (1.1)	4.7 (1.8)	0.008
Higher						
Poorer 40%	0	[4]	20	27.2 (5.5)	-	-
Richer 40%	171	31.8 (2.4)	540	37.1 (1.7)	5.2 (3.0)	0.09

[1] Difference in prevalence between the two time periods ($prevalence_{(2005/08)} - prevalence_{(1992/95)}$).
[2] Taylor-Linearised SE estimated taking the design effect into account
[3] P-value based on chi-squared test taking design effect into account
[4] There are only three women in this group so no estimate of prevalence is given.

5.1.2 THE SEPARATE AND JOINT EFFECTS OF EDUCATION AND WEALTH ON OBESITY IN THE TWO TIME PERIODS

The top half of **Table 5.4** shows the relationship between the SES indicators and obesity defined as a binary outcome, displaying separate effects for education and wealth (unadjusted and adjusted for age group, parity and area of residence). There was a positive association between age group and obesity as expected (not shown).

The unadjusted ORs indicated a positive association between each of education and wealth and obesity in the 1992/95 sample. For example, the unadjusted odds ratio comparing the higher education group with the group with no/primary education was 2.11 (95%CI: 1.75, 2.54), and the odds of being obese increased by 1.67 times for each increase of one wealth quintile (95%CI: 1.63, 1.75). Adjustment for age group, parity and area of residence diminished the magnitude of the estimates for education (OR; 95%CI: 1.32; 1.08, 1.63 for the higher education group relative to the group with no or primary education), but had little effect on the wealth estimate. In the 2005/08 sample the associations between each of education and wealth and obesity remained positive but were of smaller magnitude.

Figure 5.1 plots the log OR for obesity for each combination of education and wealth quintile. No points are plotted in 1992/95 for the two poorest groups in the higher education category as there were only three women in these groups (see **Table 5.3**). The pattern appears to be consistent in both time periods and shows a positive association between wealth and obesity in the group with no/primary education and a similar but diminished positive association in the group with secondary education. The group with higher education shows a much shallower relationship of obesity with wealth quintile. At the higher end of the wealth distribution (quintile 5 on the x-axis) education appears to have a protective effect (a high education-low obesity association; *P* for trend <0.001). There is little evidence of an association between education and obesity in the other wealth quintiles (*P* for trend not significant). The graph suggests that the effects of wealth quintile on obesity would be reasonably well described by fitting wealth as a continuous variable.

Table 5.4 Separate and joint effects of education and wealth on obesity, Egyptian DHS 1992/95 and 2005/08

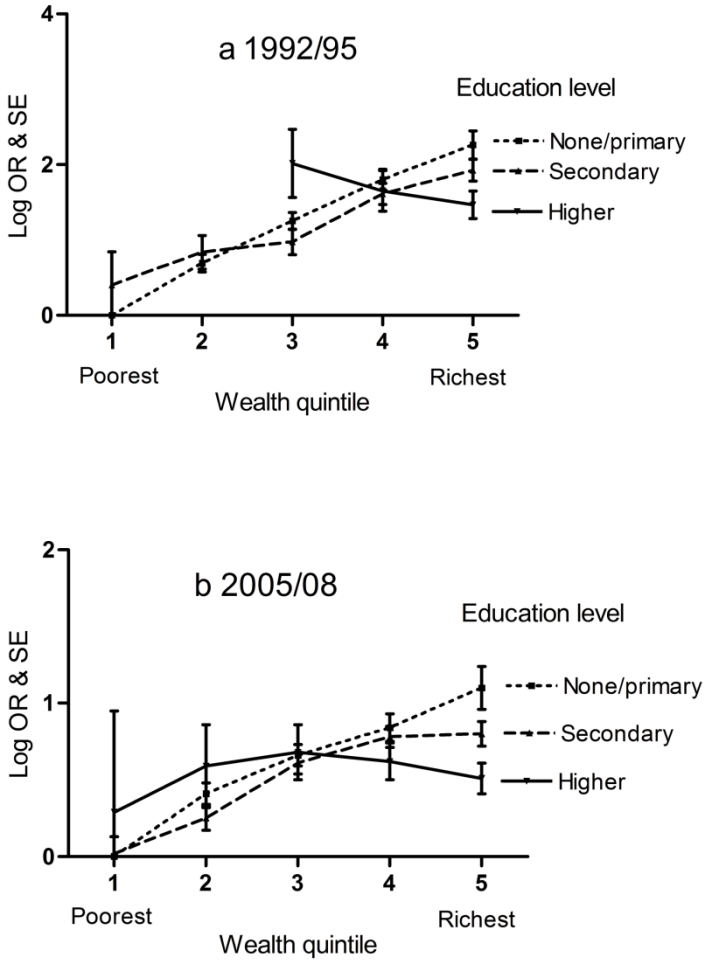
	1992/95 (N=11650)				2005/08 (N=16138)			
	Unadjusted OR		Adjusted OR[1]		Unadjusted OR		Adjusted OR[1]	
	OR	95%CI	OR	95%CI	OR	95%CI	OR	95%CI
Separate effects								
Education (level)								
None/primary	1		1		1		1	
Secondary	1.56	(1.42-1.73)	1.47	(1.30-1.65)	1.23	(1.14-1.31)	1.37	(1.27-1.49)
Higher	2.11	(1.75-2.54)	1.32	(1.08-1.63)	1.46	(1.31-1.64)	1.31	(1.15-1.49)
Wealth quintile (linear)	1.67	(1.63-1.75)	1.67	(1.59-1.75)	1.30	(1.26-1.33)	1.29	(1.25 -1.33)
Joint effects (wealth trend within education levels)[2]								
Education (level)								
None/primary			1.81	(1.70-1.91)			1.38	(1.31-1.45)
Secondary			1.56	(1.42-1.70)			1.28	(1.21-1.33)
Higher			1.09	(0.82-1.49)			1.02	(0.91-1.15)
P-value for interaction[3]			<0.001				<0.001	

[1] Adjusted for age group, area of residence, and parity

[2] Odds ratio of obesity associated with an increase in one wealth quintile in each education group estimated from the model including an interaction between education and wealth (estimates adjusted for age group and area of residence).

[3] *P*-value from the LR test for an interaction between education level and wealth quintile in its continuous form.

Figure 5.1 Interaction between women's education level and household wealth on obesity. Egyptian DHS a. 1992/95; b. 2005/08.



Each point represents the log OR of that combination of education level and wealth quintile compared with the reference category (education level=none/primary and wealth quintile=poorest). Error bars represent the standard error of the log OR. All plotted estimates are adjusted for age group, area of residence and parity.

The lower part of **Table 5.4** displays the results for the regression model including the interaction term between education level and wealth quintile in its continuous form. The LR test for whether the model fit was better with or without an interaction between education level and the linear wealth quintile variable provided strong evidence of an interaction (P<0.001 in each period). The variance inflation factors for the covariates ranged between 1.0-2.5 in both the 1992/95 and 2005/08 samples indicating multicollinearity was not a concern.

The joint effect estimates showed a strong positive association between wealth and obesity in the no/primary education group and the secondary education group, but no association in the group with higher education. In the earlier sample (1992/95) moving up one wealth quintile was associated with an 81% increase in the odds of obesity (OR; 95%CI: 1.81; 1.70, 1.91) for women with the lowest level of education (none/primary); a 56% increase in the group with secondary education (OR; 95%CI: 1.56; 1.42-1.70); while for women with the highest level of education, there was no evidence of an association (OR; 95%CI: 1.09; 0.82, 1.49).

The results for the 2005/08 sample were similar but attenuated: moving up one wealth quintile was associated with a 38% increase in the odds of obesity (OR; 95% CI: 1.38; 1.31, 1.45) in the lowest level of education (none/primary); a 28% increase (OR; 95% CI: 1.28; 1.21-1.33) in the group with secondary education; while in the highest level of education, there was no evidence again of an association between wealth and obesity (OR; 95%CI: 1.02; 0.91, 1.15). While the association between each of education and wealth and obesity has not reversed, the attenuation of the OR estimates over time suggests the association is flattening – a stage that precedes the full reversal to a negative association between the SES indicators and obesity.

5.1.3 SENSITIVITY ANALYSES

The analyses were repeated in the 2005/08 sample to expand the sample to include all ever-married women (not just those with under-5 year old children). This showed that the results were similar in both samples. The interaction model was a better fit than the model without the interaction in both samples; and the magnitude of the stratum specific estimates calculated using the interaction term were similar (see Table 5.5). This, therefore, suggested that the results of this analysis are generalisable beyond women with young children to all women of reproductive age in Egypt. In light of this, the larger, unrestricted sample was used for the analysis comparing Egypt with other countries in the next chapter.

Some authors have suggested that logistic regression is unsuitable for use when the outcome prevalence is common (>10%), proposing a modified Poisson or log binomial model instead (Zou, 2004). In this analysis, logistic regression was deemed the most appropriate method because of the cross-sectional nature of the data, and the ease of comparison with other studies (Bieler et al., 2010). However, the model using the modified Poisson and log binomial models preserved the interaction results (both the direction of the associations and their statistical significance). Finally, as individual respondents may occasionally live in the same households, there could be an argument for adjusting for intra-household clustering. An alternative model was specified and fitted to produce Huber-White robust standard errors taking this clustering into account. There was little impact on the estimates or the standard errors.

N.B. The results from all the empirical chapters (5-8) are summarised and interpreted in Chapter 9.

Table 5.5 Separate and joint effects of education and wealth on obesity comparing the restricted sample of ever-married women with children and the full sample of all ever-married women, Egyptian DHS 2005/08

		2005/08 (N=16138)				**2005/08 (N=32272)**			
		Unadjusted		Adjusted[a]		Unadjusted		Adjusted[1]	
		OR	95%CI	OR	95%CI	OR	95%CI	OR	95%CI
Separate effects									
Education (level)									
	None/primary	1		1		1		1	
	Secondary	1.23	(1.14-1.31)	1.37	(1.27-1.49)	0.94	(0.90-0.99)	1.19	(1.13-1.26)
	Higher	1.46	(1.31-1.64)	1.31	(1.15-1.49)	1.06	(0.98-1.15)	1.02	(0.93-1.11)
Wealth quintile (linear)		1.30	(1.26-1.33)	1.29	(1.25 -1.33)	1.28	(1.26-1.30)	1.26	(1.23-1.29)
Joint effects (wealth trend within education levels)[2]									
Education (level)									
	None/primary			1.38	(1.31-1.45)			1.39	(1.35-1.43)
	Secondary			1.28	(1.21-1.33)			1.25	(1.21-1.29)
	Higher			1.02	(0.91-1.15)			1.02	(0.93-1.13)
P-value[3]				<0.0001					<0.0001

[1] Adjusted for age group, area of residence, and parity
[2] Odds ratio of obesity associated with an increase in one wealth quintile in each education group estimated from the model including an interaction between education and wealth (estimates adjusted for age group and area of residence)
[3] *P*-value from the LR test for an interaction between education level and wealth quintile in its continuous form

6 CHAPTER 6: THE ASSOCIATION BETWEEN EDUCATION, WEALTH AND OBESITY - DIFFERENCES BY LEVEL OF ECONOMIC DEVELOPMENT

This chapter continues the investigation of the reversal of the SES-obesity gradient in women in low-income settings using a sample of cross-sectional studies from different low- and middle-income countries. Together with the next chapter, it addresses objective 1b of the thesis: to examine differences in the association between each of education and material circumstances in relation to obesity by level of economic development. The analysis tests the hypotheses that the SES-obesity association reverses over time as countries undergo economic development and that the reversal differs by SES indicator, as well as the main hypothesis that education might modify the obesogenic effect of improved material circumstances (proxied by household wealth). The analysis also serves to investigate whether the findings from the previous chapter are reproducible in countries other than Egypt. The methods used in the survey conducted in China are different to the DHS, therefore, the Chinese study is described in a separate chapter to enable a detailed account of these analyses.

6.1 RESULTS

The six countries selected for the analysis on the basis of the sampling strategy described in **Chapter 4** were Benin, India, and Nigeria (low-income[6]), Colombia, Jordan, and Peru (upper-middle-income), alongside Egypt (lower-middle-income).

Table 6.1 details each country sample and how the analytic sample for each country was derived. Response rates were high and few covariates were missing except in the Colombian sample (7.6% of covariates were missing in the sample of women with full anthropometry). Most women had been married, but there was notable variation in occupation levels between the countries. A greater proportion of women reported not working in the low-income countries and in Jordan, and of those who worked in low-income countries, a greater

[6] Nigeria and India are currently classified as lower-middle-income countries following their reclassification in the World Bank's 2010 global assessment, but they were classified as low-income countries at the time of the DHS surveys included in this analysis.

proportion worked in the agricultural sector, except for Benin where a relatively large proportion of women worked in sales/services for its level of economic development.

6.1.1 DEVELOPMENT AND OTHER COUNTRY INDICATORS

The development indicators in **Table 6.2** and **Table 6.3** broadly reflect the level of economic development of each country as captured by the GNI per capita measure (GNIpc). Countries with a higher GNIpc had higher levels of urbanisation, a higher Human Development Index, longer life expectancy, lower total fertility rate, lower under-5 mortality, and higher literacy and tertiary school enrolment rates. Patterns of inequality were not as straightforward. Colombia and Nigeria had high levels of poverty and inequality, while Jordan displayed low levels of poverty and inequality relative to the other countries in the sample.

In terms of nutritional indicators, the patterns were also less predictable. Peru resembled the low-income countries (higher carbohydrate, lower protein and lower fat content of the diet, as well as lower calorie per capita consumption compared with the middle-income countries), while Nigeria resembled the middle-income countries. Egypt and Benin had high calorie availability relative to their level of economic development, with Egypt being the only country of the entire sample to have in excess of 3000 calories available per capita. Low-income countries had higher levels female underweight and childhood stunting and lower levels of female obesity. The prevalence of childhood overweight was surprisingly high in Egypt (21%), Benin and Nigeria (both 11%).

Table 6.1 Sample details by economic classification at the time of the DHS survey for each country included in the analysis.

	Benin	India	Nigeria	Egypt	Jordan	Peru	Colombia
GNIpc at time of survey ($)[1]	590	720	1170	1250/1880	3110	3590	5510
Income classification[2]	LI	LI	LI	LMI	UMI	UMI	UMI
DHS Year	2006	2005	2008	2005/08	2007	2008	2010
Number of women interviewed	17794	124385	33558	36045	10876	16159	53320[3]
Response rate of women eligible for interview	94	95	97	>99	98	98	94[3]
Women with complete anthropometry	16717	118734	32358	35690	5196[4]	15228	49637
Missing covariates (% of anthropometry sample)	0	<0.01%	0	0	0	0	7.6%
Final analytic sample [5](figures below relate to this sample)	14883	113063	28901	32272	4527	14483	47709
Women reporting being married/formerly married (%)	80.0	79.5	74.8	>80	100	65.2	63.8
Women reporting being in work	81.3	44.6	62.6	20.6	11.5	75.1	77.4
Women employed in agriculture (% of working women)	35.8	58.9	24.4	21.2	0.3	33.4	5.0
Women employed in sales/services (% of working women)	51.3	10.6	52.1	17.9	5.2	25.1	69.4
Women in professions/management (% of working women)	2.0	6.3	6.9	39.2	75.4	15.1	9.3

[1] GNIpc in $ using Atlas method at time of survey, World Bank classification. <http://tinyurl.com/3bpg77q >

[2] World Bank income classification. <http://data.worldbank.org/about/country-classifications> and notes http://tinyurl.com/cnhf9aw. LMI=lower-middle-income; LI=low-income; UMI=upper-middle-income

[3] Includes women 13-49 years (the rest of the figures for Colombia are for women 15-49 years)

[4] Anthropometry collected in half of the household sample

[5] Excludes pregnant women; includes missing covariates

Table 6.2 General development, economic and education indicators by country.

	Benin	India	Nigeria	Egypt	Jordan	Peru	Colombia
Population, total (millions)	8.9	1224.6	158.4	81.1	6.1	29.1	46.3
General development and health indicators							
GNI per capita, Atlas method (current US$) – used in the Monteiro model	780	1270	1230	2420	4340	4700	5510
GNI per capita, PPP (current international $)- reflects living standards	1590	3400	2240	6060	5800	8930	9060
Human Development Index	0.4	0.5	0.5	0.6	0.7	0.7	0.7
Urban population (% of total)	42.0	30.0	50.0	43.0	79.0	72.0	75.0
Urban population growth (annual %)	4.0	2.0	4.0	2.0	2.0	1.0	2.0
Mobile cellular subscriptions (per 100 people)	80.0	61.0	55.0	87.0	109.0	100.0	96.0
Life expectancy at birth, total (years)	56.0	65.0	51.0	73.0	73.0	74.0	73.0
Fertility rate, total (births per woman)	5.3	2.6	5.5	2.7	3.8	2.5	2.1
Mortality rate, under-5 (per 1,000 live births)	115.0	63.0	143.0	22.0	22.0	19.0	22.0
Immunisation, measles (% of children ages 12-23 months)	69.0	74.0	71.0	96.0	98.0	94.0	88.0
Economic indicators							
Agriculture, value added (% of GDP)	32.0	19.0	33.0	14.0	3.0	8.0	7.0
Industry, value added (% of GDP)	13.0	26.0	44.0	38.0	31.0	34.0	36.0
Services, etc., value added (% of GDP)	54.0	55.0	24.0	48.0	66.0	57.0	57.0
Type of economy (based on above)[1]	S	S	I	S	S	S	S
Foreign direct investment per capita, net inflows (current US$; millions.pc)	12.5	19.7	38.2	78.7	281.2	252.0	149.3
Education and literacy indicators							
Literacy rate, adult female (% of females ages 15 and above)	29.0	51.0	50.0	58.0	89.0	85.0	93.0
Literacy rate, adult male (% of males ages 15 and above)	54.0	75.0	72.0	75.0	95.0	95.0	93.0
Ratio of girls to boys in primary and secondary education (%)	70.0	90.0	90.0	92.0	102.0	99.0	104.0
School enrolment, tertiary (% gross)	6.0	16.0	10.0	30.0	42.0	35.0	37.0
School enrolment, tertiary, female (% gross)	2.0	13.0	9.0	26.0	44.0	36.0	38.0
School enrolment, tertiary, male (% gross)	8.0	19.0	12.0	33.0	39.0	34.0	36.0

Source: Indices from world bank database http://data.worldbank.org/data-catalog/country-profiles

[1] Type of economy: S= service-based; I=industry-based; A=agricultural

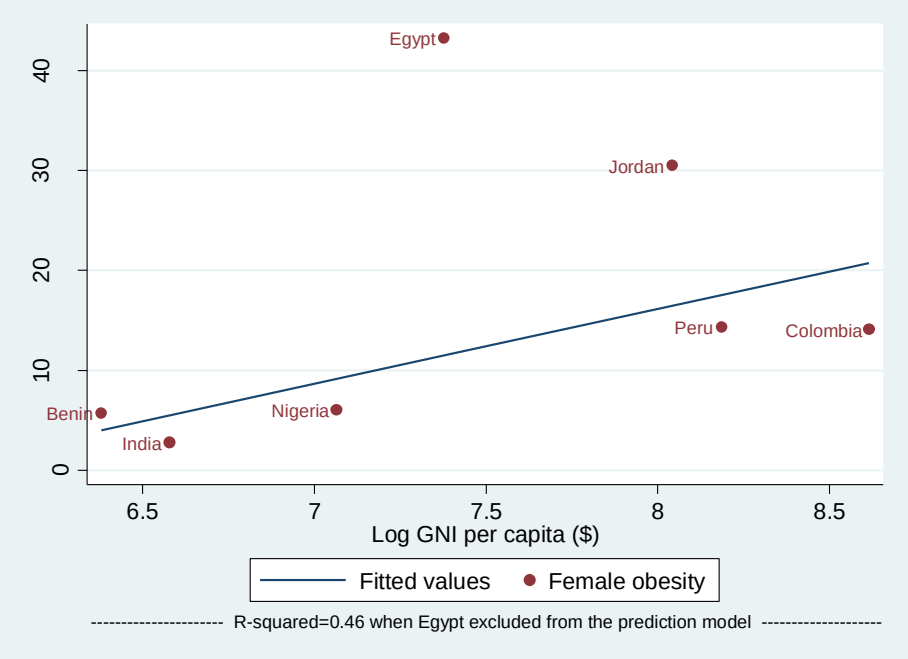
Table 6.3 Poverty, inequality and nutritional indicators by country, World Bank data.

	Benin	India	Nigeria	Egypt	Jordan	Peru	Colombia
Poverty and inequality indicators							
GINI index	39.0	33.0	49.0	31.0	35.0	49.0	57.0
Poverty headcount ratio at national poverty line (% of total population)	39.0	37.2	54.7	19.6	13.0	49.0	47.4
Poverty headcount ratio at rural poverty line (% of rural population)	46.0	41.8	63.8	26.8	19.0	70.9	56.4
Poverty headcount ratio at urban poverty line (% of urban population)	29.0	25.7	43.1	10.1	12.0	36.8	41.1
Income share held by lowest 20%	7.0	8.6	5.1	9.0	7.3	3.9	2.8
Income share held by third 20%	15.0	15.8	14.7	16.1	15.2	12.4	11.2
Income share held by highest 20%	46.1	42.4	48.6	27.6	30.8	39.7	60.3
Nutrition transition indicators							
Calorie per capita[1]	2510	214.300	2710	3160	2980	2430	2660
Contribution of carbohydrates (% of total)[1]	72.0	71.0	69.0	73.0	63.0	74.0	66.0
Contribution of proteins (% of total) [1]	9.0	10.0	9.0	12.0	10.0	11.0	10.0
Contribution of fats (% of total) [1]	19.0	19.0	22.0	15.0	27.0	15.0	24.0
Prevalence of undernourishment (% of population)	12.0	19.0	6.0	5.0	5.0	16.0	9.0
Underweight women (% of all women)	9.2	35.6	12.2	1.6	3.9	1.9	3.9
Stunting in under-5 children (% of all children)	43.0	48.0	41.0	29.0	8.0	24.0	13.0
Obesity total	5.8	0.7	.	30.3	19.5	16.3	20.1
Obesity women	9.9	2.8	5.8	39.5	20.1	12.5	16.2
Prevalence of overweight (% of children under 5)	11.0	2.0	11.0	21.0	7.0	10.0	5.0

Sources: Indices from world bank database http://data.worldbank.org/data-catalog/country-profiles except [1] from http://chartsbin.com/view/1150.

Based on the DHS data, the prevalence of female obesity seemed to correlate positively with the natural log of GNI per capita, although Egypt and possibly Jordan appeared to be outliers to this association (see **Figure 6.1**).

Figure 6.1 Prevalence of female obesity against GNI per capita, DHS and World Bank data.



6.1.2 SOCIODEMOGRAPHIC CHARACTERISTICS AND OBESITY PREVALENCE

Table 6.4 and **Table 6.5** show the socio-demographic characteristics for each country DHS sample for the separate groups and for the wealth-by-educational level subgroups. In terms of educational level, the richest or upper-middle income (UMI) countries had a smaller proportion of women with no/primary education (<30%) compared with the poorer countries, and a greater proportion with secondary or higher education (>70%). In the poorest or low-income (LI) countries, there was a large proportion of women with no/primary education (>50%), particularly in Benin where only 17% of women had secondary or higher education, whereas Nigeria and India both had 45% or more of women in this category. The richer countries had higher proportions of women living in urban areas. All countries had a similar age composition except for Egypt and Jordan which had relatively older women. There were fewer women in Egypt and Jordan with no children compared with the other countries. The subgroup frequencies shown in **Table 6.4b** indicated there were sufficient women with higher levels of education who were in the poor quintile to conduct the planned analyses including an interaction term in the model.

Table 6.4 Participant sociodemographic characteristic in each country (separate groups), DHS data.

	Benin		**India**		**Nigeria**		**Egypt**		**Jordan**		**Peru**		**Colombia**	
	14883		113063		28901		32272		4527		14483		47709	
	Total N	% (SE)	Total N	% (SE)	Total N	% (SE)	Total N	% (SE)	Total N	% (SE)	Total N	% (SE)	Total N	% (SE)
Country income bracket[1]	LI		LI		LI		LMI		UMI		UMI		UMI	
BMI (kg/m^2)														
Non-obese	14090	94.3 (0.3)	109075	97.2 (0.1)	27349	94.0 (0.3)	19146	57.0 (0.6)	2992	69.5 (1.2)	12307	85.7 (0.5)	40573	85.9 (0.2)
Obese BMI	793	5.7 (0.3)	3988	2.8 (0.1)	1552	6.0 (0.3)	13126	43.0 (0.6)	1535	30.5 (1.2)	2176	14.3 (0.5)	7136	14.1 (0.2)
Education														
None/primary	12463	82.9 (0.8)	52274	55.2 (0.6)	16810	54.2 (1.3)	16250	49.1 (0.7)	793	12.7 (0.9)	4462	28.1 (1.3)	18586	24.4 (0.4)
Secondary[2]	2420	17.1 (0.8)	60789	44.8 (0.6)	12091	45.8 (1.3)	12895	40.3 (0.5)	2554	59.1 (1.3)	6026	42.9 (0.9)	25446	54.2 (0.4)
Higher[2]							3127	10.6 (0.5)	1180	28.2 (1.4)	3995	29 (1.1)	8774	21.4 (0.4)
Area of residence														
Urban	6407	42.6 (2.1)	51030	32.4 (1.0)	9256	36.4 (1.8)	13349	41.6 (1.5)	3102	84.2 (1.8)	9919	72.9 (2.1)	34210	77.5 (0.8)
Rural	8476	57.4 (2.1)	62033	67.6 (1.0)	19645	63.6 (1.8)	18923	58.4 (1.5)	1425	15.8 (1.8)	4564	27.1 (2.1)	13499	22.5 (0.8)
Age group (years)														
15-24	5077	34.6 (0.5)	41156	36.7 (0.2)	10995	37.9 (0.4)	5361	16.3 (0.3)	506	11.8 (0.7)	4903	33.5 (0.5)	14827	30.7 (0.3)
25-34	5175	34.7 (0.5)	34726	30.6 (0.2)	8930	31.1 (0.3)	11414	35.4 (0.3)	1726	37 (1.1)	4091	28.5 (0.6)	12259	25.6 (0.3)
35-49	4631	30.7 (0.4)	37181	32.7 (0.2)	8976	31.0 (0.4)	15497	48.2 (0.4)	2295	51.2 (1.2)	5489	38 (0.6)	16864	36.3 (0.3)
Children born														
0	3335	22.9 (0.5)	35590	28.1 (0.2)	8550	30.6 (0.6)	2388	7.1 (0.2)	307	6.4 (0.6)	4466	33.0 (0.7)	16134	35.1 (0.3)
1-3	5215	35.3 (0.5)	52839	47.1 (0.3)	8774	30.3 (0.4)	17759	57.2 (0.5)	1693	40.5 (1.1)	6945	47.9 (0.7)	24409	52.6 (0.3)
4-6	4055	27.1 (0.4)	20577	20.3 (0.2)	6821	23.4 (0.3)	9386	28.4 (0.3)	1636	37.6 (1.0)	2351	14.9 (0.5)	6010	10.7 (0.2)
7+	2278	14.7 (0.4)	4057	4.6 (0.1)	4756	15.6 (0.4)	2739	7.2 (0.2)	891	15.5 (0.9)	721	4.2 (0.3)	1156	1.6 (0.1)

[1] Ranked according to the World Bank income classification. <http://data.worldbank.org/about/country-classifications> and notes http://tinyurl.com/cnhf9aw. LMI=lower-middle-income; LI=low-income; UMI=upper-middle-income.

[2] Secondary and higher education groups collapsed for Benin, India and Nigeria to ensure sufficient numbers for the analysis.

Table 6.5 Participant sociodemographic characteristic in each country (wealth-by-education subgroups), DHS data

		Benin 14883		**India** 113063		**Nigeria** 28901		**Egypt** 32272		**Jordan** 4527		**Peru** 14483		**Colombia** 47709	
		Total N	% (SE)	Total N	% (SE)	Total N	% (SE)	Total N	% (SE)	Total N	% (SE)	Total N	% (SE)	Total N	% (SE)
Country income bracket		LI		LI		LI		LMI		UMI		UMI		UMI	
Wealth by education level															
None/primary															
	Poorer 40%	5334	51.9 (1.6)	23277	70.8 (0.8)	10240	73.0 (1.5)	10338	75.7 (1.0)	1407	56.1 (2.9)	2590	74.9 (2.4)	10001	79.0 (0.9)
	Richer 40%	4510	48.1 (1.6)	15980	29.2 (0.8)	3108	27.0 (1.5)	2753	24.3 (1.0)	587	43.9 (2.9)	711	25.1 (2.4)	1448	21.0 (0.9)
Secondary															
	Poorer 40%	153	6.1 (0.7)	5344	16.5 (0.6)	1661	12.7 (1.0)	2924	26.7 (1.0)	1661	12.7 (1.0)	1231	21.9 (2.0)	12289	46.7 (1.1)
	Richer 40%	2044	93.9 (0.7)	46694	83.5 (0.6)	8190	87.3 (1.0)	7058	73.3 (1.0)	8190	87.3 (1.0)	2835	78.1 (2.0)	7280	53.3 (1.1)
Higher															
	Poorer 40%							108	3.4 (0.4)	384	33.1 (3.3)	157	3.8 (0.7)	2132	15.0 (0.8)
	Richer 40%							2792	96.6 (0.4)	524	66.9 (3.3)	3135	96.2 (0.7)	4822	85.0 (0.8)

[1] Ranked according to the World Bank income classification. <http://data.worldbank.org/about/country-classifications> and notes http://tinyurl.com/cnhf9aw. LMI=lower-middle-income; LI=low-income; UMI=upper-middle-income.

6.1.3 TRENDS IN OBESITY PREVALENCE

Table 6.6 and **Table 6.7** show the prevalence of obesity by socio-demographic characteristic for each country as separate groups and as wealth-by-education level subgroup. The prevalence of obesity in all countries was higher in urban compared with rural areas, older age groups, and in women with more children (except in the group with more than seven children which had a lower estimated prevalence). In the poorer countries the prevalence of obesity was higher in the more educated groups, while in the richer countries it was lower in the more educated groups. This pattern was particularly clear in Jordan. In **Table 6.5b**, the distribution by wealth quintile and by education group showed that the absolute difference in prevalence between the richest and the poorest wealth groups diminished with increasing education level (and even became negative in Colombia and Jordan in the highest education group), but was constant and positive in the low-income countries regardless of education group.

Table 6.6 Prevalence of obesity by sociodemographic characteristic in each country (separate groups), DHS data.

	Benin		**India**		**Nigeria**		**Egypt**		**Jordan**		**Peru**		**Colombia**	
	N=14883		N=113063		N=28901		N=32272		N=4527		N=14483		N=47709	
	N obese	% (SE)	N obese	% (SE)	N obese	% (SE)	N obese	% (SE)	N obese	% (SE)	N obese	% (SE)	N obese	% (SE)
Income bracket	LI		LI		LI		LMI		UMI		UMI		UMI	
Education														
None/primary	567	4.9 (0.3)	1194	1.7 (0.1)	679	4.4 (0.2)	6682	44.4 (0.7)	355	47.3 (3.3)	799	17.2 (1.1)	2910	21.9 (0.5)
Secondary[1]	226	9.8 (0.8)	2794	4.2 (0.2)	873	7.9 (0.4)	5112	41.1 (0.7)	853	31 (1.5)	857	13.4 (0.7)	3067	11.5 (0.3)
Higher[1]							1332	43.9 (1.5)	327	21.8 (1.9)	520	12.8 (0.9)	1159	11.9 (0.4)
Wealth quintile														
Poorest 20%	30	1.1 (0.2)	31	0.2 (0.0)	104	1.8 (0.2)	1938	30.6 (0.8)	415	30.4 (1.9)	49	4.3 (0.7)	1712	14.0 (0.5)
Poorer 20%	41	1.4 (0.2)	73	0.5 (0.1)	134	2.3 (0.2)	2285	37.6 (0.9)	344	27.7 (2.1)	323	9.4 (0.7)	2095	16.1 (0.5)
Middle 20%	89	3.2 (0.4)	219	0.9 (0.1)	235	4.1 (0.3)	2654	44.5 (0.9)	362	31.4 (2.7)	626	15.5 (0.9)	1497	14.6 (0.4)
Richer 20%	183	5.9 (0.4)	823	2.9 (0.1)	393	6.8 (0.4)	2988	49.2 (1.0)	271	34.7 (2.4)	570	18.0 (1.0)	1101	13.9 (0.5)
Richest 20%	450	13.7 (0.7)	2842	8.4 (0.3)	686	12.8 (0.6)	3261	51.4 (1.1)	143	28.4 (4.1)	608	15.6 (0.9)	731	11.9 (0.5)
Area of residence														
Urban	570	9.7 (0.6)	3083	6.1 (0.2)	831	9.5 (0.5)	6416	49.5 (0.8)	1044	29.4 (1.4)	1691	16.2 (0.6)	5048	13.9 (0.2)
Rural	223	2.7 (0.2)	905	1.2 (0.1)	721	3.9 (0.2)	6710	38.4 (0.8)	491	36.3 (1.9)	485	9.2 (0.7)	2088	14.9 (0.5)
Age group														
15-24	85	1.8 (0.2)	281	0.5 (0.0)	190	1.7 (0.1)	895	17.8 (0.7)	60	11.8 (2.2)	205	3.9 (0.4)	883	5.3 (0.2)
25-34	265	5.5 (0.4)	1071	2.5 (0.1)	516	6.5 (0.4)	3775	34.8 (0.7)	411	21.2 (1.5)	606	13.8 (0.9)	1985	14.7 (0.4)
35-49	443	10.3 (0.6)	2636	5.7 (0.2)	846	10.6 (0.5)	8456	57.6 (0.7)	1064	41.5 (1.8)	1365	23.9 (1.1)	4268	23.9 (0.4)
Children born														
0	83	2.8 (0.4)	444	1.0 (0.1)	239	2.8 (0.2)	653	29.1 (1.2)	72	17.8 (3.4)	201	4.2 (0.5)	856	5.5 (0.2)
1-3	304	6.3 (0.4)	2676	4.0 (0.2)	473	6.4 (0.4)	6610	39.4 (0.7)	385	21.6 (1.6)	1255	17.6 (0.8)	4387	17.0 (0.3)
4-6	287	7.7 (0.6)	749	2.7 (0.2)	513	8.7 (0.5)	4594	52.0 (0.8)	619	33.0 (1.9)	571	23.7 (1.5)	1597	26.7 (0.8)
7+	119	5.2 (0.5)	119	2.1 (0.3)	327	7.3 (0.5)	1269	50.1 (1.2)	459	52.8 (2.8)	149	22.7 (2.7)	296	26.9 (1.8)

[1]Secondary and higher education groups collapsed for Benin, India and Nigeria to ensure sufficient numbers for the analysis.

Table 6.7 Prevalence of obesity by sociodemographic characteristic in each country (wealth-by-education level subroups), DHS data.

	Benin N=14883		**India** N=113063		**Nigeria** N=28901		**Egypt** N=32272		**Jordan** N=4527		**Peru** N=14483		**Colombia** N=47709	
	N obese	% (SE)	N obese	% (SE)	N obese	% (SE)	N obese	% (SE)	N obese	% (SE)	N obese	% (SE)	N obese	% (SE)
Income bracket	LI		LI		LI		LMI		UMI		UMI		UMI	
Wealth by education level														
None/primary														
Poorer 40%	69	1.3 (0.2)	90	0.4 (0.0)	213	2.1 (0.2)	1124	24.8 (0.9)	226	42.3 (3.9)	270	8.7 (0.7)	2027	20.6 (0.6)
Richer 40%	415	9.6 (0.5)	944	5.5 (0.3)	316	10.5 (0.6)	332	44.4 (2.1)	48	56.6 (9.3)	243	34.9 (0.3)	365	24.0 (1.3)
Secondary														
Poorer 40%	2	1.2 (0.9)	14	0.3 (0.1)	25	1.6 (0.4)	433	21.4 (1.1)	429	26.8 (1.6)	90	7.2 (0.1)	1433	10.8 (0.4)
Richer 40%	218	11.1 (0.8)	2721	5.8 (0.2)	763	9.7 (0.5)	1420	39.3 (1.1)	220	34.9 (3.2)	488	15.5 (0.1)	898	12.1 (0.4)
Higher														
Poorer 40%							20	27.2 (5.5)	104	22.4 (3.0)	12	18.0 (0.2)	347	14.3 (1.1)
Richer 40%							540	37.1 (1.7)	146	23.5 (2.7)	447	13.9 (0.1)	569	11.1 (0.5)

6.1.4 THE SEPARATE AND JOINT EFFECTS OF EDUCATION AND WEALTH ON OBESITY BY LEVEL OF ECONOMIC DEVELOPMENT

The regression results for the model examining the separate and joint effect estimates of education and wealth on obesity are displayed in two different tables by country income category (low-income and middle-income) and include the findings for Egypt in each table for ease of comparison.

6.1.4.1 LOW-INCOME COUNTRIES (BENIN, INDIA, AND NIGERIA) COMPARED WITH EGYPT

The top part of **Table 6.8** shows the separate effects for the relationship between the SES indicators and obesity defined as a binary outcome, unadjusted and adjusted for age group, area of residence, and parity for the low-income countries and Egypt. For the poorer countries there was a positive association between each of age group and parity and obesity as expected (not shown). The association between each of education and wealth was positive both before and after adjustment in these countries. For example, in India (the largest sample), the unadjusted odds of obesity in the secondary/higher education group were 2.06 times higher (95%CI: 1.92, 2.21) compared with the group with no or primary education. Adjustment for age group, area of residence, and parity increased the magnitude of the OR estimates for education (OR; 95%CI: 2.23; 2.07, 2.41 for the secondary/higher education group compared with the group with no or primary education).

A similar pattern was observed in Nigeria, while in Benin there was little change in the education estimate after adjustment. In India, the odds of being obese increased by 2.77 times for each increase of one wealth quintile (95%CI: 2.65, 2.89) and diminished after adjustment (OR; 95%CI: 2.41; 2.30, 2.53). There was little change in the estimate for the wealth trend after adjustment in Nigeria and Benin. In comparison with Egypt, the most striking findings are that education was positively associated with obesity; and that the estimate for the increase in

obesity odds for an increase in one wealth quintile are much higher in the lower income countries.

The middle part of **Table 6.8** shows the results of examining the independent effects of education and wealth in a model that includes both of these variables. The effect of education is much smaller in magnitude compared with the estimates in the first part of the table. For example in India, the adjusted OR decreases from 2.23 to 1.18 if wealth is taken into account. This suggests that wealth may largely account for the apparent positive association between education and obesity observed in the low-income countries. The effect of wealth is little affected in this model.

The bottom part of **Table 6.8** displays the results for the regression model including the interaction term between education level and wealth quintile in its continuous form. The LR test for whether the model fit was better with or without an interaction between education level and the linear wealth quintile variable provided very strong evidence of an interaction in Egypt ($P<0.0001$) and no evidence of an interaction in the low-income countries ($P>0.05$).

Table 6.8 Separate and joint effects of education and wealth on obesity for Egypt and the low-income countries, DHS data.

	Egypt (N=32272) OR (95%CI)		**Benin** (N=14883) OR (95%CI)		**India** (N=113063) OR (95%CI)		**Nigeria** (N=28901) OR (95%CI)	
	Unadjusted	Adjusted[1]	Unadjusted	Adjusted[1]	Unadjusted	Adjusted[1]	Unadjusted	Adjusted[1]
Separate effects								
Education (level)								
None/primary	1	1	1	1	1	1	1	1
Secondary[2]	0.94 (0.90-0.99)	1.19 (1.13-1.26)	2.16 (1.84-2.53)	2.01 (1.67-2.44)	2.06 (1.92-2.21)	2.23 (2.07-2.41)	1.84 (1.68-2.04)	2.39 (2.11-2.70)
Higher[2]	1.06 (0.98-1.15)	1.02 (0.93-1.11)						
Wealth quintile (linear)	1.28 (1.26-1.30)	1.26 (1.23-1.29)	2.09 (1.94-2.23)	1.99 (1.84-2.16)	2.77 (2.65-2.89)	2.41 (2.30-2.53)	1.76 (1.68-1.83)	1.80 (1.70-1.90)
Model incorporating both SES variables (education and wealth)								
Education (level)								
None/primary		n.a.		1		1		1
Secondary/higher				1.26 (1.04-2.12)		1.18 (1.09-1.28)		1.32 (1.16-1.52)
Wealth quintile		n.a.		1.95 (1.79-2.12)		2.33 (2.23-2.46)		1.71 (1.62-1.81)
Joint effects (wealth trend by education level) [2]								
Education (level)								
None/primary		1.39 (1.35-1.43)		1.98 (1.81-2.15)		2.48 (2.29-2.70)		1.72 (1.61-1.84)
Secondary (+/-higher)[3]		1.25 (1.21-1.29)		1.67 (1.30-2.16)		2.25 (2.11-2.39)		1.70 (1.55-1.86)
Higher		1.02 (0.93-1.13)						
P-value for interaction [4]		<0.0001		0.2		0.06		0.8

[1] Estimates for education and wealth adjusted for age group, area of residence, and parity for the separate effects (top part of the table), and additionally for each other in the model incorporating both variables (middle part of the table)

[2]Joint effects estimates: OR for obesity associated with an increase in one wealth quintile in each education group estimated from the model including an interaction between education and wealth

[3] Secondary and higher education groups collapsed for Benin, India and Nigeria to ensure sufficient numbers for the analysis as discussed in the Data and Methods.

[4] *P*-value from the LR test for an interaction between education level and wealth quintile in its continuous form.

6.1.4.2 UPPER MIDDLE-INCOME COUNTRIES (COLOMBIA, JORDAN, AND PERU) COMPARED WITH EGYPT

The top part of **Table 6.9** shows the separate effects for the relationship between the SES indicators and obesity defined as a binary outcome (unadjusted and adjusted for age group, area of residence, and parity) for the middle-income countries. In contrast to India, Nigeria and Benin, the association between education and obesity tended to be negative (OR<1) both before and after adjustment. This negative association was different to that of Egypt which did not display any statistical association between education and obesity.

In Colombia (the largest sample), the adjusted OR for the secondary education group compared with the group with no/primary education was 0.82 (95%CI: 0.77-0.87) and 0.76 (95%CI: 0.70, 0.83) for the higher education group compared with the no/primary education group. In terms of the wealth-obesity association, these upper-middle-income countries displayed a similar or smaller magnitude of association to Egypt, and Colombia – the richest country - displayed an inverse wealth-obesity association (adjusted OR; 95%CI: 0.94; 0.91, 0.96). Peru was the country that most resembled Egypt in its wealth trend estimates.

The results for the regression model including the interaction term between education level and wealth quintile in its continuous form are shown in the lower part of **Table 6.9** The LR test for whether the model fit was better with or without an interaction between education level and the linear wealth quintile variable provided very strong evidence of an interaction for all countries (P<0.001). In all three countries, the estimates for the joint effects of education and wealth on obesity were similar to those seen in Egypt, but the magnitude of association between wealth and obesity in the lower two education levels tended to be greatly attenuated compared with Egypt. In Colombia and Jordan the wealth-obesity association was negative in the higher education group (OR; 95%CI: 0.86; 0.82, 0.90 and 0.84; 0.76, 0.93 respectively) whereas in Egypt there was no evidence of an association.

Figure 6.2 plots the log OR for obesity for each combination of education and wealth quintile for Jordan, Peru and Colombia. The pattern appears to be consistent across the countries and with the plot for Egypt when examining the group with no/primary education (see **Figure 5.1** for Egypt). It appears that the linear association between wealth and obesity is positive in the group with no/primary education and shallower or negative in the secondary and higher educated groups depending on the country. The plots also show that the effects of wealth quintile on obesity are reasonably well described by fitting wealth as a continuous variable particularly in the groups with secondary or higher education.

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6.1.4.3 SENSITIVITY ANALYSIS

The analyses for the middle-income countries (Egypt, Jordan, Peru and Colombia) were repeated using the modified education variable that was used for the lower-income countries (Benin, Nigeria and India) to examine whether this might mask the interaction. The results showed that the interaction was still present ($P<0.001$) and that the combined secondary/higher education group had lower obesity odds for every increase in wealth quintile than the no/primary education group.

Table 6.9 Separate and joint effects of education and wealth on obesity for Egypt and the middle-income countries, DHS data.

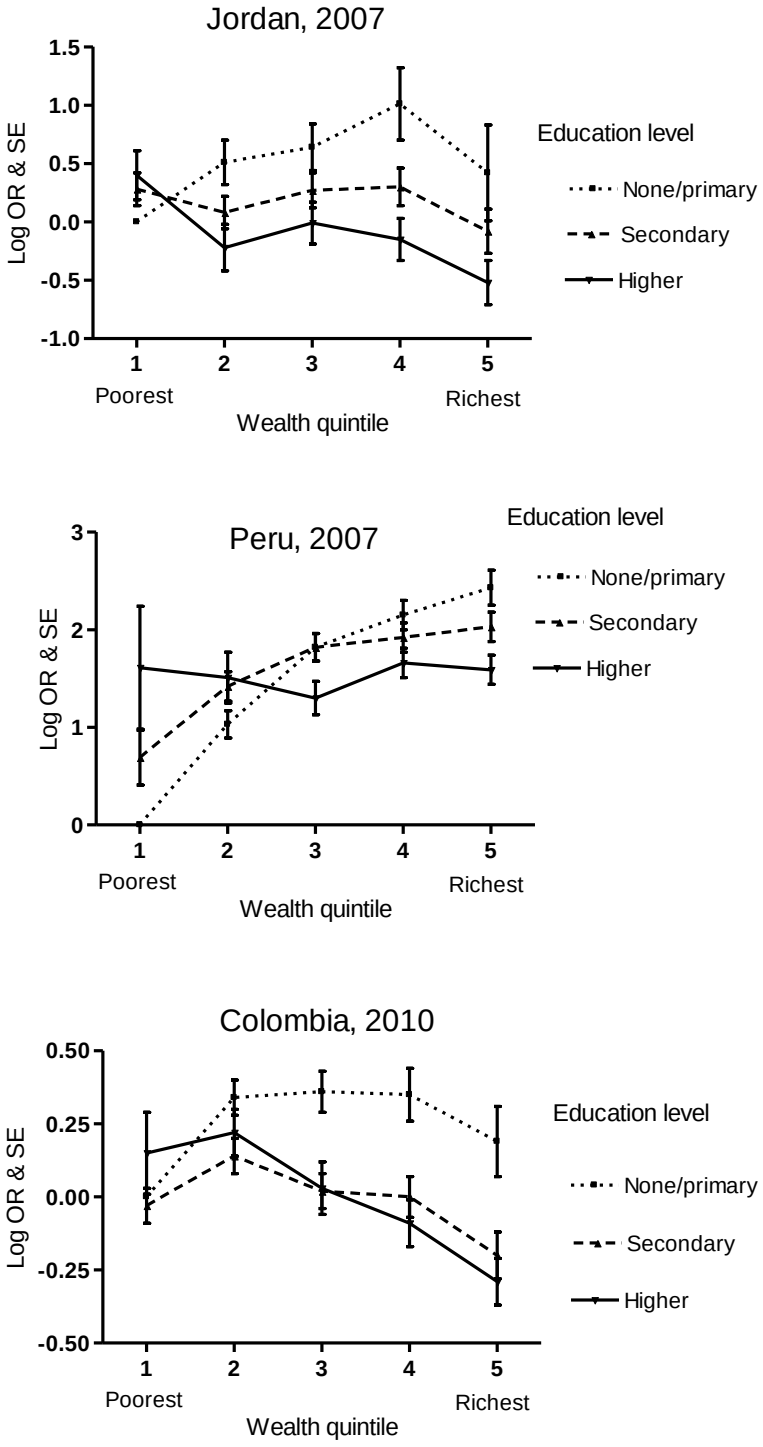
	Egypt (N=32272)		**Jordan** (N=4527)		**Peru** (N=14483)		**Colombia** (N=47709)	
	OR (95%CI)		OR (95%CI)		OR (95%CI)		OR (95%CI)	
	Unadjusted	Adjusted[1]	Unadjusted	Adjusted[1]	Unadjusted	Adjusted[1]	Unadjusted	Adjusted[1]
Separate effects								
Education level								
None/primary	1	1	1	1	1	1	1	1
Secondary	0.94 (0.90-0.99)	1.19 (1.13-1.26)	0.62 (0.53-0.73)	0.98 (0.85-1.12)	0.76 (0.68-0.84)	1.07 (0.94-1.21)	0.50 (0.47-0.53)	0.82 (0.77-0.87)
Higher	1.06 (0.98-1.15)	1.02 (0.93-1.11)	0.47 (0.39-0.57)	0.84 (0.72-0.99)	0.69 (0.61-0.77)	0.79 (0.69-0.92)	0.55 (0.51-0.60)	0.76 (0.70-0.83)
Wealth quintile (linear)	1.28 (1.26-1.30)	1.26 (1.23-1.29)	1.23 (1.16-1.30)	0.95 (0.90-0.99)	1.23 (1.18-1.27)	1.21 (1.15-1.28)	0.96 (0.94-0.98)	0.94 (0.91-0.96)
Joint effects (wealth effect by education level)[2]								
Education level								
None/primary		1.39 (1.35-1.43)		1.27 (1.11-1.45)		1.65 (1.51-1.80)		1.09 (1.04-1.14)
Secondary		1.25 (1.21-1.29)		0.97 (0.91-1.04)		1.15 (1.07-1.25)		0.94 (0.91-0.97)
Higher		1.02 (0.93-1.13)		0.84 (0.76-0.93)		1.10 (0.98-1.23)		0.86 (0.82-0.90)
P-value [3]		<0.001		<0.001		<0.001		<0.0001

[1] Estimates adjusted for age group, area of residence, and parity

[2] OR for obesity associated with an increase in one wealth quintile in each education group estimated from the model including an interaction between education and wealth.

[3] *P*-value from the LR test for an interaction between education level and wealth quintile in its continuous form

Figure 6.2 Interaction between women's education level and household wealth on obesity. DHS data for Jordan, 2007; Peru, 2008; and Colombia, 2010.



Each point represents the log OR of that combination of education level and wealth quintile compared with the reference category (education level=none/primary and wealth quintile=poorest). Error bars represent the standard error of the log OR. All plotted estimates are adjusted for age group area of residence and parity.

7 CHAPTER 7: THE ASSOCIATION BETWEEN EDUCATION, OCCUPATION AND OBESITY IN CHINESE WOMEN

In the following analysis, the analytic model developed and applied to the Demographic and Health Surveys data in the previous chapters is applied to data from the Chinese Four-Provinces (4-P) study. The analysis further tests the hypotheses of objective 1, including that the reversal of the SES-obesity association differs by SES indicator (see Chapter 2), as well as the main hypothesis that education might modify the obesogenic effect of improved material circumstances (proxied in this Chapter by occupation). It also serves to investigate whether the findings from the DHS are reproducible in another dataset.

7.1 RESULTS

7.1.1 SAMPLE SELECTION AND IMPUTATION

Figure 7.1 illustrates how the sample of complete cases of women with full anthropometric and covariate data was derived (N=1928). **Table 7.1** compares the participants with and without anthropometric data. It shows that the participants who had complete covariate data but were missing anthropometric data (N=79) were more likely to live in urban areas, have no education and report 'agricultural' as their occupation than the complete cases. The data missingness pattern was monotone. The sample was fully imputed including the complete cases missing waist circumference data (n=79) and participants missing covariates (n=50). These cases added to the number of participants with complete anthropometric and covariate data (n=1928) resulted in a fully imputed sample of 2057 cases.

The results for the complete case analysis and those using the imputed sample are shown alongside each other in the results tables below. There was a higher proportion of women with no education and agricultural occupation in the imputed sample. The rest of the results in this section refer to the imputed sample (N=2057).

Figure 7.1 Selection of participants for the analytic sample from the Four-Provinces study.

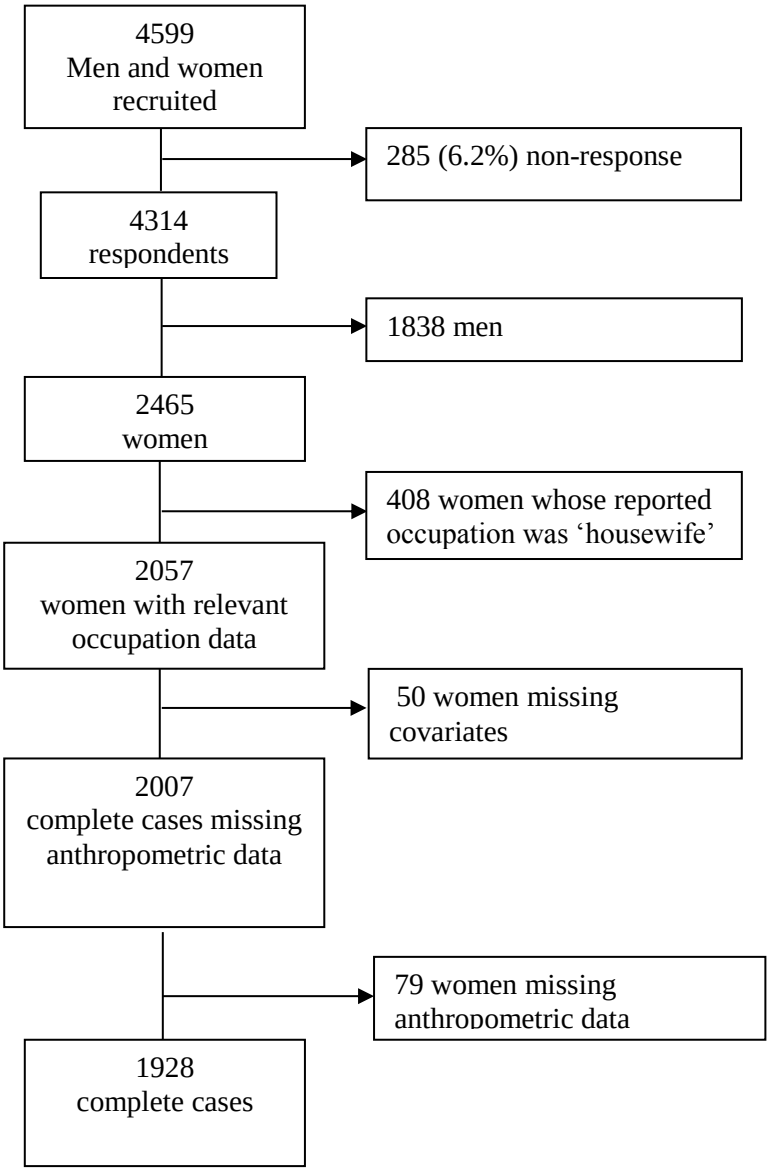


Table 7.1 Missing data pattern for the waist circumference variable (differences between complete cases with and without waist circumference data.

Total N=2007[1]		Complete cases N = 1928	Complete cases missing anthropometry N = 79	Chi^2 test
		n (%)	n (%)	P-value
Age group				0.3
	60-69	877 (45.5)	33 (41.8)	
	70-79	752 (39.0)	29 (36.7)	
	80+	299 (15.5)	17 (21.5)	
Area of residence				<0.001
	Urban	998 (51.8)	78 (98.7)	
	Rural	930 (48.2)	1 (1.3)	
Parity				0.02
	0	29 (1.5)	3 (3.8)	
	1-3	955 (49.5)	28 (35.4)	
	4+	944 (49)	48 (60.8)	
Education level				0.001
	None	951 (49.3)	54 (68.4)	
	Any	977 (50.7)	25 (31.7)	
Occupation group				<0.001
	Agricultural	1054 (54.7)	64 (81)	
	Non-agricultural	874 (45.3)	15 (19)	
Income quintile				0.001
	Poorest	380 (20.5)	3 (4.4)	
	Poorer	355 (19.1)	14 (20.6)	
	Middle	470 (25.3)	26 (38.2)	
	Richer	411 (22.1)	21 (30.9)	
	Richest	240 (12.9)	4 (5.9)	

[1] This does not include participants missing covariates (n=50) which are included in the imputed sample later.

7.1.2 SOCIODEMOGRAPHIC CHARACTERISTICS AND CENTRAL OBESITY PREVALENCE

Table 7.2 summarises the characteristics of participants. Two thirds of the women were classified as centrally obese, and there was a high proportion of women with no education (50.2%), and of women reporting 'agricultural' as their longest held occupation (55.9%). **Table 7.3** shows that the prevalence of central obesity was greater in urban areas than in rural areas, in women with no children (although this subgroup was small), those with education, those with a non-agricultural occupation, and those who were richer. The prevalence by educational and occupational subgroup showed that the absolute difference in prevalence between those who worked in non-agricultural occupations and those who did was greater in women with no education.

Table 7.2 Participant characteristics in the Four-Provinces Study, China (2008-09).

N=2466	Original sample (complete cases) Total=1928		Imputed sample Total=2057
	N	Sample % (SE)	Sample % (SE)
WC (cm)			
Not centrally obese[1]	654	33.9 (1.08)	33.8 (1.08)
Centrally obese[2]	1274	66.1 (1.08)	66.2 (1.08)
Age group			
60-69	877	45.5 (1.13)	44.9 (1.1)
70-79	752	39.0 (1.11)	39.0 (1.08)
80+	299	15.5 (0.82)	16.1 (0.81)
Area of residence			
Urban	998	51.8 (1.14)	53.6 (1.1)
Rural	930	48.2 (1.14)	46.4 (1.1)
Parity			
0	29	1.5 (0.28)	1.6 (0.28)
1-3	955	49.5 (1.14)	48.9 (1.11)
4+	944	49.0 (1.14)	49.5 (1.11)
Education level			
None	951	49.3 (1.14)	50.2 (1.11)
Any	977	50.7 (1.14)	49.8 (1.11)
Occupation group			
Agricultural	1054	54.7 (1.13)	55.9 (1.1)
Non-agricultural	874	45.3 (1.13)	44.1 (1.1)
Occupation by education level			
No education			
Agricultural	764	80.3 (1.29)	80.9 (1.23)
Non-agricultural	187	19.7 (1.29)	19.1 (1.23)
Any education			
Agricultural	290	29.7 (1.46)	30.8 (1.45)
Non-agricultural	687	70.3 (1.46)	69.2 (1.45)

[1] Not centrally obese: WC<80cm
[2] Centrally obese: WC≥80cm

Table 7.3 Prevalence of central obesity by participant characteristic in the Four-Provinces Study, China (2008-09).

	Original sample (complete cases) Total N = 1928		Imputed sample Total N = 2057
	n	Sample % (SE)	Sample % (SE)
Age group			
60-69	554	63.2 (1.63)	63.2 (1.61)
70-79	523	69.5 (1.68)	69.8 (1.67)
80+	197	65.9 (2.75)	65.6 (2.69)
Area of residence			
Urban	726	72.7 (1.41)	72.8 (1.43)
Rural	548	58.9 (1.61)	58.6 (1.6)
Parity			
0	24	82.8 (7.14)	82.9 (7.03)
1-3	634	66.4 (1.53)	66.3 (1.52)
4+	616	65.3 (1.55)	65.5 (1.55)
Education level			
None	605	63.6 (1.56)	63.9 (1.54)
Any	669	68.5 (1.49)	68.5 (1.50)
Occupation group			
Agricultural	646	61.3 (1.5)	61.7 (1.49)
Non-agricultural	628	71.9 (1.52)	71.8 (1.53)
Income quintile			
Poorest	235	61.8 (2.5)	60.9 (2.45)
Poorer	226	63.7 (2.56)	63.3 (2.58)
Middle	297	63.2 (2.23)	63.9 (2.16)
Richer	298	72.5 (2.21)	72.5 (2.15)
Richest	174	72.5 (2.89)	72.9 (2.86)
Occupation by			
No education			
Agricultural	460	60.2 (1.77)	61.1 (1.74)
Non-agricultural	145	77.5 (3.06)	77.1 (3.06)
Any education			
Agricultural	186	64.1 (2.82)	64.4 (2.79)
Non-agricultural	483	70.3 (1.74)	70.2 (1.74)

[1] Not centrally obese: WC<80cm
[2] Centrally obese: WC≥80cm

7.1.1 SEPARATE AND JOINT EFFECTS OF EDUCATION AND OCCUPATION ON CENTRAL OBESITY

The top half of **Table 7.4** shows the relationship between each SES indicator and the central obesity binary outcome. The unadjusted ORs indicate a positive association between each of education and occupation and central obesity. The OR comparing those with any education to those with none in the imputed sample was 1.23 (95%CI: 1.02, 1.48); and the OR comparing those with a non-agricultural *vs* an agricultural occupation was 1.58 (95% CI: 1.30, 1.91). Adjustment for age group and parity had little impact on the estimates. However, after additional adjustment for area of residence there was no evidence of an association between the SES indicators and central obesity.

Figure 7.2 plots the adjusted ORs for central obesity in women for each combination of education level and occupational group. The pattern of estimates suggested that the women with the highest odds of obesity were those with a non-agricultural occupation and no education. On the other hand, higher (non-agricultural) occupational class had little effect on the odds of obesity in women with education.

The lower part of **Table 7.4** displays the results for the regression model including the interaction term between education level and occupational status. The Wald test for the interaction term was suggestive of an interaction ($P<0.05$). The joint effect estimates adjusted for age group and parity showed that having a non-agricultural *vs.* agricultural occupation was associated with higher odds of central obesity in women with no education (OR; 95%CI: 2.09; 1.44, 3.03), but there was no evidence of such an effect in women with education, corroborating the findings from **Figure 7.2**. The occupation-obesity association persisted despite adjustment for urban/rural residence (OR; 95%CI: 1.58; 1.06, 2.34 after adjustment).

7.1.2 SENSITIVITY ANALYSIS

The analyses were repeated with a modified Poisson and log binomial model with a log link function recommended by Zou for outcomes with a high prevalence (Zou, 2004). Although

the magnitude of the estimates changed to some extent, the results were similar in terms of the direction of the associations and their statistical significance. For example, the ORs for central obesity in agricultural *vs.* non-agricultural women using the log binomial model on the non-imputed sample were: 1.17 (95%CI: 1.05, 1.30) in women with no education, and 0.97 (95%CI: 0.87, 1.08) in women with any education. The Wald test *P*-value for the interaction term between education and occupation using this model was <0.01.

7.1.2.1 COMPARISON OF ORIGINAL AND IMPUTED DATA RESULTS

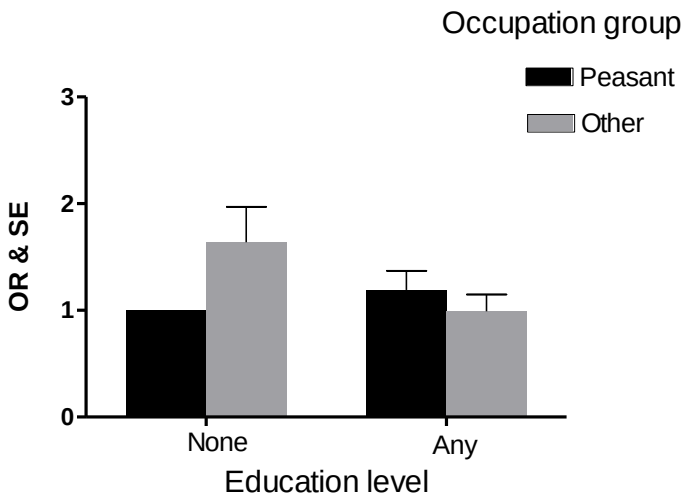
Although there are some differences in the sample proportions and the regression estimates, the results are overall very similar and the missingness therefore appears to have not affected the analysis.

Table 7.4 Separate and joint effects of education and occupation on central obesity - Four-Provinces Study (2008/09).

	Complete cases sample (N=1928)			Imputed sample (N=2057)		
	Unadjusted OR (95%CI)	Adjusted[1] OR (95%CI)	Fully Adjusted[2]	Unadjusted OR (95%CI)	Adjusted[1] OR (95%CI)	Fully Adjusted[2]
Separate effects						
Education level						
None	1	1	1	1	1	1
Any	1.24 (1.03,1.50)	1.28 (1.05, 1.55)	0.97 (0.77, 1.20)	1.23 (1.02, 1.48)	1.27 (1.04, 1.54)	0.97 (0.78, 1.21)
Occupational status						
Agricultural	1	1	1	1	1	1
Non- agricultural	1.61 (1.33, 1.95)	1.59 (1.30, 1.94)	1.10 (0.84, 1.44)	1.58 (1.30, 1.91)	1.56 (1.27, 1.90)	1.08 (0.83, 1.41)
Joint effects[3]						
Odds of obesity for occupational status [non-agricultural *vs.* agricultural] within education levels						
Education level						
None		2.21 (1.52, 3.22)	1.64 (1.10, 2.45)		2.09 (1.44, 3.03)	1.58 (1.06, 2.34)
Any		1.25 (0.92, 1.69)	0.83 (0.58, 1.19)		1.24 (0.54, 1.84)	0.84 (0.35, 1.99)
P-value for interaction[4]		0.02	<0.01		0.03	<0.01

[1] Adjusted for age group and parity
[2] Adjusted for age group, parity and urban/rural residence
[3] Effect of occupational status in each education group estimated from the model including an interaction between education and occupation.
[4] *P*-value for the LR test comparing the model with and without the interaction term between education and occupation

Figure 7.2 Interaction between education and occupation (adjusted ORs* and 95%CI).



* Each bar represents the predicted odds in each group relative to the reference group (education=none; occupation=agricultural). ORs adjusted for age group, area of residence and parity.

8 CHAPTER 8: THE IMPACT OF LITERACY, MEDIA EXPOSURE AND DIETARY BEHAVIOUR ON THE ASSOCIATION BETWEEN EDUCATION, WEALTH AND OBESITY

This chapter addresses the second and final objective of the thesis using the Egyptian DHS 2008 dataset. It aims to investigate plausible pathways explaining the role of education in protecting against the obesogenic effects of improved material circumstances and, therefore, elucidate its role as a possible driver of the reversal of the social gradient of female obesity. The analysis tests the hypothesis that cognitive skills proxied by literacy, media exposure and dietary behaviour are mediators on the pathway linking education, material circumstances and obesity. Two additional confounders are explored in the final model. The first is the respondent's occupation as a crude measure of differences in physical activity which is treated as a confounder as the main interest of the thesis investigation is in the dietary pathway to obesity. The second is partner's occupation which is incorporated as an additional SES indicator confounding the association between education, wealth with obesity.

8.1 RESULTS

The sample characteristics and data exploration are described first followed by an account of the mediation analysis results. **Table 8.1** shows the regression models used to examine the association between education, wealth and obesity incorporating the mediators (literacy, media exposure and dietary indicators) and the additional confounders.

Table 8.1 Logistic regression models used to examine the association between education, wealth and obesity incorporating mediators and confounders.

Model	Description	Variables
Model 0 (separate effects)	Adjusted estimates	Variable + *age group + parity + area of residence*
Model 1 (joint effects on obesity)	Original interaction model	Education*wealth + *age group + parity + area of residence*
Model 2 (role of literacy)	Substitution of literacy for education in model 1	Literacy*wealth + *age group + parity + area of residence*
Model 3a (role of media exposure)	Model 1 + media exposure	Education*wealth + media exposure + *age group + parity + area of residence*
Model 3b (role of media exposure)	Model 1 + education*media exposure	Education*wealth + education*media exposure + *age group + parity + area of residence*
Model 4 (role of dietary behaviour)[1]	Model 3b + dietary indicator(s)	Education*wealth + education*media exposure + sweet snack use[1] + *age group + parity + area of residence*
Model 5 (impact of additional confounders)	Model 4 + additional confounders	Education*wealth + education*media exposure + sweet snack use + respondent's occupation + partner's occupation + *age group + parity + area of residence*

[1] A model incorporating a third interaction term between education and dietary indicators was not explored due to lack of power in the sample

8.1.1 SAMPLE CHARACTERISTICS

The sample distribution and the prevalence of obesity for all the variables included in the original model examining the wealth by education interaction adjusted for age group, area or residence and parity, as well as for literacy is shown in **Table 8.2**. An estimated 39.2% of women were obese (SE: 0.6). Most women were 35 years and over and lived in rural areas. The majority of women belonged to either the no/primary or secondary education groups with less

than 12% belonging to the higher education group; and over a third of women could not read. The prevalence of obesity was more common in older women who lived in urban areas, were wealthier, and had a greater number of children. On the other hand, women with secondary or higher education and those who could read easily had a lower prevalence of obesity than those with no/primary education or were illiterate respectively.

Table 8.2 Distribution of the variables included in the original model incorporating an interaction between education and wealth on obesity as well as literacy, EDHS 2008.

N= 14795	Sample distribution		Prevalence of obesity		Adjusted OR
	Total N	% (SE)	(95%CI)	% (SE)	(95%CI)
BMI (kg/m^2)					
Non-obese (BMI<30)	9225	60.8 (0.6)			
Obese BMI (≥30)	5570	39.2 (0.6)			
Age group (years)[1]					2.50 (2.37, 2.63)
15-24	2445	16.3 (0.4)	332	14.1 (0.8)	
25-34	5296	35.8 (0.4)	1627	32.0 (0.8)	
35-49	7054	47.9 (0.5)	3611	53.2 (0.9)	
Area of residence[2]					0.78 (0.73, 0.84)
Urban	6017	41.6 (1.6)	2557	43.1 (0.9)	
Rural	8778	58.4 (1.6)	3013	36.5 (0.8)	
Parity[3]					1.00 (0.95, 1.06)
0	1125	7.2 (0.2)	272	25.5 (1.6)	
1-3	8415	59.2 (0.6)	2891	35.9 (0.7)	
4-6	4201	27.6 (0.4)	1935	48.2 (1.0)	
7+	1054	6.0 (0.3)	472	47.9 (1.8)	
Education					
None/primary	7002	45.8 (0.8)	2744	42.1 (0.9)	1
Secondary	6258	43.0 (0.6)	2259	36.9 (0.8)	1.19 (1.09, 1.29)
Higher	1535	11.2 (0.5)	567	36.5 (1.5)	1.00 (0.88, 1.14)
Wealth quintile					1.24 (1.20, 1.28)
Poorest			847	29.4 (1.0)	
Poorer			1007	36.0 (1.1)	
Middle			1212	42.4 (1.1)	
Richer			1228	43.5 (1.1)	
Richest			1276	43.9 (1.3)	
Literacy					
Can't read	5613	36.5 (0.8)	2180	41.8 (1.0)	1
Reads with difficulty	1089	7.2 (0.3)	413	39.9 (1.6)	1.06 (0.92, 1.22)
Reads easily	8093	56.3 (0.8)	2977	37.5 (0.7)	1.20 (1.10, 1.30)

1 Unadjusted estimate
[2] Adjusted for age group and parity
[3]Adjusted for age group and area of residence

Table 8.3 shows the sample distribution for the subgroups of wealth by education level and literacy by education level. Most of the women who were illiterate or in the no/primary education group were in the poorer two quintiles (>80%), while most women with higher education or who could read easily were in the richest two quintiles (>70%). The absolute difference in obesity prevalence between the poorest and richest 40% was smaller in the group with higher education compared with the no/primary education group and secondary education group. The same pattern was not true when comparing poorer and richer women in the illiterate and fully literate groups. The frequency distribution of literacy by education level is shown in **Table 8.4.**

Table 8.3 Sample distribution and obesity prevalence shown for subgroups of wealth by education level and wealth by literacy level, EDHS 2008.

N= 14795		Sample distribution		Prevalence of obesity		Adjusted OR[1]
		Total N	% (SE)	N obese	% (SE)	(95%CI)
Wealth by education level						
None/primary						
	Poorer 40%	4199	77.7 (1.2)	1514	36.1 (1.0)	1
	Richer 40%	1204	22.3 (1.2)	578	54.1 (1.7)	1.34 (1.27-1.40)
Secondary						
	Poorer 40%	1398	28.8 (1.3)	322	22.6 (1.2)	1
	Richer 40%	3460	71.2 (1.3)	1413	42.8 (1.1)	1.26 (1.19-1.33)
Higher						
	Poorer 40%	62	4.1 (0.6)	18	32.8 (6.7)	1
	Richer 40%	1462	95.9 (0.6)	513	37.3 (1.6)	1.07 (0.91-1.25)
Wealth trend by literacy level						
Can't read						
	Poorer 40%	3671	83.8 (1)	1358	37.0 (1.1)	1
	Richer 40%	710	16.2 (1)	393	55.3 (2.2)	1.35 (1.28-1.43)
Reads with difficulty						
	Poorer 40%	443	57 (2.5)	126	28.4 (2.3)	1
	Richer 40%	333	43 (2.5)	167	50.0 (0.3)	1.32 (1.17-1.50)
Can read easily						
	Poorer 40%	1546	23.3 (1.1)	370	23.9 (0.1)	1
	Richer 40%	5082	76.7 (1.1)	2117	41.7 (0.1)	1.20 (1.15-1.26)

[1]Adjusted for age group, area of residence and parity

Table 8.4 Cross-tabulation showing the relationship between education level and literacy level, Egyptian DHS 2008.

	Literacy level			
N= 14795	Cannot read	Reads with difficulty	Reads easily	Total
	% (n)	% (n)	% (n)	% (n)
Education level				
None/primary	79.6 (5613)	15.7 (1089)	4.7 (300)	100 (7002)
Secondary	0 (0)	0 (0)	100 (6258)	100 (6258)
Higher	0 (0)	0 (0)	100 (1535)	100 (1535)

Table 8.5 shows the sample distribution and obesity prevalence for the media exposure variables (TV, newspaper and radio exposure) and for the additional confounders investigated in the final model (own and partner's occupation). In terms of media exposure, almost all women (97.2%; SE: 0.2) reported watching TV once a week or more while half reported listening to the radio once a week or more. Newspaper reading was comparatively unusual (approximately one in ten women). An estimated 82.8% of women reported not having an occupation and those who worked were mostly in the non-agricultural sector, and 47.8% of respondents had a partner who worked in a non-manual and non-agricultural occupation.

Table 8.5 Sample distribution and obesity prevalence shown for media exposure and the additional confounders (own and partner's occupation), EDHS 2008.

N= 14795	Sample characteristic		Prevalence of obesity		Adjusted OR[1]
	Total N	% (SE)	Total N	% (SE)	OR (95%CI)
TV exposure					
< once a week	670	3.8 (0.2)	166	26.4 (1.9)	1
≥ once a week	14125	96.2 (0.2)	5404	39.7 (0.6)	1.89 (1.57, 2.28)
Newspaper exposure					
< once a week	13261	89.1 (0.5)	4927	39.0 (0.6)	1
≥ once a week	1534	10.9 (0.5)	643	41.0 (1.7)	1.00 (0.89, 1.12)
Radio exposure					
< once a week	7906	51 (0.8)	2817	37.5 (0.8)	1
≥ once a week	6889	49 (0.8)	2753	41.1 (0.8)	1.15 (1.07, 1.23)
Own occupation					
Agricultural	387	2.6 (0.2)	132	39.1 (3.0)	1
Non-agricultural	2146	14.7 (0.5)	1001	47.1 (1.3)	1.36 (1.07, 1.72)
Unemployed	12262	82.8 (0.5)	4437	37.9 (0.7)	1.21 (0.97, 1.51)
Partner's occupation					
Agricultural	2625	17.7 (0.7)	860	35.1 (1.2)	1
Manual	4856	34.5 (0.6)	1716	37.3 (0.9)	1.21 (1.08, 1.35)
Non agricultural/non-manual	6654	47.8 (0.8)	2694	41.3 (0.8)	1.32 (1.19, 1.47)

[1]Adjusted for age group, area of residence and parity

Table 8.6 shows sample characteristics of the subgroups of media exposure by education level. TV watching was similarly frequent in all education groups, but newspaper reading was appreciably more frequent among women with higher education. The prevalence of obesity was higher in women who worked in the non-agricultural sector and women whose partner had a non-agricultural/non-manual occupation.

Table 8.6 Sample distribution and obesity prevalence shown for subgroups of TV and newspaper exposure by education level, EDHS 2008.

N= 14795		Sample characteristic		Prevalence of obesity		Adjusted OR[1]
		Total N	% (SE)	Total N	% (SE)	OR (95%CI)
TV by education level						
None/primary						
	< once a week	433	6.4 (0.4)	115	26.7 (2.2)	1
	≥ once a week	6356	93.6 (0.4)	2742	43.1 (0.9)	1.94 (1.57, 2.39)
Secondary						
	< once a week	109	1.7 (0.2)	26	23.9 (4.3)	1
	≥ once a week	6252	98.3 (0.2)	2323	37.1 (0.8)	1.55 (0.99, 2.42)
Higher						
	< once a week	17	1.0 (0.3)	6	34.2 (11.8)	1
	≥ once a week	1642	99.0 (0.3)	600	36.5 (1.5)	0.98 (0.37, 2.62)
Newspaper by education						
None/primary						
	< once a week	6722	99.0 (0.1)	2828	42.1 (0.9)	1
	≥ once a week	67	1.0 (0.1)	30	43.9 (6.7)	1.25 (0.73, 2.13)
Secondary						
	< once a week	5557	87.4 (0.6)	1974	35.5 (0.8)	1
	≥ once a week	804	12.6 (0.6)	375	46.6 (2.1)	1.17 (0.99, 1.37)
Higher						
	< once a week	915	55.2 (1.9)	348	38.0 (1.9)	1
	≥ once a week	744	44.8 (1.9)	257	34.6 (2.4)	0.76 (0.61, 0.96)

[1]Adjusted for age group, area of residence and parity

Table 8.7 shows the distribution of dietary indicators available from the women included in the dietary survey (N=5363). The obesity prevalence was lower than in the main sample (25.2% SE: 0.7). Most women had consumed bread, fatty foods (prevalence >80% for both) and meat (69.1% SE: 0.8), but fewer women had consumed fruit/vegetables (49.6% SE: 0.8) and a small proportion (16.4% SE: 0.7) had consumed sweet snacks. As for children, giving the child a sweet snack, bread or fatty foods (prevalence ≥40% for all) was more common than giving the child meat or fruit/vegetables (prevalence <30%). Obesity was more common in

those who were exposed to TV once a week or more (39.7% SE: 0.6 *vs.* 26.4% SE: 26.4% SE: 1.9%), whereas the difference by newspaper or radio exposure was small. The variation in the prevalence of obesity according to the respondent's diet was not particularly striking but was relatively high if women had consumed meat or fatty foods in the previous 24 hours. There was greater variation in the respondents' obesity prevalence according to their child's diet. The highest prevalence of obesity was found in women who had given their child sugary foods in the previous 24 hours.

Table 8.7 Sample distribution and obesity prevalence shown for dietary indicators, Egyptian DHS 2008.

N=5363	Sample characteristic		Prevalence of obesity		Adjusted OR[1]
	Total N	% (SE)	Total N	% (SE)	OR (95%CI)
BMI (kg/m^2)					
Non-obese (BMI<30)	4050	74.8 (0.7)			
Obese BMI (≥30)	1313	25.2 (0.7)			
Dietary consumption in					
Sweet snack					
No	4484	83.6 (0.7)	1103	25.4 (0.8)	1
Yes	879	16.4 (0.7)	210	23.9 (1.6)	0.88 (0.74-1.05)
Fruit/vegetables					
No	2664	50.4 (0.8)	745	25.5 (1.0)	1
Yes	2699	49.6 (0.8)	568	24.9 (1.0)	0.96 (0.85-1.09)
Meat/fish					
No	1697	30.9 (0.8)	374	22.9 (1.2)	1
Yes	3666	69.1 (0.8)	939	26.3 (0.9)	1.20 (1.04-1.38)
Fatty foods					
No	856	15.9 (0.7)	179	21.0 (1.5)	1
Yes	4507	84.1 (0.7)	1113	26.0 (0.8)	1.22 (1.02-1.46)
Bread					
No	537	10.0 (0.5)	108	21.4 (2.0)	1
Yes	4826	90.0 (0.5)	1205	25.6 (0.8)	1.31 (1.04-1.63)
Food given to youngest					
Sweet snacks					
No	3351	60.2 (0.9)	747	22.9 (0.9)	1
Yes	2012	39.8 (0.9)	566	28.7 (1.1)	0.88 (0.74-1.05)
Fruit/vegetables					
No	3935	73.9 (0.7)	968	25.3 (0.8)	1
Yes	1428	26.1 (0.7)	345	25.0 (1.4)	0.92 (0.80-1.07)
Meat/fish					
No	4079	75.9 (0.7)	967	24.6 (0.8)	1
Yes	1286	24.1 (0.7)	346	27.2 (1.4)	1.11 (0.96-1.29)
Fatty foods					
No	2353	43.6 (0.8)	521	22.6 (1.0)	1
Yes	3012	56.4 (0.8)	792	27.2 (1.0)	1.14 (1.00-1.30)
Bread					
No	2031	37.4 (0.7)	444	22.4 (1.1)	1
Yes	3334	62.6 (0.7)	869	26.9 (0.9)	1.13 (0.99-1.30)

[1]Adjusted for age group, area of residence and parity

Table 8.8 shows the subgroup frequencies for the use of sweet snacks and the consumption of fruit/vegetables by education level. The prevalence of mother's giving a sweet snack to their child seemed to increase with higher education level but that of giving the child fruit/vegetables did not seem to change.

Table 8.8 Sample distribution and obesity prevalence shown for subgroups of sweet snack use and fruit and vegetable use (given by the respondent to their youngest child) by education level, Egyptian DHS 2008.

N=5363	Sample characteristic		Prevalence of obesity		Adjusted OR[1]
	Total N	% (SE)	Total N	% (SE)	OR (95%CI)
Sweet snack use by education level					
None/primary					
No	1178	66.0 (1.3)	241	20.4 (1.3)	1
Yes	607	34.0 (1.3)	177	29.2 (2.1)	1.47 (1.16, 1.85)
Secondary					
No	1673	59.2 (1.1)	378	22.6 (1.1)	1
Yes	1151	40.8 (1.1)	339	29.4 (1.5)	1.39 (1.16, 1.66)
Higher					
No	366	49.8 (2.2)	114	31.2 (2.7)	1
Yes	369	50.2 (2.2)	97	26.3 (2.5)	0.72 (0.51, 1.00)
Fruit/vegetable use by education level					
None/primary					
No	1409	78.8 (1.1)	327	22.7 (1.3)	1
Yes	378	21.2 (1.1)	93	26.2 (2.5)	1.08 (0.84, 1.40)
Secondary					
No	2156	76.4 (0.9)	551	25.5 (1.1)	1
Yes	667	23.6 (0.9)	166	25.1 (1.8)	0.87 (0.72, 1.07)
Higher					
No	562	76.5 (1.9)	169	31.3 (2.2)	1
Yes	173	23.5 (1.9)	42	23.6 (2.9)	0.74 (0.51, 1.05)

[1]Adjusted for age group, area of residence and parity

8.1.2 SIMPLE ADJUSTED REGRESSION ESTIMATES

These are estimated using model 0 (see **Table 8.1**) and presented in the last column of **Tables 8.2** to **8.9** as the regression estimates for the odds of being obese adjusted for age group, area of residence and parity. These confirm the patterns observed using the frequencies. There was a positive association between obesity and increasing age group, wealth, number of children, partner's occupation, media exposure (including TV and radio, but not newspaper exposure), as well as consuming bread and fatty foods, and feeding the youngest child sugary foods. There was a negative or inverse association between obesity and education, area of residence (lower odds for rural dwellers than urban dwellers), and literacy. Those with an agricultural/unskilled manual occupation had lower obesity odds relative to those with a non-agricultural occupation.

8.1.3 MEDIATION ANALYSIS

This section presents the results following the rationale of models presented in **Table 8.1** building up to the final model. The intermediate models examining whether literacy modifies the wealth-obesity association, and whether education modifies the association between mediator variables (media exposure and dietary indicators) and obesity are presented individually in **Table 8.9, Table 8.10** and **Table 8.11**.

8.1.3.1 SUBSTITUTING LITERACY FOR EDUCATION IN THE MAIN INTERACTION MODEL

Table 8.9 compares the original model with the model substituting literacy for education using the main sample (N=14795). This shows that literacy has a protective effect and attenuates the association between wealth and obesity, similarly to education.

Table 8.9 Estimates comparing the model of the interaction of education and wealth on obesity and the model of the interaction of literacy and wealth on obesity, Egyptian DHS 2008.

N=14795	Model 1[1] (original model: Education*wealth interaction)	Model 2[1] (Original model with literacy substituted for education: Literacy*wealth interaction)
	Adjusted OR (95%CI)[1]	Adjusted OR (95%CI)[1]
Separate effects		
Wealth quintile	1.24 (1.20-1.28)	1.24 (1.20-1.28)
Education		
None/primary	1	-
Secondary	1.19 (1.09-1.29)	-
Higher	1.00 (0.88-1.14)	-
Literacy		
Cannot read	-	1
Reads with difficulty	-	1.06 (0.92-1.22)
Reads easily	-	1.20 (1.10-1.30)
Joint effects on obesity		
Wealth trend by education level		
None/primary	1.35 (1.29-1.42)	-
Secondary	1.24 (1.18-1.31)	-
Higher	1.06 (0.92-1.21)	-
P for interaction	*<0.001*	
Wealth trend by literacy level		
Cannot read	-	1.37 (1.30-1.45)
Reads with difficulty	-	1.33 (1.19-1.48)
Reads easily	-	1.19 (1.13-1.24)
P for interaction		*<0.001*

[1] Estimates adjusted for age group, area of residence and parity.

8.1.3.2 THE EFFECT OF WEALTH ON MEDIA EXPOSURE BY EDUCATION LEVEL

Table 8.10 examines the modifying effect of education on the association between wealth and three types of media exposure in the main sample (N=14795), using regression models incorporating the three different media exposures as outcome variables in turn, and adjusting the estimates for age group, area of residence and parity. The results show that there

was a positive association between wealth and each type of media exposure, the magnitude of which was much greater for TV exposure compared with radio or newspaper exposure.

The joint effect estimates for the wealth trend within each education group showed that increasing education level reduced TV exposure but increased newspaper exposure. The LR test comparing the model with and without an interaction term between education and wealth with media exposure as the outcome provides strong evidence for the model incorporating an interaction between education and TV exposure (P<0.001), the latter being the media exposure of main interest. TV exposure was chosen as the media exposure of interest informed by the conceptual framework and the above results which confirmed that TV viewing had the highest odds of obesity compared with newspaper reading or radio listening.

Table 8.10 Estimates for the model examining the interaction of education and wealth on three different types of media exposure, Egyptian DHS 2008.

	Outcome=TV N=14795	Outcome=radio N=14795	Outcome=newspaper N=14795
	Adjusted OR[1]	Adjusted OR[1]	Adjusted OR[1]
Separate effect			
Wealth	3.18 (2.88, 3.52)	1.47 (1.42-1.51)	2.44 (2.28-2.60)
Joint effects on media exposure			
Wealth trend by education level			
None/primary	3.88 (3.31, 4.56)	1.49 (1.42, 1.56)	1.43 (1.18, 1.73)
Secondary	2.45 (2.07, 2.88)	1.24 (1.19, 1.30)	1.52 (1.40, 1.65)
Higher	2.34 (1.62, 3.37)	1.28 (1.14, 1.45)	1.90 (1.61, 2.24)
P for interaction	*<0.001*	*<0.001*	*0.02*

[1]Adjusted for age group, area of residence and parity

8.1.3.3 THE EFFECT OF MEDIA EXPOSURE ON DIETARY BEHAVIOUR BY EDUCATION

Table 8.11 examines the modifying effect of education on the association between TV exposure and the two dietary indicators of interest, using the smaller dietary subsample (N=5363). Due to a lack of power it was not possible to derive estimates from the regression model using the education variable with three levels. Therefore, the education variable was

collapsed so that the secondary and higher education groups formed a single group (see education variable section in Chapter 4). The adjusted OR estimates suggest that exposure to TV once a week or more was associated with increased odds of a mother giving a sweet snack to her child, and this association was stronger in mothers with no or primary education. On the other hand, the estimates suggested that mothers with no/primary education who were exposed to TV once a week or more were less likely to feed their child fruit or vegetables compared with mothers who had higher levels of education. While statistically there was no evidence to support this association, the magnitude of estimates and their pattern by education level are suggestive. The absence of statistical evidence may be explained by the small sample size limiting the study's power to detect these associations.

Table 8.11 Estimates for the model examining the interaction of education and wealth on dietary behaviour, Egyptian DHS 2008.

N=5363	Outcome = Respondent gave a sweet snack to her child in the last 24 hours	Outcome = Respondent gave fruit/vegetables to her child in the last 24 hours
	Adjusted OR (95%CI)[1]	Adjusted OR (95%CI)[1]
Separate effect		
TV exposure		
<once a week	1	1
≥ once a week	1.74 (1.30-2.34)	0.79 (0.38-1.66)
Joint effects on dietary behaviour[2]		
TV exposure by education level		
None/primary	1.71 (1.19, 2.46)	1.02 (0.71, 1.47)
Secondary/higher	1.26 (0.74, 2.14)	1.75 (0.91, 3.38)
P for interaction	*0.4*	*0.1*

[1]Adjusted for age group, area of residence and parity
[2] Effect in the group exposed to TV '≥ once a week' with the group exposed to TV '<once a week'

8.1.3.4 FULL MODEL FOR THE INTERACTION BETWEEN EDUCATION AND WEALTH INCORPORATING MEDIA EXPOSURE AND DIETARY BEHAVIOUR

Table 8.12 and **Table 8.13** show the results for all the models listed in **Table 8.1** and incorporates the intervening media exposure, dietary indicator and additional confounders to examine the role of the mediators on the interaction between education and wealth. The following description focuses on the changes in the magnitude of the wealth trend within each education level. In **Table 8.12**, the results show that the addition of the TV exposure variable had little impact on the estimates but the addition of an education by TV exposure interaction term reduced the magnitude of the wealth trend enough that the ORs for this model (model 3b) were just outside the 95% confidence interval for the wealth trend estimates of model 1. For example, the wealth trend estimate in the no/primary education group in model 1 was 1.35 (95%CI: 1.29, 1.42); whereas the estimate for model 3b in this group was 1.28 (95%CI: 1.21, 1.35).

No attempt was made to add an interaction term between education and the dietary variables as it was already known that power would be insufficient to test this. However, the models to estimate the wealth effect by education group shown in **Table 8.1.** were all fitted to the smaller dietary subsample (N=5363) and are shown in **Table 8.13.** This allowed a comparison to be made of these estimates with the estimates obtained from the full sample (N=14975). The results show that the magnitude and direction of the wealth trend by education level estimates were similar suggesting consistency between the larger and smaller dietary samples.

8.1.3.5 INCORPORATING ADDITIONAL CONFOUNDERS

The occupational variables (partner's occupation and own occupation) had little impact and showed no association with the outcome.

Table 8.12 Estimates for the model examining the interaction of education and wealth on obesity and incorporating media exposure as a mediator, EDHS 2008 – full sample.

N=14795	Model 1 (original interaction model) Adjusted OR (95%CI)[1]	Model 3a (model 1 + TV exposure) Adjusted OR (95%CI)[1]	Model 3b = model 1 + education*TV interaction Adjusted OR (95%CI)[1]
Joint effects on obesity			
Wealth trend by education level			
None/primary	1.35 (1.29,1.42)	1.33 (1.27,1.40)	1.28 (1.21 , 1.35)
Secondary	1.24 (1.18,1.31)	1.24 (1.18,1.30)	1.17 (1.10 , 1.24)
Higher	1.06 (0.92,1.21)	1.05 (0.92,1.21)	0.98 (0.84 , 1.15)
P for interaction	<0.001	0.002	0.003
TV exposure by education level			
None/primary			1.54 (1.24, 1.92)
Secondary			1.25 (0.80, 1.97)
Higher			1.00 (0.37, 2.68)
P for interaction			0.5

[1]Adjusted for age group, area of residence and parity

Table 8.13 Estimates for the model examining the interaction of education and wealth on obesity and incorporating media exposure and swe et snack use as mediators, EDHS 2008 – dietary sample.

N=5363	Model 1 (original interaction model) Adjusted OR (95%CI)[1]	Model 3a (Model 1 + TV exposure Adjusted OR (95%CI)[1]	Model 3b = model 1 + education*TV interaction Adjusted OR (95%CI)[1]	Model 4 = model 3b + sweet snack use Adjusted OR (95%CI)[1]	Model 5 = model 4 + additional confounders Adjusted OR (95%CI)[1]
Joint effects on obesity					
Wealth trend by education level					
None/primary	1.37 (1.23, 1.52)	1.35 (1.21, 1.50)	1.35 (1.21, 1.51)	1.34 (1.21,1.50)	1.35 (1.21,1.51)
Secondary	1.33 (1.22, 1.44)	1.32 (1.22, 1.43)	1.31 (1.21, 1.42)	1.31 (1.21,1.42)	1.30 (1.20,1.41)
Higher	1.17 (0.96, 1.44)	1.17 (0.95, 1.44)	1.18 (0.96, 1.44)	1.17 (0.95,1.43)	1.19 (0.97,1.47)
P for interaction	0.4	0.5	0.2	0.1	0.2
TV exposure by education level					
None/primary			1.18 (0.77, 1.80)	1.16 (0.76, 1.78)	1.21 (0.78, 1.87)
Secondary			2.18 (0.86, 5.57)	2.19 (0.86, 5.58)	2.16 (0.84, 5.51)
Higher			0.65 (0.10, 4.22)	0.65 (0.10, 4.24)	0.64 (0.10, 4.23)
P for interaction			0.4	0.3	0.4

[1]Adjusted for age group, area of residence and parity

9 CHAPTER 9: DISCUSSION AND CONCLUSIONS

This chapter summarises the findings of the thesis and discusses them with reference to the conceptual framework proposed in the literature review. The interpretation of the results draws on the theory that education may be a key driver of the reversal of the social gradient of obesity, but competing interpretations are also discussed together with the methodological issues and limitations of the thesis research. The chapter ends with a brief discussion of policy implications and a summary of lessons learnt from the doctoral research process.

9.1 SUMMARY OF THE EMPIRICAL FINDINGS

The thesis sought to investigate the SES-obesity association in women in more detail than had been done previously in low- and middle-income countries (LMICs) and focused in particular on the possible role of education as a protective factor driving the reversal of the SES-obesity gradient in women. The findings were consistent with the reversal of the social gradient and showed that education can modify the obesogenic association between improved material circumstances and obesity at middle-levels of country economic development. The postulated mechanism of better cognitive skills influencing the impact of TV exposure had some support, although inferences regarding the impact of dietary behaviour were limited by the statistical power of the sample. The results from the individual chapters are summarised below.

The analysis of the nationally representative Egyptian DHS samples of women in **Chapter 5** showed that an interaction existed whereby education level modified the association between household wealth and obesity and was present in the 1990s as well as in the late 2000s. In women with the lowest education level (no/primary education), moving up one wealth quintile was associated with a 38 to 81% increase in the odds of obesity depending on the time period. In contrast, for women with the highest level of education there was little evidence of a significant association. Secondary findings were: 1) a diminution of the magnitude of the positive estimates for the associations between each of education and wealth and obesity over time; and 2) a faster rate of increase in obesity prevalence among the poorer, less educated and

rural groups. These findings support the hypothesis of reversal of the SES-obesity association over time (for both SES indicators) and begin to provide an explanation – an increase in the prevalence of obesity in lower educated and poorer women relative to their more educated and richer counterparts.

Chapter 6 placed the findings from the Egyptian DHS data within a global context using a cross-country comparison. The main objective was to further model the time-variation in the SES-obesity association in LMICs including the separate and joint effects of education and wealth on obesity. The country sample obtained for comparison with Egypt consisted of six countries - three were appreciably wealthier (Colombia, Jordan, Peru) and three appreciably poorer (Benin, India, and Nigeria). The analysis provided further support for a time-varying SES-obesity association dependent on the level of economic development - assuming a positive trajectory of economic growth over time in LMICs. The analysis also showed that the interaction between education and wealth was only present at middle levels of country income thus suggesting that education becomes a protective factor when countries reach middle-levels of GNI per capita. The estimates for the separate effects of education and wealth on obesity were consistent with the reversal of the social gradient. The wealthier countries displayed associations that were similar to Egypt with education protecting against the obesogenic effect of wealth and the wealth-obesity association becoming attenuated, while the poorer countries displayed positive associations between each of education and wealth and obesity with no protective education effect.

The analysis in **Chapter 7** further investigated the hypothesis that education modifies the association between material circumstances (proxied by occupation) and central obesity in another middle-income country. China was examined as a critical case with a similar level of economic development as Egypt and similarly fast rate of increase in obesity levels but where obesity levels remain comparatively low. Data from the China Four-Provinces study on women's longest-held occupation was used to model the improvement in material circumstances that occurs with transition from an agriculture-based to manufacturing and

service-based economy. The results show that moving from a peasant to a non-peasant occupation was associated with twice the levels of central obesity in women who had received no formal education, while in women who were educated there was no evidence of this association. Secondary findings included a high prevalence of high-risk central adiposity in this representative population.

Finally, **Chapter 8** explored a putative pathway linking education, wealth and obesity through mediators (literacy, TV exposure and the use of sweet snacks). The analysis strategy focused on two possible points of influence for education on the obesogenic wealth pathway. The results showed that increased wealth resulted in higher exposure to TV watching; and TV watching, in turn, increased the odds of unhealthy dietary behaviours measured as the odds of a mother feeding her child sweet snacks. However, education appeared to modify these effects by attenuating the wealth-TV association, as well as attenuating the TV-sweet snack use association. The results also showed that a proxy for cognitive skills –literacy- could substitute for education in the interaction model and may therefore mediate the protective effect of education. The impact of adding an interaction term between education and TV watching to the main model seemed to have a small but statistically significant effect on the estimates for the wealth-obesity association by education level (adjusted OR outside the 95%CI of the original OR). The dietary sample was too small to fully assess the impact of adding the dietary indicator to the model.

Secondary findings from the exploratory analyses in **Chapter 8** were that wealth and education both influenced the type and frequency of media exposure. Wealth was positively associated with TV watching (greatest magnitude of OR in the group with no/primary education); and more weakly so with newspaper reading (greatest magnitude of OR in the group with higher education). Similarly TV watching reduced the use of fruit and vegetables but higher education enhanced it. The statistical evidence was stronger for the influence of education on the first part of the pathway (wealth-media exposure) than the second (media-

dietary behaviour) which, as mentioned above, was likely to be the result of insufficient study power in the dietary sample.

9.2 PLAUSIBLE INFERENCES

The thesis sought to contribute empirical evidence to the concept of a unique and context specific social epidemiology of obesity, particularly to the notion that there may be different causal pathways linking social factors and obesity, by investigating two commonly considered social determinants of health - education and material circumstances. This was made possible by the unique social epidemiology of obesity in LMICs. The material and cognitive pathways were explored in this thesis with wealth (and occupation) representing the primary exposure in a material, obesogenic pathway; and education the primary exposure in a protective cognitive pathway.

Bearing in mind that the thesis was hypothesis driven, the following sections discuss the findings in an attempt to answer the two main questions posed in the thesis title. The evidence for the causal associations is discussed in the light of the Bradford-Hill criteria to evaluate causality including: the coherence of the findings with prior studies, the strength of the main association, the consistency of the findings, the existence of a dose-response relationship, the theoretical plausibility and the relationship to alternative explanations. The criteria of reversibility, temporality and specificity could not be adequately addressed due to the cross-sectional nature of the data used in the thesis.

9.2.1 IS THE SOCIAL GRADIENT OF FEMALE OBESITY REVERSING?

The findings support the existence of a SES-obesity reversal through their consistency across the thesis empirical findings as well as corroboration with prior studies in the published literature, as follows.

9.2.1.1 CONSISTENCY OF FINDINGS IN THE THESIS ANALYSIS

The attenuation of the education-obesity and wealth-obesity associations both over time in Egypt and with increasing level of economic development when comparing different countries is consistent with the reversal of the social gradient of obesity. For example in **Chapter 6**, all of the poorer countries displayed a positive association for each of education and wealth with obesity and no evidence of an interaction between the two, while all of the middle-income countries displayed the existence of an interaction.

In terms of explanations, the large difference in overall female obesity prevalence between Egypt and Jordan on the one hand (>30%) and Peru and Colombia on the other (<15%) suggests that regional factors of a cultural nature may have a role in explaining the obesity epidemic in middle-income countries, through cultural context, social norms and network effects. In addition, concerns over social distinction may lead individuals, and particularly women, to adopt the behaviours that allow them to meet expected standards of beauty defined by regional or national preferences. In Egypt and Jordan these social norms may favour plumpness in women. This may lead to the expectation that the social epidemiology of obesity may also differ.

However, the protective effect of women's education was consistent across all middle-income countries regardless of region or overall obesity levels and was also reproduced in the two different datasets used. The findings in China using the Four-Provinces Study show that the protective role of education can be found in middle-income countries with relatively low levels of female obesity. The findings from the thesis analyses suggest that level of economic

development is the strongest determinant of the presence or absence of the protective education effect, although explanations for this can only be speculated upon.

The results for Peru were the most similar to those of Egypt, which may be explained by the fact that it is close to Egypt in terms of GNIpc, while Jordan, which is culturally more similar to Egypt as well as being close to Egypt in terms of GNIpc at the time of the survey, displayed results more similar to Colombia. One explanation is that Jordan is a highly urbanised country and the majority of its residents live in cities and therefore exposed to a more advanced stage of the nutrition transition and greater media reach than Peru or Egypt where a greater proportion of women were rural. The levels of foreign direct investment and country inequality did not appear to explain the country differences observed.

9.2.1.2 COMPARISON WITH PRIOR STUDIES

Since the early 1990s, there has been a growing number of studies using data from lower income countries to examine the association between SES indicators and adiposity (Martorell et al., 2000, Sobal and Stunkard, 1989, Ziraba et al., 2009, Monteiro et al., 2004a) and how it changes over time (Austin et al., 2011, Molarius et al., 2000, Jones-Smith et al., 2011, Neuman et al., 2011). The implication from the thesis findings that there is a dynamic change in the SES-obesity association corroborates findings from most studies in this area (Sobal and Stunkard, 1989, Martorell et al., 1998, Martorell et al., 2000, Puoane et al., 2002, Monteiro et al., 2004a, McLaren, 2007, Jones-Smith et al., 2011, Dinsa et al., 2012). Assuming there is a reversal of the SES-obesity association, the thesis findings suggest that it is the education-obesity association that reverses first and may therefore drive the overall reversal of the SES-obesity association. As described in Chapter 3, findings from Brazil would corroborate this. Regional differences show that in the poorer North both education and income are positively associated with obesity while in the richer South, the education-obesity associated is inverse.

There are few studies claiming that DHS data do not provide any evidence of an SES-obesity reversal including the Subramanian et al and Neumann et al studies (Subramanian et al., 2011, Neuman et al., 2011). For example, the latter report that the magnitude of the wealth-overweight association is unchanged based on repeat surveys in 36 LMICs. This may be due to the use of different outcomes (overweight rather than obesity) but, notably, the authors place little emphasis on the education-overweight association in their interpretation of the findings.

One argument for emphasising material circumstances captured by wealth over education is that the former may be a more reliable indication of socio-economic status but, as discussed in the introduction, this may mask the complexity of the social transition experienced in LMICs and obscure aetiological pathways. A number of studies from LMICs have reported separate effects of education and economic resources including Peru, the Philippines, China and Brazil (Poterico et al., 2011, Dahly et al., 2010, Hou et al., 2008, Monteiro et al., 2001) – patterns comparable to earlier findings from Eastern Europe during its economic transition in the early 1990s, when education and material circumstances acted differently as SES indicators of health outcomes (Bobák et al., 2000).

The proposition that the education-adiposity association may reverse before the wealth-adiposity association would allow a reinterpretation of these studies (Subramanian et al., 2011, Neuman et al., 2011) by suggesting that the education-adiposity association and the wealth-adiposity association may reverse at different times during economic development and that the education-adiposity association may appear flat or absent and make the wealth-adiposity association look more impressive.

Finally, the diminishing magnitude of the estimates for education and wealth reported in the thesis is consistent with the predicted tipping point for the reversal (a GNP per capita of $2500 (Monteiro et al., 2004a)). The findings from the period examined in Egypt (1992-2008) show that the association between the two SES indicators and obesity weakened over this period while Egypt's GNI per capita grew from ~$600 to $1,801. The prevalence estimates reported in

Chapter 5 suggest that this is mainly driven by a large increase in the prevalence of obesity in lower SES and rural groups relative to a much smaller increase in the higher SES and urban groups. Other, recent studies using DHS data have reported that lower SES groups are experiencing the most rapid increase in obesity risk (Jones-Smith et al., 2011, Austin et al., 2011).

9.2.1.3 BIOLOGICAL PLAUSIBILITY

The thesis could not examine physiological or genetic factors. In the context of the thesis, *biological* refers to the existence of social and psychological pathways leading to increased consumption of calories and their reduced expenditure which themselves have biological consequences on body composition.

As theorised in the conceptual chapter, the obesogenic effect of wealth and the protective effect of education may be explained through the changing social and economic context and its relationship to knowledge, culture and health behaviours. Increasing wealth in LMICs will result in greater access to food including take-away and fast food and an escape from physical labour (Du et al., 2004), therefore resulting in a higher risk of obesity. The faster rate of increase in obesity levels in the lower SES groups has been attributed to a disproportionate response to contextual changes linked to the nutrition transition (Jones-Smith et al., 2011). Explanations include a link with food insecurity (Rosen and Shapouri, September 2008) and a mismatch between early life poverty and the potentially greater abundance experienced in adult life in LMICs causing a significant mismatch between metabolic programming and energy availability (Gluckman et al., 2008, Prentice, 2009).

The results from the cross-country comparison in Chapter 6, suggesting that the reversal occurs over time and that the education-obesity association reverses first, may be explained through the level of food insecurity. In the low-income countries - where absolute poverty is more common - any means of acquiring greater economic resources including a higher

education level, may be employed towards securing economic resources and enough food through behaviours geared towards energy accumulation and the maximisation of consumption. The existence of absolute poverty and hunger means that obesity is not a health concern at all compared with undernutrition, and therefore that women with higher education do not acquire health knowledge related to obesity prevention.

Furthermore, the perception of wellbeing and success will also change with the country's level of economic development and affect the relationship of education and wealth with obesity. In a context where food is becoming abundant and obesity more common, as in middle-income countries, cognitive skills may start to take on a new role allowing individuals to see the health consequences of excessive nutrition and empowering them to use any available health information to better control their life outcomes (Marmot and Wilkinson, 2001, Mirowsky and Ross, 2003, Pickett et al., 2005).

In addition, at later stages of economic development, when cheap energy-dense foods are abundant, the stress of inequality experienced by lower SES individuals may manifest through overeating, whereas in lower income countries this option is not available to the poorest groups. With respect to the latter, Egypt is a special case where calories have been relatively cheap for a long time through the subsidy system, thus potentially explaining why obesity levels are exceptionally high particularly among low SES groups. From a cultural perspective, thinness may be used as a new form of social distinction in an environment where calories are available to all. As discussed in Chapter 3, these are likely to be transient aspects of the social, dietary and cultural environments that occur with economic development, and that eventually transform for those with the most economic resources into new norms of healthy eating and beauty that favour thinness.

Therefore, the remarkably large increase in obesity prevalence observed in the lower SES groups in Egypt, and that may account for the reversal of the SES-obesity association, could be a result of the adoption of new patterns of consumption (diets high in sugar and

saturated fat) and sedentary levels of physical activity (Ezzati et al., 2005). There are few empirical studies of SES and dietary patterns in Egypt in the literature, however, one study reported a greater propensity to consume meat, fats and sugar in the poorer rural populations than in urban ones (Dawoud, 2005). Furthermore, the consumption of soft drinks in Egypt has increased dramatically over the period examined, particularly in groups of lower SES status (Euromonitor, 2012).

The findings from the analysis of the Four-Provinces data suggest that education may counteract the detrimental effect that changes in occupational status from agricultural to non-agricultural may have on obesity odds. Possible explanations include better occupational and therefore living conditions afforded to those with a degree of education, as well as the cognitive advantages put forward in this thesis. Working in a non-peasant occupation is likely to be associated with more sedentary patterns of physical activity and higher levels of consumption of foods rich in fat and sugar, therefore leading to a higher risk of excess adiposity, particularly as moving to non-agricultural work may involve migration to urban environments (Gong et al., 2012). It is estimated that 229.8 million migrant-rural workers living and working in Chinese cities for most of the year, find that their lifestyle is altered both by the nature of their work and their urban environment (Yang et al., 2010a).

There was a high prevalence of central obesity in the rural areas of the Chinese Four-Provinces study corroborating findings from a meta-analysis of Chinese secular trends showing that the prevalence of overweight and obesity has increased at a faster rate in poorer rural areas than in richer urban areas (Wang et al., 2007). As for Egypt, one explanation is that lower income groups have disproportionately increased their consumption of animal fat and edible oil and reduced their consumption of healthier traditional foods catalysed by economic growth and urbanisation which has been demonstrated empirically (Du et al., 2004). Remittances sent from urban relatives back to their rural families may also have a role (Gong et al., 2012).

9.2.2 CAN EDUCATION DRIVE THE REVERSAL OF THE SOCIAL GRADIENT OF FEMALE OBESITY?

The conceptual chapter built a hypothesis proposing that education can be considered to be a health asset in a knowledge economy and that it protects against the obesogenic effects of improved material circumstances experienced by individuals in countries currently undergoing economic development.

9.2.2.1 THEORETICAL PLAUSIBILITY

The thesis was hypothesis driven and the theoretical elements of the conceptual framework informed by research in the fields of social epidemiology, psychology and nutritional policy. However, important additions to the role of education as a protective factor against obesity in emerging economies can be made by drawing on other disciplines. As described previously from an economics' perspective, increasingly marketised capitalist societies make available an ever growing number of products and services to emerging middle classes and may result in an asymmetry of information between buyers and sellers (Eizenbergy and Salvoz, 2012). This asymmetry of information leads to inefficient transactions and market failure and constitutes a social and ethical problem as well as an economic one. For example, the increasingly complex nature of the products consumed, including manufactured and processed foods, muddy the contract between buyer and seller in terms of where the responsibility lies for ensuring an understanding of the nature and quality of the product being exchanged (Becher, 2008).

Behavioural economics has emerged as a discipline aiming to realign the observed (mis)behaviour of consumers - poor lifestyle and consumption choices – and very much operates within the economic paradigm that individuals are responsible, rational agents that should be left to behave in their own best interest. A central reason put forward for these aberrant behaviours is the limited ability of individuals to retain and use accurate health

information as well as low levels of self-control over instincts rooted in our biological programming.

However, markets are also given a small measure of responsibility in the behavioural economics paradigm for nurturing these *perverse and sub-optimal* behaviours, since the profit motivations of companies can become predatory particularly in their use of marketing to achieve their ends (Just and Payne, 2009). The advantage these corporations have both financially and in terms of know-how, cannot be matched by the often embryonic public health and regulatory systems in these lower –income countries, not to mention the need for revenue and job creation, thus potentially creating an imbalance between national interests and those of transnational corporations. As a result, the information asymmetry problem can be difficult to remedy through traditional policies (Vining and Weimer, 1988) but the nature of the asymmetry may be reduced through better information availability and use through improved educational levels of civil society or consumers. In other words, the information asymmetry in lower-income countries calls for an important role for promoting access to formal education and the development of relevant cognitive skills to empower individuals.

Another theoretical argument for the role of education in providing cognitive skills to protect against the new diseases of affluence affecting lower-income countries comes from the psychology of media communication. Research shows that the availability of cognitive resources to process media exposure is an important determinant of the knowledge gap between socioeconomic groups (Grabe et al., 2009) - knowledge gaps being the discipline's equivalent of health inequalities in epidemiology. In other words, knowledge acquisition from media outlets is defined along socioeconomic lines (Kwak, 1999). The knowledge gap hypothesis formalised by Tichenor, Donohue and Olien in 1970 posits that: *"As the infusion of mass media information into a social system increases, segments of the population with higher socioeconomic status tend to acquire this information at a faster rate than the lower segments, so that the gap in knowledge between these segments tends to increase rather than decrease"* (Kwak, 1999).

In lower-income countries where a liberalisation of the economy has taken place, there may be a large amount of information to process, for example from widespread marketing and advertising of new consumer products that is not balanced by more objective information available through public health systems and consumer protection agencies, or restricted by regulatory bodies that minimise the harm products may cause through false advertising claims. Therefore, those who are less well equipped to acquire the right kind of information are likely to be at a disadvantage. They may lack the cognitive skills that can help sift and sort the information encountered by individuals and assist in making healthy decisions more salient amid the many competing needs and demands resulting from the of rapidity of social change and the effects of longstanding economic and food insecurity. Arguably, in these intermediate stages of economic development where markets open before adequate state and social institutions can develop, formal education may be the only asset available to individuals in protecting their health from the diseases of overconsumption.

9.2.2.2 DOSE-RESPONSE RELATIONSHIP

The declining magnitude of the estimates for the joint effects of wealth and education with increasing education level supports the protective role of education. The wealth-obesity association appears to be attenuated with increasingly higher education level in the middle-income countries examined in this thesis: the estimates for the association in the group with no/primary education are larger than those in the group with secondary education which in turn are larger than those with higher education.

9.2.2.3 CONSISTENCY ACROSS DATASETS

Despite the slightly different model specification, the validity and generalisability of the findings from the DHS may be strengthened by the fact that education was also found to have a protective role against obesity in a different dataset in China (the Four-Provinces study).

9.2.2.4 EMPIRICAL EVIDENCE OF A MECHANISM

The thesis investigation was hypothesis driven and the statistical evidence supported the hypothesis that wealth and education may be linked to obesity. The addition of mediator variables did not have a large impact on the SES-obesity association investigated but some of the results were suggestive within the power limitations (see summary of findings section).

9.2.2.5 COMPETING EXPLANATIONS

Alternative hypotheses explaining the association between education, wealth and obesity may explain why there was little change in the main estimates after the addition of the postulated mediator variables to the model. However, they do not necessarily invalidate the current hypothesis and, in fact, may complement it. As discussed in the conceptual chapter, there are numerous putative pathways linking education and health.

Education may offer better employment opportunities and higher income as a result, thus affording individuals the possibility to acquire more of what they consider valuable for their well-being (Bartley, 2004). However, when occupation and income/wealth are taken into account, studies show that there is still a residual protective effect of education, which may be explained through early life or cumulative effects, or through adult characteristics such as time preferences. For example impulsive behaviour in early childhood has been linked to health outcomes in adulthood (Chandola et al., 2006b). Psychosocial mechanisms may also have a role in that higher education and social status may minimise the stress of frustrated expectations resulting from exposure to the advertising of products that are not within the reach of a large proportion of households in any LMIC.

Other pathways, related to the cultural context, social norms and network effects may also be at play (Christakis and Fowler, 2007). Concerns over social distinction may lead individuals, and particularly women, to adopt the behaviours allow them to meet expected standards of beauty for their socio-economic group. For example in Egypt, education may not

be a guaranteed way out of poverty (Galal, March 2002), therefore, some women may choose to forego education and seek upward mobility through other routes such as marriage, thus creating a stratum of women who have better living conditions but low education levels. These women are likely to come from more traditional backgrounds which may impose restrictions on their mobility and favour higher body weight as a beauty standard. In contrast, less wealthy women with high levels of education may come from progressive families, and adopt more Western norms of female beauty that favour slim body shapes as well as endorse more physically active leisure time activities. At the higher end of the wealth distribution, women may be able to reap more fully the benefits of higher education, because wealth may enable them to adopt healthier behaviours through access to expensive foods and sports facilities.

However, cultural preferences shaping body shape norms and attitudes towards physical activity may be shaped by educational level through cognitive skills. Christakis and Fowler's social network study of obesity (Christakis and Fowler, 2007) postulated that person-person induction of obesity can occur through the influence of personal norms regarding weight. The spread appeared to depend less on behavioural imitation and more on a subject's general perception of social norms regarding the acceptability of obesity. The latter is likely to be related to an individual's level of education. The contribution of these pathways could not be tested in this thesis but the wide geographical variation in the middle-income countries displaying the interaction between education and wealth (see Chapter 6) suggests that economic development is more important that national culture or identity. For a more complete understanding of the interaction between education and wealth contextual factors such as urbanisation, changes in the food environment as well as locally relevant factors would need to be taken into account.

The focus in this thesis has been on dietary pathways, but it is possible for SES-obesity association to be mediated through the physical environment and cultural restrictions on female mobility rather than through media exposure and dietary behaviour. With respect to the built environment in Egypt however, a recent study representative of the Cairo population reported

the absence of an association between access to parks and green spaces and obesity (Mowafi et al., 2012). It was not possible to test this using the DHS data and small area data are needed. Finally, social cohesion may be higher among those who are educated, for example, as a result of living in safer neighbourhoods (Mowafi et al., 2011). Social cohesion has been postulated as a key determinant of Japan's exceptional longevity and good health, although high education levels and adherence to traditional diets were also put forward (Takasaki et al., 2012).

9.3 METHODOLOGICAL STRENGTHS AND LIMITATIONS

Some have argued that the causes of obesity cannot be adequately studied through observational studies and that epidemiology is limited in a number of ways including: the fact that associations do not prove causation; (residual) confounding; reverse causation; limitations of methods to study energy expenditure and intake; and non-differential misclassification of energy intake. The latter describes the phenomenon whereby underreporting of energy intake increases with BMI creating an erroneously negative association between energy intake and BMI. Moreover, different sources of calories may contribute in different ways to energy balance (Seidell et al., 2005). For instance, soft drinks may bypass our satiety mechanisms through lack of bulk in the stomach (Wells, 2010). However, cross-sectional studies including time-trend and country comparisons have provided important insights for the study of obesity as a modern epidemic and, when considering the totality of the evidence, they help draw up a compelling case for making causal inferences based on the Bradford Hill criteria within the limitations of the data and methods. The methodological limitations of the thesis analysis are described below.

9.3.1 CROSS-SECTIONAL DATA

The thesis aimed to go beyond the uni-dimensional analysis of SES and obesity in order to separate the associations between individual SES indicators and obesity, and examine how

they intersect. The weight of evidence from all the analyses combined suggests education may well have a protective role. However, the cross-sectional nature of the data limits the temporal interpretation of the findings in relation to the reversal of the SES-obesity association. Furthermore, the bi-directionality (reverse causality) of the associations could not be taken into account since all the covariates were measured at the same time. However, it is unlikely that obesity limited access to educational opportunities in the countries examined in any significant way and it is more likely that higher levels of education are associated with lower levels of obesity based on theory and prior studies that provide corroborating evidence for the protective effect of education (see above).

9.3.2 SAMPLE SELECTION AND GENERALISABILITY

In C**hapter 5**, the analysis took advantage of the opportunity offered by the Egyptian DHS data, which are unique in the number of repeat standard survey waves they include, to create two samples of pooled data. This provided large sample sizes and hence greater power to reveal underlying trends and associations which could otherwise be obscured by large sampling variability in smaller individual datasets. The data restrictions to ensure comparability over the time periods reduced the sample to women who had been married and had a child under five years old and would have limited the generalisability of the findings. However, the high marriage rate in Egypt (estimated at >80% in the 20-49 years age group) and the findings of the sensitivity analysis which relaxed the data restrictions meant that the patterns observed were likely to be found in the general population of Egyptian women in the reproductive age range whether they were married or had children.

An important limitation of the cross-country comparison in **Chapter 6** is that only seven countries are used whereas larger samples (reaching up to 37 countries) are used in the key cross-country comparisons in the published literature. However, the latter do not allow for the level of detailed analysis employed in this thesis. In addition, the use of a systematic

selection criterion resulting in a broad range of countries representing different geographical regions increased the validity and generalisability of the findings.

The characteristics of the Egyptian DHS and Four-Provinces participants in the thesis research were consistent with national estimates from other sources suggesting they are representative. For example, the Egyptian national census shows stable proportions of urban and rural dwellers as in the DHS (El-Zanaty and Way, 2009) and the reasons for this have been investigated elsewhere (Zohry, 2002). Similarly, the proportion of women reporting that they are not in paid employment in the Egyptian DHS samples was greater than 70%, which was consistent with the relatively low labour participation rates (<30%) reported in Egyptian women over 15 years of age during the time period of 1992-2008 .

In **Chapter 7**, the Four-Provinces Study data consisted of randomly recruited older women from four provinces in China. The studied population had a high response rate and included anthropometric data. The prevalence of central obesity in the analysis using the Four-Provinces data collected in 2008/09 corroborates others in documenting the high levels in China. Estimates from the China Health and Nutrition Survey from 1993 to 2009, representing a total of 52621 participants, showed that there was a significant increase in central obesity in Chinese women 60 years and over from 47.4% (SE: 2.4) in 1993 to 66.5% (SE:1.3) in 2009 (Xi et al., 2012). The latter figure for central obesity prevalence is comparable to that found in the thesis analysis of 66.1% in this population of women aged 60 years and over drawn from four Chinese provinces (see Table 7.2).

9.3.3 MEASUREMENT ERROR AND CROSS-COUNTRY COMPARABILITY

9.3.3.1 MATERIAL CIRCUMSTANCES

As discussed in the Data and Methods chapter, wealth is thought to be a more reliable measure of economic status than income which displays more seasonal variation and is more vulnerable to reporting error. But a wealth index based on asset information has its own limitations. First, it is arguably more difficult to understand what it is that the wealth indicator is measuring compared to non-composite indicators like formal income. Some studies have argued that it is poorly correlated with expenditure in LMICs which it was designed to capture (Howe et al., 2009). In addition, the indicator is context dependent in that the objects that represent a luxury asset may vary and therefore invalidate cross-country comparisons. For instance, having a second television may be common in HICs but may be an indicator of high wealth in poorer countries. In this thesis, context specific indicators were based on locally tested questionnaires and the main purpose of the analysis was to identify whether the interaction pattern found in Egypt would be found in other countries. Therefore, it was not necessary for the measures to be identical across countries and, in fact, the use of country-specific measures may be seen as an advantage in being able to detect subtle interactions.

Most of the key SES-adiposity studies in lower income countries focusing on women favour education and wealth as SES indicators and do no incorporate occupation (Monteiro et al., 2001, Monteiro et al., 2004a, Schooling et al., 2008, Dahly et al., 2010, Poterico et al., 2011, Jones-Smith et al., 2011, Neuman et al., 2011, Dinsa et al., 2012). In the Chinese data analysis, occupation was used, in the absence of asset data and on the assumption that the income measure was unreliable and that occupational status (agricultural/non-agricultural) would capture significant variation in material circumstances. The use of this occupational division modelled the economic transition from an agricultural to an industrial/service-based economy and, arguably, was a more pertinent approach for the Chinese context. The effect of occupation

on health outcomes has been shown to vary according to its coding in other studies from China (Schooling et al., 2008, Shimokawa et al., 2009).

The coding of the occupation variable used in Chapter 7 aimed to reflect important differences in diet but is highly likely to have captured a change in physical activity levels as well which could not be separated from the dietary pathway due to the data limitations. On the other hand, evidence from China suggests that physical activity may have a less important role that diet in explaining changes in obesity risk by material circumstance. A study based on a sample of 7011 Chinese women 50 years and older examined the association between education and occupation (coded as manual *vs*. non-manual) and a composite index of the metabolic syndrome (that included waist circumference). The associations did not change in magnitude or precision after adjustment for physical activity (Allman-Farinelli et al., 2010). Another study (Reynolds et al., 2007) examined urban/rural differences in central obesity in 8014 women and found that diet explained 43.8% of the excess risk of central obesity in women and was more important than physical activity in accounting for the higher urban risk.

9.3.3.2 EDUCATION AND COGNITIVE SKILLS

Similarly to the wealth index, the comparability of educational levels across studies and countries may not be valid due to cohort effects and country variation determining the quality and content of education. It is thought that family background and community factors contribute differently to educational attainment depending on level of economic development. For example, community level factors have a greater influence than family background on access to education in LMICs compared to HICs due to the variability in the quality of schools (Buchmann and Hannum, 2001). Of note, most research on education and obesity examines the quantity not quality of education which may be of great relevance in understanding the association in transition settings as education quality may vary greatly in urban and rural regions for example.

In the media and communication psychology literature from high income countries, education is considered to be an important modifier of media processing through its role in information storage and retrieval as well as on the ability to connect pieces information mentally. Biologically, it is speculated that the educational processes that increase an individual's reading and writing skills create neural pathways that facilitate the processing of information (Grabe et al., 2009). Whether these effects occur in low- and middle-income countries as well is not easily predictable as the contribution of education to knowledge acquisition is influenced by factors that may be different in lower-income countries including baseline motivational factors and the frequency of media exposure (in HICs the greater the frequency of TV watching, the smaller the impact of educational level) (Kwak, 1999).

Reading literacy was used as a proxy for cognitive skills in this analysis which misses other dimensions of the complex process of cognition and information processing that might be important in health-related decision making in the rapidly evolving social and economic landscape of emerging economies. The Limited Capacity Model of Mediated Message Processing (LC3MP) framework which treats cognitive processes as a non-linear composite of three dimensions may be a useful tool for future research in this area. The dimensions are information encoding (measured through recognition memory), information storage (measured through cued recall), and information retrieval (measured through free recall) (Grabe et al., 2009).

Finally, educational status is a proxy of early adult life SES while material circumstances recorded later in life represents later-life conditions. Therefore, the findings of the thesis suggest that, in women, early adult life influences may modify the association between material circumstances and adiposity in later life. These early life effects captured by education cannot be disentangled from later life cognitive effects and would require data over the life course for a more detailed investigation.

9.3.3.3 MEDIA EXPOSURE

The media exposure variables were used as a measure of exposure to the advertisement of energy-dense processed food marketing in Egypt, and the hypothesis was that educated women might be more immune to the cognitive effects of such advertising on their dietary behaviours. The fact that women who had higher odds of obesity were more likely to have given their child a sweet snack in the previous 24 hours, and lower odds if they had given their child fruit or vegetables, supports this possibility, assuming that this dietary indicator captures the mother's general approach to diet, and does so more accurately than information on her own dietary consumption. However, media exposure was only a proxy for exposure to marketing messages and therefore has limitations.

For example, TV viewing, radio listening, and newspaper reading may each communicate other types of information including public health messages from government or other agencies and organisations. In addition, the main media variable examined – TV viewing – increases sedentariness. Overall physical activity levels were taken into account by using 'own occupation' as a crude proxy in the DHS analyses, but a recent study from Denmark showed that sedentary leisure time resulting from TV watching was associated with increased BMI independently of overall physical activity levels (Frydenlund et al., 2012). Therefore, while the main role postulated for the media was related to advertising exposure influencing purchasing behaviour and dietary habits in an obesogenic manner, measurement error limits the causal inferences that can be made and may explain why there was little change in the main estimates after adding this variable to the main model.

Future research on media exposure and obesity would benefit from more precise measurement instruments that survey the frequency of viewing specific kinds of advertisements. Relevant methodology could be borrowed from smoking studies (Yong et al., 2008, Niederdeppe et al., 2011, Li et al., 2012).

9.3.3.4 DIETARY BEHAVIOUR

The DHS dietary survey was limited in size and only included participants who had a child under the age of three living with them which constituted approximately one third of the full 2008 Egyptian DHS sample used for the rest of the analysis in **Chapter 8**. Dietary data are subject to recall error particularly for overweight or poorer women who may under-report their consumption, but also for children as a mother may not be able to report fully on the child's intake of food and liquids if the child was fed by other individuals. The absence of statistical associations between the mother's own dietary behaviour and the outcomes may reflect the recall bias leading to misreporting that affects dietary surveys. However, the dietary diversity assessment is an important source of information.

9.3.4 STUDY POWER

One major issue in the empirical analysis was the availability of sufficient power within the sample to examine the interaction between education and wealth, particularly the possibility of subgroups with no participants the presence of which was assessed by examining the subgroup sizes of wealth groups by educational level. Where power was insufficient, education groups were collapsed so that secondary and higher education groups formed a single group – this was necessary in the poorer countries in **Chapter 6**, the Chinese study in **Chapter 7** and when examining the role of mediators in **Chapter 8**. The strategies used to optimise power did not undermine the interpretability of the results which tended to follow expected patterns and were validated by the sensitivity analysis. The small dietary sample limited the investigation of the mediating pathways as described above.

9.3.5 URBAN/RURAL RESIDENCE AS A POTENTIAL MODIFIER

One of the original objectives considered for the thesis was to examine area of residence (urban/rural) as an effect modifier and, therefore, conduct all the analyses by area of residence. Urban/rural residence is known to affect the direction and magnitude of associations between SES indicators and obesity (Popkin, 1999, Swinburn et al., 2011) and had the sample sizes been larger, these effects would have been examined. However, the aim of the research was to produce results at country level that allow comparability with the majority of multi-country studies in the area, while affording a more detailed but feasible analysis of the separate and joint effects of components of SES, and this was achieved without the need for separate analyses by urban/rural residence. The latter could form part of a further investigation.

9.3.6 VALIDITY OF THE ANALYTIC STRATEGY AND MODEL SPECIFICATION

The analysis tested a mechanism postulated from a review of the literature using a deductive, hypothesis driven approach, but a valid alternative would have been to use a data driven approach. This constitutes an avenue for further research using datasets with more detailed information on health behaviours, cognitive skills, and knowledge, attitudes and beliefs. Nonetheless, the results from this analysis provide foundations to build on.

The use of complex survey data required the use of advanced analytical techniques to take the survey design into account and minimise bias in the estimates. Although, the most up to date statistical methods for complex surveys were used, (Heeringa et al., 2010) this approach was limited by current statistical knowledge which cannot provide appropriate tests and calculation methods for these complex surveys yet, as well as the availability of software to conduct these analyses. But it was less of a problem than anticipated as the regression model was sufficiently well specified to dispense with adjustment for the survey design (see **Chapter 4**). Sensitivity analyses examining estimates and standard errors calculated using a design-based

and survey-based approach showed little impact from the use of the more complex, design-based approach which was therefore not required. Hence, survey adjustments were only required for the frequency tabulations.

Similarly, the use of logistic regression rather than binomial regression or modified Poisson regression which would have taken into account the large prevalence of the outcome was judged appropriate after comparing the estimates and standard errors obtained from the different models. Differences in the magnitude of the estimates were expected to a certain extent and were not sufficient to justify their use, particularly as their use in the literature is not widespread and would have therefore limited the comparability of the thesis results with other studies.

9.4 CONTRIBUTION AND POLICY IMPLICATIONS

Methodological and conceptual contribution

One of the key contributions is to have developed and used a method for examining the interaction between education and wealth on obesity. The other contribution is conceptual in promoting a multidimensional view of socioeconomic status (SES) in LMICs and emphasising a potential protective pathway for education. While an inverse association between education and obesity has been described in the literature, none of the previous studies have gone further in assessing the impact of adjustment for wealth or of the inter-relationship between education and wealth. Furthermore, these studies have tended to focus on education as a measure of SES rather than as a social determinant of obesity in its own right, and none have promoted the hypothesis that education may be protective against the obesogenic effect of material circumstances.

Another possible avenue of future investigation concerns the use of indicators of women's dietary behaviour of towards their children. The analyses in this thesis suggest that what mothers feed their children may be a sensitive indicator of their own obesity risk.

Policy implications

The scale of the obesity epidemic requires policies to address it urgently, but because these policies may have an economic impact on commercial organisations, it is important to learn from the lessons of tobacco and infant formula regarding the different strategies which are put forward to influence policy change. National strategies to enable individuals to make healthier choices that are not related to simple health promotion through health education should be considered. If better education allows for cognitive advantage in the face of aggressive marketing techniques and the overwhelming increase in product availability and information of consumer societies, greater investment in education for women should be a priority, in combination with broader policies to address issues in agriculture and trade that affect the food system as well as marketing practices.

While exercising due caution in making policy suggestions based on findings from cross-sectional data, the health benefits of women's education are well documented in the fields of maternal and child health (Hatt and Waters, 2006). This analysis shows how the education of women can also protect against non-communicable disease risk factors such as obesity, and therefore that potential synergies with development programmes in different health fields may exist. The association between economic development and higher obesity levels in women may not be inevitable, and may be broken by investment in education programs alongside programs promoting economic growth. The findings also caution against the unintended consequences of poverty alleviation programs that do not do so.

As discussed above, at a broad societal level, education may help balance out the information asymmetry between large multinational corporations and consumers - an information asymmetry which is likely to be greater in LMICs. Some have argued that information asymmetry does not have a role in the obesity epidemic based on the fact that, in New York City, the newly enforced calorie labels were ignored by consumers. But the evaluation of this policy also showed that those who did read the labels reduced their calorie consumption (Vadiveloo et al., 2011). Higher education levels at national level may help to empower individuals and communities to better advocate for their needs and their health, and perhaps bring about a realignment of the for-profit motivations of marketers with the long-term wellbeing of ordinary citizens. More equitable access to education may help redistribute the opportunities to reach high level positions of influence in society and therefore allow representatives from all sections of society to express and incorporate their views in national policy making.

Finally, the improvement of material circumstances in an environment in which calories and fuel are available at reduced prices through energy subsidies may require reform, particularly in the Arab region where female obesity levels are extremely high and energy subsidies are widely implemented. In 2011, these were estimated to cost 212 billion (7.2% of GDP) (IMF, 2012). They are likely to promote the use of mechanised transport and there is evidence that they promote the consumption of high calorie food (Asfaw, 2007). Yet they are inefficient in targeting vulnerable groups and fail to meet their economic and nutritional needs (IMF, 2012). Therefore, food subsidy programme reform should aim to promote dietary quality as well as food security among those who need it.

9.5 LESSONS LEARNT FOR FUTURE RESEARCH

The PhD project had originally sought to examine the effect of income on the risk of obesity in poor women in Egypt using a community-based intervention study, but the research plan was changed on account of the mounting uncertainty over the availability of the data in Egypt due to the Arab Spring. Therefore, changes to the research plan were made so that: 1) the thesis was expanded to include other countries for comparison with Egypt; 2) the DHS data further explored to investigate potential mechanisms; 3) other datasets were examined to test the main hypothesis. As a result, a more elaborate thesis emerged and a deeper understanding of the challenges of the research process particularly of international collaborative research gained. This provided a good practical experience for the doctoral candidate in the principle of turning problems into opportunities.

9.6 CONCLUSION

In summary, the thesis demonstrates that wealth appears to be positively related to obesity in women in low-and-middle-income countries (LMICs), but education may offer some protection against this - particularly higher education. This is the first time that this interaction has been demonstrated, exploiting the unique social epidemiology of LMICs to disentangle SES effects that have otherwise been too collinear to explore in high income countries (HICs). In addition, the study supports the existence of a dynamic association between each of education and household wealth in relation to obesity over time, consistent with expectations from the majority of prior studies documenting a reversal of the association between socioeconomic status and obesity as economic development proceeds. It goes further in proposing that education is the dimension of socioeconomic status that drives the reversal of the social gradient of female obesity.

The findings also support the proposition that economic development and its associated social, dietary and cultural transitions result in period effects that modify the pathways by which

education and wealth are linked to obesity. Media exposure may have a role in linking the education and wealth to obesity through dietary behaviours but this part of the analysis was limited by the data in terms of study power and measurement precision of the media and dietary variables. The interactions explored between education and types of media were conclusive and corroborated what is known in the literature from HICs, but it was not possible to test the complex relationship between media exposure and the behavioural outcomes.

Despite the data limitations, this exploratory analysis lays important foundations for further research on the role of education in protecting against obesity and by extension related non-communicable diseases as LMICs enter the global economy. Compared with higher income countries, the relationship between SES and body size appears to be more complex in lower income countries undergoing rapid economic growth. Future studies on SES and excess adiposity in these rapidly changing settings should consider the relationship between SES indicators with greater scrutiny, while the remarkable increase in obesity prevalence among the less educated, poorer and rural dwelling women requires further investigation.

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APPENDIX A: WHO DATA ON THE PREVALENCE OF FEMALE AND MALE OBESITY IN 61 COUNTRIES

(Accessed October 2012. http://www.data360.org/pub_dp_report.aspx?Data_Plot_Id=665)

Country		Prevalence of obesity[1]		Difference	Income category[2]
	Survey year	Men >15yrs	Women>15yrs	(women – men)	
Samoa	1/1/2002	44.9	66.3	21.4	2
Seychelles	1/1/2004	15.0	35.2	20.2	3
Swaziland	1/1/2007	3.9	23.1	19.2	1
Tonga	1/1/2004	56.1	74.9	18.8	2
South Africa	1/1/2003	8.8	27.4	18.6	3
Saudi Arabia	1/1/2000	26.4	44.0	17.6	4
Fiji	1/1/2002	9.8	26.4	16.6	2
Zimbabwe	1/1/2005	3.9	19.4	15.5	1
United Arab Emirates	1/1/2000	25.6	39.9	14.3	4
Azerbaijan	1/1/2006	4.9	17.9	13.0	3
Guyana	1/1/2000	14.3	26.9	12.6	2
Syrian Arab Republic	1/1/2003	15.5	27.7	12.2	2
Iraq	1/1/2006	26.2	38.2	12.0	.
Bulgaria	1/1/2001	11.3	23.1	11.8	3
Vanuatu	1/1/2005	14.4	25.2	10.8	2
Mexico	1/1/2006	24.2	34.5	10.3	3
Iran (Islamic Republic of)	1/1/2005	9.1	19.2	10.1	3
Bosnia and Herzegovina	1/1/2002	16.5	25.2	8.7	3
Malaysia	1/1/2003	10.1	18.8	8.7	3
Cook Islands	1/1/2003	57.4	65.7	8.3	.
Russian Federation	1/1/2005	11.8	20.1	8.3	3
Colombia	1/1/2005	8.8	16.6	7.8	3
Oman	1/1/2000	16.7	23.8	7.1	.
Thailand	1/1/2003	3.3	10.2	6.9	3
Chile	1/1/2003	19.0	25	6.0	3
Latvia	1/1/2006	12.3	18.1	5.8	3
Israel	1/1/2001	19.8	25.4	5.6	4
Mongolia	1/1/2005	7.2	12.5	5.3	2
Australia	1/1/2006	20.6	25.5	4.9	4
Nauru	1/1/2004	55.7	60.5	4.8	.
Brazil	1/1/2003	8.9	13.1	4.2	3
Poland	1/1/2001	15.7	19.9	4.2	4
Cuba	1/1/2001	8.0	11.8	3.8	3
Sweden	1/1/2007	11.0	14.0	3.0	4
Czech Republic	1/1/2002	13.7	16.3	2.6	4
Indonesia	1/1/2001	1.1	3.6	2.5	2
United States of America	1/1/2004	31.1	33.2	2.1	4
Romania	1/1/2000	7.7	9.5	1.8	3
Netherlands	1/1/2001	10.2	11.9	1.7	4
Uzbekistan	1/1/2002	5.4	7.1	1.7	2
Estonia	1/1/2006	14.9	16.5	1.6	3
France	1/1/2007	16.1	17.6	1.5	4
India	1/1/2006	1.3	2.8	1.5	2
Italy	1/1/2004	7.4	8.9	1.5	4
Slovakia	1/1/2002	13.5	15.0	1.5	4
New Zealand	1/1/2004	21.9	23.2	1.3	4
Croatia	1/1/2003	21.6	22.7	1.1	3
Eritrea	1/1/2004	2.3	3.4	1.1	
Hungary	1/1/2004	17.1	18.2	1.1	4
China	1/1/2002	2.4	3.4	1.0	3

Country		Prevalence of obesity[1]		Difference	Income category[2]
	Survey year	Men >15yrs	Women>15yrs	(women – men)	
Singapore	1/1/2004	6.4	7.3	0.9	4
United Kingdom	1/1/2002	22.3	23	0.7	4
Germany	1/1/2007	20.5	21.1	0.6	4
Spain	1/1/2003	13.0	13.5	0.5	4
Japan	1/1/2001	2.9	3.3	0.4	4
Canada	1/1/2004	22.9	23.2	0.3	4
Viet Nam	1/1/2000	0.3	0.6	0.3	2
Iceland	1/1/2002	12.4	12.3	-0.1	4
Switzerland	1/1/2002	7.9	7.5	-0.4	4
Norway	1/1/2002	6.4	5.9	-0.5	4
Denmark	1/1/2005	11.8	11.0	-0.8	4
Cyprus	1/1/2003	12.9	11.8	-1.1	4
Lithuania	1/1/2006	20.6	19.2	-1.4	3
Portugal	1/1/2005	15.0	13.4	-1.6	4
Finland	1/1/2007	16.0	14.0	-2.0	4
Ireland	1/1/2002	14.0	12.0	-2.0	4
Slovenia	1/1/2001	16.5	13.8	-2.7	4
Malta	1/1/2002	25.0	21.3	-3.7	4
Greece	1/1/2003	26.0	18.2	-7.8	4

[1] Obesity is defined as a body mass index (BMI ≥30 kg/m^2

[2] Based on World Bank recent income classification 1= low income, 2=lower-middle income, 3=upper-middle income, 4=high income. (Accessed October 2012. http://data.worldbank.org/about/country-classifications/country-and-lending-groups#Low_income)

APPENDIX B: WEALTH INDEX VARIABLE ASSET COMPOSITION BY YEAR OF SURVEY (EGYPTIAN DHS, 1992, 1995, 2005, 2008).

Variable	**1992**	**1995**	**2005**	**2008**
Number of *de jure* members per room	✓	✓	✓	✓
Type of accommodation				
Lives in owned or jointly owned apartment	✓	✓	✓	✓
Lives in rented or other apartment	✓	✓	✓	✓
Lives in owned or jointly owned free standing house	✓	✓	✓	✓
Lives in owned or jointly owned free standing house	✓	✓	✓	✓
Lives in rented or other free standing house	✓	✓	✓	✓
Lives in other type of dwelling	✓	✓	✓	✓
Sanitation and housing				
Drinking water supply	✓	✓	✓	✓
Source of non-drinking water	✓	✓	✓	✓
Toilet facility	✓	✓	✓	✓
Electricity	✓	✓	✓	✓
Flooring	✓	✓	✓	✓
Share toilet with households	x	x	✓	✓
Toiletflush/drain	x	x	✓	✓
Roofing, cooking fuel, cooking structure	*x*	*x*	*x*	*x*
Waste disposal				
Disposal of kitchen waste	x	x	✓	✓
Possessions (transport)				
Bicycle	✓	✓	✓	✓
Motorcycle/scooter	✓	✓	✓	✓
Car/truck	✓	✓	✓	✓
Possessions (electrical)				
Cooking stove (gas/electric)	✓	✓	x	x
Dishwasher	✓	x	✓	✓
Radio	✓	✓	✓	✓
Television	✓	✓	✓	✓
Refrigerator	✓	✓	✓	✓
Color TV	✓	✓	✓	✓
Black and white TV	✓	✓	✓	✓
Video/dvd	✓	✓	✓	✓
Sewing machine	✓	✓	✓	✓
Water heater	✓	✓	✓	✓
Automatic washing machine	✓	✓	✓	✓

Variable	1992	1995	2005	2008
Non-automatic washing machine	✓	✓	✓	✓
Electric fan	✓	✓	✓	✓
Telephone	x	x	✓	✓
Mobile phone	x	x	✓	✓
Animal drawn cart	x	x	✓	✓
Personal home computer	x	x	✓	✓
Air conditioning	x	X	✓	✓
Satellite TV	x	x	✓	✓
Freezer	x	X	✓	✓
Watch	x	x	✓	✓
Possessions (furniture)				
Bed	x	x	✓	✓
Sofa	x	x	✓	✓
Green lamp without cover	x	x	✓	✓
Table	x	x	✓	✓
Tablia	x	x	✓	✓
Chair	x	x	✓	✓
Kola/zeer	x	x	✓	✓
Possessions (bank account)				
Bank account	x	x	✓	✓
Possessions (land)				
Own land usable for agriculture	✓	✓	✓	✓
Land ownership	x	x	✓	✓
Area of land	*x*	*x*	✓	✓
Possessions (livestock)				
Own livestock/herds/farm animals	✓	✓	✓	✓
Cattle	x	x	✓	✓
Cows/bull	x	x	✓	✓
Horses/donkeys/mules	*x*	*x*	✓	✓
Goats	x	x	✓	✓
Sheep	x	x	✓	✓
Chicken	*x*	*x*	✓	✓
Geese	x	x	✓	✓
Ducks	x	x	✓	✓
Pigeons	*x*	*x*	✓	✓
Quail	x	x	✓	✓
Turkey	x	x	✓	✓

APPENDIX C: INDIVIDUAL DIETARY DIVERSITY QUESTIONNAIRE USED IN THE DEMOGRAPHIC AND HEALTH SURVEYS.1,2

Please describe the foods (meals and snacks) that you ate yesterday during the day and night, whether at home or outside the home. Start with the first food eaten in the morning,

Question number	Food group	Examples	YES=1 NO=0
1	CEREALS	bread, noodles, biscuits, cookies or any other foods made from millet, sorghum, maize, rice, wheat + *insert local foods e.g. ugali, nshima, porridge or pastes or*	
2	VITAMIN A RICH VEGETABLES AND TUBERS	pumpkin, carrots, squash, or sweet potatoes that are yellow or orange inside + *other locally available vitamin-A rich vegetables*	
3	WHITE TUBERS AND ROOTS	white potatoes, white yams, cassava, or foods made from roots.	
4	DARK GREEN LEAFY VEGETABLES	sweet pepper, dark green/leafy vegetables, including wild ones + *locally available vitamin-A rich leaves such as cassava leaves etc.*	
5	OTHER VEGETABLES	other vegetables, including wild vegetables	
6	VITAMIN A RICH FRUITS	ripe mangoes, papayas + *other locally available vitamin A-rich fruits*	
7	OTHER FRUITS	other fruits, including wild fruits	
8	ORGAN MEAT (IRON-RICH)	liver, kidney, heart or other organ meats or blood-based foods	
9	FLESH MEATS	beef, pork, lamb, goat, rabbit, wild game, chicken, duck, or other birds	
10	EGGS		
11	FISH	fresh or dried fish or shellfish	
12	LEGUMES, NUTS AND SEEDS	beans, peas, lentils, nuts, seeds or foods made from these	
13	MILK AND MILK PRODUCTS	milk, cheese, yogurt or other milk products	
14	OILS AND FATS	oil, fats or butter added to food or used for cooking	
15	SWEETS	sugar, honey, sweetened soda or sugary foods such as chocolates, sweets or candies	
16	COFFEE/TEA	tea (black, green, herbal) or coffee	
			YES=1 NO=0
B.	Did you eat anything (meal or snack) outside of the home yesterday?		

[1] FAO/Nutrition and Consumer Protection Division, version of February, 2007.
[2] For children under three, the dietary diversity questionnaire for young children is used.