WEALTHY BUT UNHEALTHY

Overweight and Obesity in Asia and the Pacific: Trends, Costs, and Policies for Better Health

Edited by Matthias Helble and Azusa Sato

ASIAN DEVELOPMENT BANK INSTITUTE

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Abbreviations

AP	Asia and the Pacific
BMI	body mass index
CDC	Centers for Disease Control and Prevention
CHL	Children's Healthy Living
CI	confidence interval
DALY	disability-adjusted life year
DLHS	District Level Household Survey
GDA	guideline daily amount
GDP	gross domestic product
GLM	generalized linear model
GNI	gross national income
HI	high-income
IHDS	India Human Development Survey
KNHANES	Korea National Health and Nutrition Examination Survey
LMI	lower middle-income
MNL	multinomial logistic
NCD	noncommunicable disease
NFHS	National Family Health Survey
NHES	National Health Examination Survey
NHIS	National Health Insurance Service
NNMB	National Nutrition Monitoring Bureau
NSC	National Sample Cohort
NUC–OM	non-underweight child and overweight mother
OMB	US Office of Management and Budget
OR	odds ratio
PAF	population attributable fraction
PICTs	Pacific Island countries and territories
PRC	People's Republic of China
PYLL	potential years of life lost
RR	relative risk
SES	socioeconomic status

SSB	sugar-sweetened beverage
UC–OM	underweight child–overweight mother
UMI	upper middle-income
US	United States
USAP	United States-affiliated Pacific
USDA	United States Department of Agriculture
WHO	World Health Organization
WHR	waist–hip ratio
YLD	years of life lost due to disability
YLL	years of life lost due to premature mortality

NOTE

In this book, "฿" refers to Thai baht, "Rp" refers to Indonesian rupiah, "₩" refers to Korean won, and "¥" refers to Japanese yen.

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Matthias Helble and Azusa Sato

Introduction

Matthias Helble and Azusa Sato

The obesity and overweight "time bomb," as it has come to be known, deserves urgent attention in developing countries. The World Health Organization (WHO) (2017) estimates that in 2016, of adults over 18, more than 1.9 billion were overweight and 650 million were obese, which means 39% of adults worldwide were overweight and 13% obese. That over half the world's population is overweight or obese is of significant concern. Also alarming is the rate at which obesity grows: worldwide prevalence of obesity nearly tripled between 1975 and 2016 (WHO 2017). The difficulty in treating excessive weight is reflected in the fact that no country has successfully tackled the problem and reduced obesity rates in recent years (Ng et al. 2014). Further, such statistics are no longer just a challenge of those in developed countries: 62% of overweight people reside in a developing country (Ng et al. 2014). Asia and the Pacific (AP) region is home to the largest absolute number of overweight and obese people, about 1 billion—that is, two out of every five adults.

The common storyline is simple: obesity is caused by a chronic positive energy balance, i.e., energy intake in the form of food and beverages consumed exceeds, over a considerable period of time, the energy expenditure (the sum of physical activity, basal metabolism, and adaptive thermogenesis) (Spiegelman and Flier 2001; Webber 2003).[1] Researchers and policymakers, however, have increasingly looked towards proximal socioeconomic explanations for obesity and overweight. The AP region has enjoyed impressive economic progress over the past three decades. In most countries, economic success translated into better health outcomes: life expectancy in AP is among the highest in the world. However, economic prosperity is also accompanied by behavioral change which can be linked to increased prevalence of noncommunicable diseases (NCDs). WHO has identified tobacco use, the harmful use of alcohol, physical inactivity, and unhealthy diets as the main risk factors of NCDs, as they lead to key

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1 We recognize other factors such as genetic susceptibility, endocrinology, psychological, and ecological factors contribute to obesity. It is widely accepted that obesity is a multi-factorial, multi-dimensional, multi-determinant and multi-causal disorder with no single explanation for its development (Vandenbroeck et al. 2007).

metabolic/physiological changes (raised blood pressure, overweight/obesity, raised blood glucose and raised cholesterol). Further, economic growth has made food cheaper, with the region seeing a massive shift from agriculture to manufacturing and the service sector, which require less physical activity. In addition, rapid urbanization has been associated with more sedentary lifestyles, dining out and longer commuting times. Public health experts have described this shift in eating patterns as the "global nutrition transition" (e.g., Popkin et al. 2012).

Overweight and obesity has serious consequences for the individual in terms of general welfare and health: excess weight negatively affects body strength, mobility and ability to carry out daily activities (Jenkins 2004). Hargrave et al. (2016) similarly observe that excess body weight and obesity increases the risk of cognitive decline. In 2010, about 3.4 million deaths were caused by obesity and overweight (Lim et al. 2012). Overweight and obesity also increase the risks of NCDs including ischemic heart disease, hypertension, osteoarthritis, sleep apnea, stroke, diabetes and cancer. About 70% of global deaths each year are caused by NCDs (WHO 2017); positive associations between body mass index (BMI) and increased mortality from NCDs have been found (Ng et al. 2014). High BMI is an important factor contributing to cardiovascular diseases and coronary heart disease or stroke (Singh et al. 2013; Wormser et al. 2011; Whitlock et al. 2009). The latter killed 7.4 million people in 2012.

The implications of obesity and overweight are not limited to health. Significant economic costs are incurred due to increased costs of care and morbidity, as well as lost productivity. Evidence consistently indicates that health care costs of overweight and obese individuals are higher than those of the general population (Colagiuri et al. 2010; Hoque et al. 2016). One systematic review estimates obesity accounts for 0.7% to 2.8% of a country's total health expenditure (Withrow and Alter 2011). Another review in 10 European countries shows obesity can account for 0.09% to 0.61% of gross domestic product (Müller-Riemenschneider 2008) while others (Hoque 2016) identify economic burden to be between 1.5% to 9.9% of total health expenditure.

In parallel, undernutrition is also becoming more prominent. In this book, undernutrition is defined as the outcome of insufficient food intake (hunger), and includes being underweight for one's age, too short for one's age (stunted), dangerously thin (wasted), and deficient in vitamins and minerals (micronutrient malnutrition) (UNICEF).[2] Surprisingly, the phenomena of both overweight and obese and undernutrition can

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[2] https://www.unicef.org/progressforchildren/2006n4/index_undernutrition.html.

even be found in the same household under what has become known as an intra household dual burden. Clearly, inequitable health outcomes are no longer contained to differences across countries or income groups within countries, and households may themselves represent a microcosm of the undernutrition and obesity problem.

Yet, the broader goals—to which all countries covered in this book have committed—are clear. The United Nations' 2015–2030 Sustainable Development Goals include two goals relevant to food and nutrition security and health: (i) end hunger, achieve food security and improved nutrition and promote sustainable agriculture and (ii) ensure healthy lives and promote well-being for all, at all ages. The second goal is particularly prominent because obesity is increasingly problematic for children—and policy interventions must increasingly target younger populations.

To attain both goals, we must first understand the situation using robust evidence and data. Second, we must analyse this further to show the implications. Third, we must provide more robust tools for equip policymakers. This book covers these three areas using the AP region to illustrate key issues in tackling obesity and overweight. First, the book gives an overview of trends through detailed analysis of obesity and overweight by gender, age, rural-urban location and socioeconomic status, among other factors. Second, we provide evidence on the cost of obesity by studying different countries, such as the Republic of Korea and Thailand, as well as the region as the whole. Third, various policy options are discussed.

The main audience of the book is policymakers and researchers. Chapters were written by health economists, medical doctors and public health experts to increase accessibility for all stakeholders, not just those focused on health.

Before jumping into the chapters, here we briefly define overweight and obesity and present common measures for them, which are used throughout this book. We also describe key trends in AP to paint an overall picture for the region and covering countries that do not have dedicated chapters.

Defining and Measuring Overweight and Obesity

Obesity is defined by WHO (2017) as an abnormal or excessive fat accumulation in the body that may impair a person's health and increase the risk of certain diseases. The body mass index (BMI) is a widely accepted and arguably the simplest method of measuring overweight and obesity, computed by dividing the weight in kilograms by the square of the height in meters (kg/m^2). For an adult, WHO (2017) classifies BMI values between 18.5 kg/m^2 and 24.9 kg/m^2 as normal or healthy weight, values between 25 kg/m^2 and 29.9 kg/m^2 as overweight and values over 30 kg/m^2 as obese. A BMI of 40 kg/m^2 or above denotes morbid obesity; under 18.5 kg/m^2 is considered underweight.

Different ethnic groups have different levels of body fat and disease risk. For example, Asians are known to have higher per cent body fat and higher disease risk compared to Europeans (Deurenberg et al. 2002); Pacific populations appear to have more lean mass than Europeans but also a higher risk of diseases like diabetes (Swinburn et al. 1996; Rush et al. 2004; Snowdon et al. 2014). For the purposes of the book, different thresholds for defining obesity and overweight are illustrated where appropriate to reflect these ethnic-specific nuances.[3]

Prevalence and Key Trends in Asia and the Pacific

The incidence of overweight and obesity is growing in the AP region. Today, AP is home to about 1 billion overweight and obese people. The following table shows the prevalence of overweight and obesity in 5 subregions for 1990 and 2013, and the % change between these years.

In Central Asia, almost 50% of the population was considered overweight and obese in 2013. Five countries—Armenia, Azerbaijan, Kazakhstan, the Kyrgyz Republic, and Turkmenistan—had more than 50% of the population overweight and obese in 2013. Azerbaijan had the largest increase in Central Asia, from 49% in 1990 to 63% in 2013. Georgia had the lowest prevalence in this region.

While prevalence of overweight and obesity in East Asia appears low (except for Mongolia, which almost reached 50% in 2013), the rate of overweight and obesity more than doubled in the People's Republic of China from 13% in 1990 to 28% in 2013. Overweight and obesity rates also rose rapidly in the Republic of Korea and Taipei,China.

Looking at the South Asia region, Bangladesh's overweight and obesity prevalence increased from 8% in 1990 to 17% in 2013, the largest percentage increase in that region by far. Nepal and Sri Lanka also showed a rapid increase in the percentage of overweight and obese

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3 Similarly, WHO recommends alternative BMI cut-offs for children and adolescents to account for changes in body dimension and composition. In line, we follow these standards: overweight: >+1 standard deviation (SD) (equivalent to BMI 25 kg/m^2 at 19 years), obesity: >+2SD (equivalent to BMI 30 kg/m^2 at 19 years), thinness: <-2SD and severe thinness: <-3SD. At 19 years, the new BMI values at +1SD are 25.4kg/m^2 for boys and 25.0 kg/m^2 for girls and +2SD value 29.7 kg/m^2 (Cole et al. 2000). To capture body fat distribution, some authors use waist-to-height ratio to measure abdominal obesity.

Prevalence of Overweight and Obesity in Asia and the Pacific (% of population)

	1990	2013	% Change
Mean for Asia and the Pacific	34.6	40.9	18.3
Central Asia			
Armenia	45.4	53.0	16.7
Azerbaijan	49.4	63.4	28.3
Georgia	22.9	29.7	29.7
Kazakhstan	47.0	54.8	16.6
Kyrgyz Republic	48.1	50.8	5.6
Tajikistan	34.5	40.8	18.3
Turkmenistan	47.3	53.6	13.3
Uzbekistan	43.9	47.9	9.1
Mean for Central Asia	*42.3*	*49.3*	16.4
East Asia			
People's Republic of China	13.2	27.9	111.4
Rep. of Korea	25.2	32.3	28.2
Japan	20.2	23.3	15.3
Mongolia	41.3	49.4	19.6
Taipei,China	25.8	32.4	25.6
Mean for East Asia	25.1	33.1	31.5
South Asia			
Afghanistan	43.3	45.9	6.0
Bangladesh	8.0	16.9	111.3
Bhutan	31.5	35.3	12.1
India	17.3	20.1	16.2
Maldives	33.4	40.3	20.7
Nepal	9.1	13.0	42.9
Pakistan	27.1	33.1	22.1
Sri Lanka	19.3	26.2	35.8
Mean for South Asia	23.6	28.9	22.1
Southeast Asia			
Brunei Darussalam	17.5	20.6	17.7
Cambodia	10.1	15.5	53.5
Indonesia	14.8	26.0	75.7

continued on next page

Table *continued*

	1990	2013	% Change
Lao People's Democratic Republic	19.3	24.6	27.5
Malaysia	38.3	46.3	20.9
Myanmar	14.7	18.2	23.8
Philippines	17.8	24.5	37.6
Singapore	30.7	38.2	24.4
Thailand	20.8	36.0	73.1
Viet Nam	5.8	13.1	125.9
Mean for Southeast Asia	19.0	26.3	38.6
The Pacific			
Fiji	44.2	51.2	15.8
Papua New Guinea	39.1	42.9	9.7
Solomon Islands	59.5	64.8	8.9
Timor-Leste	4.7	4.9	4.3
Vanuatu	45.3	50.6	11.7
Palau	44.2	51.2	15.8
Marshall Islands	66.7	76.9	15.3
Micronesia	69.6	74.9	7.6
Samoa	80.3	84.0	4.6
Tonga	82.5	86.1	4.4
Kiribati	75.1	79.1	5.3
Mean for the Pacific	*55.6*	*60.6*	*9.1*

Source: Authors, based on data from Ng et al. (2014).

population. Within this region, Afghanistan, Bhutan, Maldives, and Pakistan had rates higher than 30% in 2013.

The change was most dramatic in the Southeast Asia region, where the prevalence of overweight and obesity increased by almost 40% from 1990 to 2013. The rate of overweight and obesity in Indonesia was around 15% in 1990 but this grew to 26% in 2013. A similar trend happened in Thailand, rising from 21% in 1990 to 36% in 2013. Similarly, overweight and obesity cases increased rapidly in Cambodia and the Philippines. The numbers are likewise increasing in Viet Nam. Although this country has one of the lowest rates of overweight and obesity in the region, the change from 6% in 1990 to 13% in 2013 means that Viet Nam had the biggest percentage increase in Southeast Asia.

Compared to Asia, the Pacific region has a higher percentage of overweight and obese population (in 2013, 61% of the population). Of all the countries in this region, only Timor-Leste had a prevalence rate of less than 5%. In comparison, Tonga (at 86%) and Samoa (at 84%) had the highest rates in 2013. Compared to the other regions, the increase in the overweight and obese population in the Pacific has been more moderate over the years; the growth in overweight and obesity rates in any of the Pacific countries was less than 20% between 1990 and 2013.

The evidence on the costs of overweight and obesity in the AP region is still sparse. In this book we provide a first estimate of the direct and indirect cost of overweight and obesity for countries in the Asia-Pacific region. The estimates suggest that the direct costs (mainly costs associated with higher health care expenditures) amount to about 8.90% of health expenditure in the region, whereas the indirect costs (mainly costs due to disability and premature mortality) are as high as 3.46% of health care expenditure. We estimate that the total costs associated with overweight and obesity are about 0.78% of gross domestic product, equivalent to about $166 billion. These conditions have the potential to severely undermine the economic and human development of the region.

Obesity Policies

Although the problem of excess body weight has received tremendous public attention in recent years, no country has implemented successful policy interventions to curb the increasing number of overweight and obese individuals in the past 33 years (Murray and Ng 2014). This may partly be due to the paucity of data to quantify and document until more recently, or the lack of comprehensive policy approaches.

Overweight and obesity can be tackled from at least two policy angles: improving nutritional intake and increasing physical activity. These, in turn, are closely associated with cultural, environmental and socioeconomic factors, which make manipulating these angles difficult. Policymakers have chosen to influence food choices through market mechanisms (price changes) and government interventions (regulations against unhealthy foods), and to target behaviors as early as possible (at childhood and in school). To increase physical activity, policymakers have targeted sports curricula at school and better urban planning, designing cities with well-functioning public transportation as well as sidewalks and green areas.

Costs of these interventions vary substantially. For example, regulations to restrict marketing to children have relatively low costs and possibly a high effectiveness. Food labeling requirements can impose substantial costs on producers; if badly designed, rather than leading to better food choices, labels may confuse the consumer. Programs to improve school food may impose a substantial burden on schools already operating on tight budgets. Making the urban landscape conducive to physical activity can also be costly. Another important area of action concerns the health care system. Overweight and obesity are often observed by health care workers, but are typically not well responded to: health care professionals tend to be trained in curative health services, not in weight management, and facilities are often ill-equipped to receive obese patients.[4] In these areas and beyond, more cost-effectiveness research is warranted, especially in developing countries.

Book Outline

The book has two parts. The first part shows trends and patterns in obesity and overweight populations in the AP region, while the second part estimates the costs of excessive weight. In Part 1, Chapter 1 by Dang and Meenakshi provides evidence on the rapid increase in the proportion of adult women in India who are overweight and obese, including in rural areas. The authors also find an increasing rate of households suffering from a dual burden of malnutrition, where the child is undernourished while the mother is overweight. The authors show how these trends hold important consequences for public health systems in India, especially in rural areas.

Chapter 2 by Wate studies the case of the Pacific Island countries, which suffer from some of the highest prevalence rates of adult obesity in the world. The author recommends tackling obesity early, even before conception, and taking an approach that addresses the entire life course or whole of society. Wate argues that policies need to be well designed and evaluated to ensure maximum impact, and that they draw on global and regional recommendations including efforts focusing on schools, communities and other environmental settings.

In Chapter 3, Novotny et al. examine obesity and underweight in children in the United States-affiliated Pacific region and find that household income is not significantly related to obesity, while jurisdiction income level is strongly related. Upper-middle-income jurisdictions had relatively high levels of both undernutrition and obesity. The authors argue that policies and strategies for improvement

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4 For example, in Malaysia currently only one hospital is equipped receive patients weighing more than 250 kg.

of child growth status should protect local food systems and active living during economic transition.

In Chapter 4, Aizawa and Helble analyze obesity trends across income groups in Indonesia between 1993 and 2014. They find that that the proportions of overweight and obese people in Indonesia increased rapidly and poorer income groups exhibited the strongest growth in excess weight. The authors demonstrate that a large part of the relatively fast weight increase among poorer income groups can be explained by the decrease in inequality in living standards as well as improved sanitary conditions.

Part 2 starts with Chapter 5 by Chung on the costs of excessive weight in the Republic of Korea. Chung estimates that obesity increased medical costs much more for women than for men. Furthermore, he shows that obesity is positively associated with disability, so obesity is associated with a significant economic burden in terms of medical costs and disability in the Republic of Korea.

In Chapter 6, Teerawattananon and Luz give an overview of all possible costs related to obesity, including obesity's direct health impact as well as the non-health impacts of obesity, the cost to the health care system of obesity-related illnesses, and the social impact of obesity in Thailand. The authors estimate that the economic burden of obesity in terms of direct and indirect costs is about $400 million annually, equivalent to 0.13% of Thailand's gross domestic product.

In Chapter 7, Kosen provides a cost estimate (direct and indirect) of the health and economic burden of overweight and obesity in Indonesia in 2016. Kosen estimates that in 2016 the total macroeconomic loss due to overweight and obesity was approximately 369.7 trillion rupiah ($28.4 billion) or about 3.04% of Indonesia's gross domestic product. His recommendation is to improve data collection and to prioritize interventions according to their potential impact, cost-effectiveness, and feasibility.

In Chapter 8, Helble and Francisco provide the first cost estimate of overweight and obesity for the entire AP region (42 countries). Their estimates, including direct and indirect costs, suggest that obesity causes 12% of total health care expenditures or 0.78% of gross domestic product in the region. The authors conclude that obesity is a serious threat to the prosperity of the region.

In the last chapter, Thavorncharoensap discusses possible interventions to curb the obesity epidemic. She reviews four types of interventions: sugar-sweetened beverage taxes, nutrition labeling, advertising bans on unhealthy food, and school-based interventions. The review finds that sugar-sweetened beverage taxes and nutrition labeling are an effective and cost-effective intervention but due to limited evidence on the impact of restricted unhealthy food advertising and school-based interventions, the effectiveness of these interventions is inconclusive.

This book constitutes a primer on the causes and the costs of overweight and obesity in the Asia-Pacific region. While many countries in the region have already started to discuss or implement policies, more and faster action is needed to tackle this multi-sectoral problem. We hope that presenting evidence on the problems and consequences of obesity serves as a valuable contribution to the current debate and contributes to better policy design.

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PART I

Obesity and Overweight Trends in Asia and the Pacific

1

The Nutrition Transition and the Intra-Household Double Burden of Malnutrition in India

Archana Dang and J. V. Meenakshi

1.1 Introduction

Much of the discourse on malnutrition in India has focused on undernutrition—the inadequate intake of food—manifest as poor anthropometric outcomes, especially for children. Yet, the country has also seen a significant rise in overweight and obesity in recent years. This latter trend is no longer a predominantly urban phenomenon, but characterizes many rural populations as well. Thus, India seems to be going through a *nutrition transition*, a term that refers to the processes of change in the food environment, physical activity, and lifestyle that result in declining levels of undernutrition and increasing levels of overnutrition over time (Popkin 1993).

Nationally representative surveys conducted between 2011 and 2013 suggest that the prevalence of overweight or obesity ranges across states from 6% to 31% among women, while the figures for rural areas are 5% to 28% (Meenakshi 2016). These magnitudes have been increasing rapidly over time. Being overweight or obese poses significant risks for noncommunicable diseases (NCDs) including heart disease and diabetes. According to the Global Burden of Disease study, in India, the number of disability-adjusted life years (DALYs)—an aggregate measure of cause-specific disease burden that accounts for both disability and premature mortality—lost to diabetes increased by nearly 40% between 2000 and 2012. Over the same period, the number of DALYs lost to heart disease increased by 20%, even as the overall number of DALYs lost due to disease *decreased* by nearly 9%.[1]

[1] World Health Organization. Health Statistics and Information Systems: Cause-Specific Mortality. www.who.int/healthinfo/global_burden_disease/estimates/en/index1.html (accessed 1 September 2016).

These increases in overweight and obesity and its health consequences are occurring even as the magnitude of undernutrition among children in India remains high. Between 2011 and 2013, the prevalence of underweight among preschool children ranged from 21% to 46% across states; the corresponding range in rural areas was 23% to 49% (Meenakshi 2016). Undernutrition among young children is often irreversible, has consequences into adulthood, and may lead to the intergenerational transmission of malnutrition.

While this double burden of malnutrition—the coexistence of under- and over-nutrition—may simply be a reflection of marked and increasing inequalities in economic and social access to resources and thus be reflective of distinct subpopulations, studies suggest that as economies develop, undernutrition among children and overnutrition among adults often coexist *within the same household* (Garrett and Ruel 2005; Doak et al. 2002). For example, in many African and Asian countries, nearly 10% of households have a stunted child and overweight mother; figures for Latin American countries are higher (Garrett and Ruel 2005). This phenomenon, referred to as the *intra-household dual burden of malnutrition*, merits further study since it is clearly not an indication of socioeconomic inequalities in the aggregate, nor of inadequate access to food at the household level (since adults are overnourished) but rather reflects inequalities *within* the household in the distribution of food and other health resources. In India, very few studies have examined this phenomenon.

This study has two objectives. First, the chapter reviews the literature and quantifies the changes in the prevalence of overweight and obesity (using body mass index [BMI] thresholds that are appropriate for Asian populations), and of diabetes and hypertension among adults (Sections 1.2 and 1.3). The focus is on the richer states[2] because overweight and obesity is more pronounced in these states, and also (though not exclusively) on women, as they are more susceptible than men to being overweight or obese (see for example Ramachandran 2014, Subramanian et al. 2009, Chhabra and Chhabra 2007, and Kulkarni et al. 2017). Second, we examine correlates of the intra-household double burden of malnutrition (Section 1.4) using unit record data from the second round of the India Human Development Survey (IHDS 2). Section 1.5 concludes.

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2 Richer states are defined as the nine states with the lowest head count ratios of poverty in 2011–2012. The states are Karnataka, West Bengal, Maharashtra, Tamil Nadu, Haryana, Andhra Pradesh, Punjab, Himachal Pradesh, and Kerala.

1.2 Overweight and Obesity in India

The primary explanation for increasing BMI is the imbalance between energy or food intake on the one hand and energy expenditure through physical activity on the other. But there is no evidence to suggest that average energy intake in India has increased. In fact, energy intake as derived from consumer expenditure surveys has shown a secular decline over time. While these estimates are known to suffer from significant measurement errors (from inadequate capturing of processed foods and meals purchased outside the home) that have likely only increased over time, the reduction in average intakes is also documented by other surveys. For instance, 24-hour dietary recall surveys—considered the gold standard in dietary assessment—conducted by the National Nutrition Monitoring Bureau (NNMB) for rural areas also document a similar decline (see Ramachandran 2014). However, a reduction in average intake is consistent with a rightward shift of the upper tail of the distribution of energy intakes. There has also been a change in the composition of diets, with decreased reliance on cereals and an increased reliance on fats and sugars (more details in Meenakshi 2016).

It has been argued that some of this reduction in intake is explained by the declining needs for energy associated with (a) decline in infectious diseases and (b) a reduction in physical activity levels (see Deaton and Drèze 2009). While it is clear that there has been an expansion in the use of labor-saving devices in urban areas, it is not evident that an expansion of a similar magnitude has occurred in rural areas. To what extent the mechanization of agriculture has led to the substitution of women's labor is also not clear. But Ramachandran (2014) suggests that it is the rapid decline in physical activity levels accompanied by a modest decline in energy intake that is responsible for the rapid increases in overnutrition. Similarly, Siddiqui and Donato (2016) argue that some states have a more obesogenic[3] environment, with infrastructure encouraging more sedentary behavior, a rapid expansion in the availability of fast foods, or cultural factors that stimulate overeating among some populations.

The literature also suggests that socioeconomic status (as reflected in wealth or income levels as well as educational attainment) is a strong predictor of overweight and obesity (in a direction opposite to that found in developed countries, where obesity is associated with

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[3] The term "obesogenic environment" refers to "an environment that promotes gaining weight and one that is not conducive to weight loss" within the home or workplace (Swinburn et al. 1999). In other words, the obesogenic environment refers to an environment that contributes to obesity.

poverty). Griffiths and Bentley (2001) find that for women (in Andhra Pradesh), having high income or more education, pursuing sedentary occupations, and watching television more than once a week are all factors associated with being overweight or obese. Socioeconomic status is the most important predictor of women's nutrition status, not rural or urban residence. Subramanian et al. (2009) also report a strong and positive association between socioeconomic status and BMI for women. More recently, Kulkarni et al. (2017) also find that overweight and obesity is largely concentrated among high-income groups and that the relationship between socioeconomic status and the risk of being overweight or obese is stronger in urban than in rural areas. Furthermore, Ackerson et al. (2008) find that after accounting for individual factors, neighborhood wealth was independently and positively related with BMI and the risk of being overweight among women. Gaiha et al. (2011) find that increasing age and growing affluence are key factors in explaining the prevalence of NCDs in India.

Similarly, there appears to be a positive association between education and overweight among women, as noted for example by Griffiths and Bentley (2001) and Kulkarni et al. (2014). While this finding may seem contradictory to the role education plays in enabling good health in developed countries, it is likely that the positive association is a reflection of the low levels of education in India in general, and the correlation between income and educational attainment. For example, Siddiqui and Donato (2016) find a nonlinear relationship between education and overnutrition, where increasing education translates into a reduction in the likelihood of overweight and obesity after a threshold; they suggest that this is indicative of weight-control behaviors among highly educated women.

In addition to these household- and individual-level variables, Schmidhuber and Shetty (2005) and Popkin et al. (2012) suggest that the macro environment also matters, with falling relative prices of food, freer trade, and globalization all associated with a rapid nutrition transition.

Another strand of literature highlights the community-specific and regional variation in the prevalence of overweight and obesity in India. For instance, after controlling for socioeconomic status, Muslim women and Sikhs appear to have greater likelihood of overweight and obesity as compared with Hindus (Siddiqui and Donato 2016; Griffiths and Bentley 2001). Although they do not directly test for differences in dietary patterns across these groups, they argue that differences in cultural practices related to food may lead to these observed differences.

Regional variations are also highlighted by Siddiqui and Donato (2016), Kulkarni et al. (2014), and Ackerson et al. (2008), with some states in the north and far south seeing higher obesity and overweight levels (as also seen later in Section 1.3). Even within these regions, Sengupta et al. (2014) find that in Delhi, Punjab, and Kerala, the problem of overnutrition has trickled down to poorer, rural, and less educated sections of the population.

Finally, one factor that is perhaps particular to economies that have dealt with hunger and undernourishment is the role played by inadequate nutrition in utero or in infancy. Extensive literature suggests that this stimulates a set of anatomical, hormonal, and physiological changes that enhance survival in a "resource poor" environment. However, in a postnatal environment with plentiful resources, these developmental adaptations may increase susceptibility to obesity and chronic diseases (Popkin 1994; Popkin et al. 2012).

1.3 The Magnitude of Overweight, Obesity, and Noncommunicable Diseases

This section focuses on richer states with higher prevalence of overnutrition. The recently conducted fourth round of the District Level Household and Facility Survey, 2012–2013 (DLHS4), implemented in selected states (accounting for about 38% of the rural and 54% of the urban population), highlights the high prevalence of overnutrition in India. To track changes over time, unit record data from the second and third National Family Health Surveys (NFHS2 and NFHS3), for the years 1998–1999 and 2005–2006, are also used. We use lower BMI benchmarks than those globally used, as Asians appear to be at risk of NCDs at lower levels of BMI than other populations due to higher percentage of body fat than other populations (see Yajnik 2002; Zhou 2002). The World Health Organization (WHO) has identified 23 kilograms per meters squared (kg/m^2) and 27.5 kg/m^2 as trigger points for overweight and obesity, respectively (WHO Expert Consultation 2004).

Figures 1.1 and 1.2 use unit record data from the DLHS4, NFHS2, and NFHS3 surveys to compute the percentage of adult women whose BMI exceeds 23 kg/m^2 and 27.5 kg/m^2.[4] States are arranged in decreasing order of proportion of population below the poverty line using poverty estimates from 2011–2012. For almost all (the richer) states, more than 20% of women have a BMI greater than 23 kg/m^2. Kerala shows the highest prevalence, which increased from 36% in 1998–1999 to 48% in 2012–2013. Despite regional differences in the level of overweight

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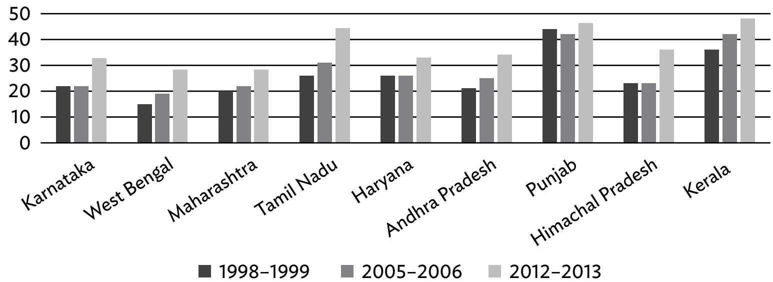
4 Trends in the magnitudes of overweight and obesity using the conventional cutoffs, and for all states, are discussed in Meenakshi (2016).

and obesity, all these states have seen a rise in the proportion of obese women with BMI exceeding 27.5 kg/m^2 (Figure 1.2).

The problem of overnutrition has percolated to rural areas as well: by 2012–2013, all the states considered here had at least 20% of rural

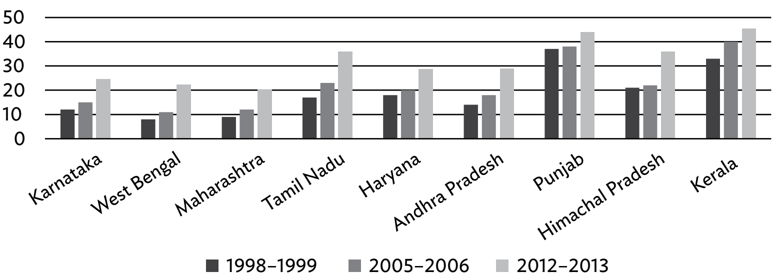
Figure 1.1A Percent of Adult Women Overweight/Obese, by State, Overall



Notes: Data refer to women aged 15 to 49 years. Adult woman is classified as overweight or obese if her BMI is ≥ 23 kilograms per meters squared.

Sources: 1998–1999 and 2005–2006 data are computed from the unit record data of the second and third rounds of the National Family Health Survey; 2012–2013 data are from the fourth round of the District Level Household and Facility Survey.

Figure 1.1B Percent of Adult Women Overweight/Obese, by State, Rural



Notes: Data refer to women aged 15 to 49 years. Adult woman is classified as overweight or obese if her BMI is ≥ 23 kilograms per meters squared.

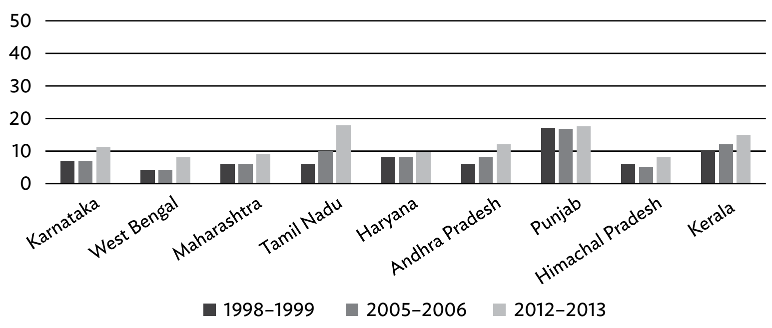
Sources: 1998–1999 and 2005–2006 data are computed from the unit record data of the second and third rounds of the National Family Health Survey; 2012–2013 data are from the fourth round of the District Level Household and Facility Survey.

women with BMI more than 23 kg/m^2 (Figure 1.1B). The increases between 2005–2006 and 2012–2013 were particularly dramatic. If the higher BMI cutoff of 25 kg/m^2 is used, in states such as Kerala, the prevalence of overweight and obesity in 2012–2013 was 30% (as compared with 48% using the 23 kg/m^2 threshold), suggesting that there is a substantial mass in the distribution of BMI between 23 and 25 kg/m^2—a pattern seen in nearly all other states.

That overnutrition is not only an urban phenomenon is borne out by other data as well. Surveys by the National Nutrition Monitoring Bureau (NNMB) have tracked heights and weights over time in rural areas of 10 states. Using this data, Ramachandran (2014) notes that while less than 5% of adults were either overweight or obese in the 1970s and 1980s, by 2004–2005, this figure had grown to nearly 11% of women and 8% of men (NNMB 2006), figures that are comparable in magnitude to those reported by the NFHS3 for 2005–2006. As noted above, in less than 10 years, these figures nearly doubled in most states.

Also, there is clear evidence of regional differences in magnitudes of overnutrition even within this subset of richer states, although there is a weak (negative) correlation with poverty levels. Punjab in the north and Kerala in the south have the highest proportions of adult women with BMI greater than 23 kg/m^2, in both rural and urban areas. These regional differences have been highlighted in other studies as well, including Ackerson et al. (2008) and Sengupta et al. (2014) as noted in Section 1.2.

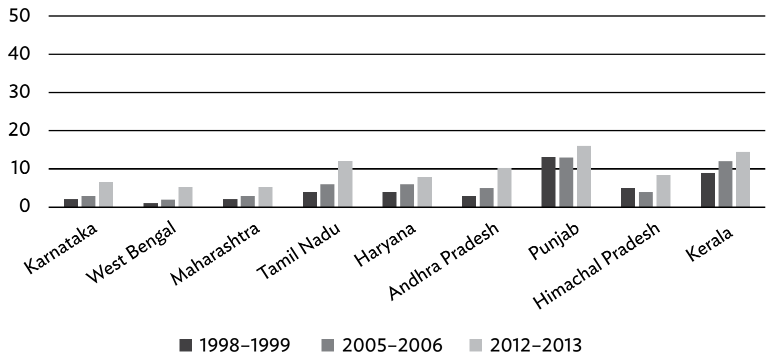
Figure 1.2A Percent of Adult Women Obese, by State, Overall



Notes: Data refer to women aged 15 to 49 years. Adult woman is classified as obese if her BMI is ≥27.5 kilograms per meters squared.

Sources: 1998–1999 and 2005–2006 data are computed from the unit record data of the second and third rounds of the National Family Health Survey; 2012–2013 data are from the fourth round of the District Level Household and Facility Survey.

Figure 1.2B Percent of Adult Women Obese, by State, Rural



Notes: Data refer to women aged 15 to 49 years. Adult woman is classified as obese if her BMI is ≥27.5 kilograms per meters squared.

Sources: 1998–1999 and 2005–2006 data are computed from the unit record data of the second and third rounds of the National Family Health Survey; 2012–2013 data are from the fourth round of the District Level Household and Facility Survey.

The magnitudes presented here are not age-standardized. Over the period 2005–2006 to 2012–2013, there was a shift in the age distribution of adult women toward older age groups. In 2005–2006 about 47% of urban and rural women were above the age of 30, but by 2012 and 2013 these figures had changed to 52% and 50%, respectively. Thus a part of the increase in magnitude of overweight and obesity may simply be a reflection of an aging population because body metabolism tends to decrease with age, leading to increased weight and BMI. To investigate whether this is the case, Figure 1.3 plots the distribution of BMI for women who are 20, 25, 30, and 40 years old over this time period, taking advantage of the relatively large size of the sample in both the NFHS3 and DLHS4 surveys. While there was little change in the distribution of BMI of 20-year-old women, all older age groups saw a systematic increase in BMIs.[5] On average, the prevalence of overweight and obesity increased by 3% for 30-year-old women and 2% for 40-year-old women, figures not very different from the 4% increase seen (on average) in the age-unadjusted prevalence of overweight and obesity.

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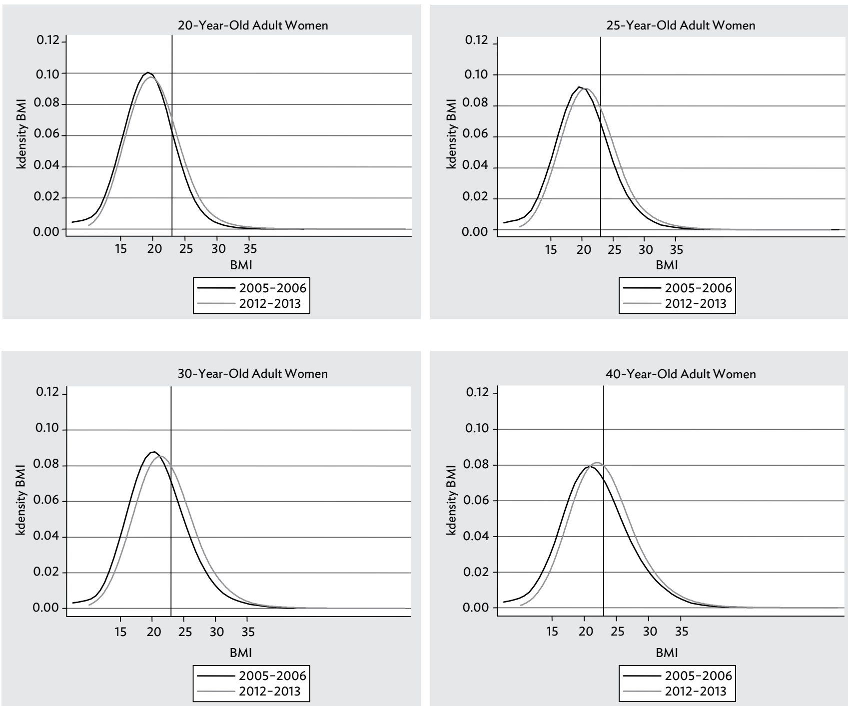
5 In each case, the Kolmogorov-Smirnov test rejects the null hypothesis of the equality of the BMI distributions across the two years 2005–2006 and 2012–2013, for all the age groups shown in Figure 1.3.

Figure 1.3 Changes in the Probability Density Function of Body Mass Index of Adult Women, 2005–2006 to 2012–2013, by Age Group



BMI = body mass index.

Sources: Computed from the unit record data of the third round of the National Family Health Survey (2005–2006) and the fourth round of the District Level Household and Facility Survey (2012–2013).

The NNMB surveys also provide information on other anthropometric indicators of overnutrition, including the waist–hip ratio (WHR), with a WHR of greater than 0.8 being indicative of abdominal obesity (Willett et al. 1999; Huxley et al. 2008; however, WHO 2011 uses a higher cutoff of 0.85). In 2004–2005, nearly 64% of all adult women in the 10 states surveyed had abdominal obesity; this figure was as high as 88% in Kerala (NNMB 2012).

Table 1.1 presents data from DLHS4 on the prevalence of pre-diabetes or diabetes as captured by the percentage of adults whose random blood sugar levels exceed 140 mg/dl. Nearly a quarter of adults in rural Kerala either have, or are at risk of developing, Type 2 diabetes

Table 1.1 Adults with Random Blood Sugar Levels Greater than 140 mg/dl, Rural Areas, by State and Gender, 2012–2013 (%)

	Random blood sugar level above 140 mg/dl	
	Male	Female
Kerala	26	24
Himachal Pradesh	18	16
West Bengal	16	14
Haryana	14	13
Punjab	13	14
Maharashtra	13	11
Tamil Nadu	12	11
Karnataka	9	8
Andhra Pradesh	8	7

mg/dl= milligrams per deciliter.
Source: State reports of the fourth round of the District Level Household and Facility Survey.

(note that this includes individuals who may have been diagnosed with diabetes and were already on medication); this figure is lowest in Andhra Pradesh, with nearly 8% of adults being in this situation. An NNMB survey conducted the year before and using a cutoff of *fasting* blood glucose levels of 126 mg/dl, an indication of Type 2 diabetes, found that approximately 8% of men and 7% of women (including new and old cases) were diabetic. There are no significant differences by gender.

Hypertension is also a significant problem. The proportion of rural women with high blood pressure ranges from 16% to 32%, while for men it ranges from 20% to 41% (Table 1.2). These figures are higher than the NNMB survey referred to above, which suggested that the proportion of adult rural women with blood pressure greater than 140/90 mmHg ranged from 12% to 27%.

Taken together, the evidence in this section highlights the rapid increase—much of it in the last 10 years—in the magnitude of overweight and obesity at which Asian populations are at greater risk of NCDs, in both urban and rural areas; not surprisingly, these are reflected in a high and increasing prevalence of hypertension and diabetes. Also highlighted are regional specificities—with states in the south and north witnessing the highest magnitudes.

Table 1.2 Adults with Blood Pressure Greater than 140/90 mmHg, Rural Areas, by State and Gender, 2012–2013 (%)

	Blood pressure above 140/90 mmHg	
	Male	Female
Punjab	41	29
Himachal Pradesh	39	32
Kerala	37	30
Haryana	27	20
Maharashtra	25	20
Andhra Pradesh	24	18
Tamil Nadu	23	16
Karnataka	21	19
West Bengal	20	18

mmHg = millimeters of mercury.
Source: State reports of the fourth round of the District Level Household and Facility Survey.

1.4 The Intra-household Dual Burden of Underweight Children and Overweight Mothers

As noted earlier, the coexistence of overweight women and underweight children within a household suggests that more than resource constraints, it is intra-household equity that matters. Unit record data from the first (2004–2005) and second (2011–2012) rounds of the India Human Development Surveys (IHDS) is used to quantify the magnitude of the dual burden of malnutrition, defined as a household that has an underweight child (a preschool child younger than 60 months with a weight-for-age less than 2 standard deviations of the median of the age-specific reference population) and an overweight mother[6] (with a BMI greater than 23 kg/m^2 following the lower cutoffs for Asian populations), abbreviated as UC-OM.

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6 A similar definition has been used by Barnett (2011) and Jehn and Brewis (2009). It is also common to define a dual burden household as one that has a stunted (compromised height) child, but since there was significant measurement error in the data on child heights in this survey of children, it is not used.

Table 1.3 Cross-Tabulation of Households by Child and Mother's Anthropometric Outcomes, by Region of Residence, 2004–2005 and 2011–2012 (% of households)

	2004–2005			2011–2012		
	Normal weight child	Under-weight child	Total	Normal weight child	Under-weight child	Total
Rural Areas						
Underweight mother	17	16	32	18	14	32
Normal weight mother	33	22	55	33	16	49
Overweight/ obese mother	9	4	13	14	5	19
Total	59	41	100	65	35	100
Number of observations		7,938			4,709	
Urban Areas						
Underweight mother	13	9	22	11	7	18
Normal weight mother	33	16	49	30	11	41
Overweight/ obese mother	23	6	29	33	8	41
Total	68	32	100	74	26	100
Number of observations		3,809			2,263	

Notes: Data refer to children aged 0 to 5 years and mothers aged 15 to 49 years. A child is defined as normal weight when weight-for-age z-score≥-2; a child is defined as underweight when weight-for-age z-score<-2. Underweight mother is defined as a mother with BMI<18.5 kilograms per meters squared (kg/m^2), normal weight mother as 18.5≤BMI<23 kg/m^2, and overweight as BMI≥23 kg/m^2.
Source: 2004–2005 and 2011–2012 figures are computed from unit record data of the India Human Development Surveys 1 and 2.

Table 1.3 shows that the percentage of households with overweight or obese mothers has increased from 13% in 2004–2005 to 19% in 2011–2012 in rural areas, while in urban areas it increased from 29% to 41%. Over the same time period, there was a decrease in the proportion of households with underweight children in both urban and rural areas, although one-third of rural households and one-quarter of urban households continue to have underweight children. These figures are consistent with those reported in other surveys.

Despite this decrease in households with underweight children, however, the % of UC-OM households increased from 4% to 5% in rural India and from 6% to 8% in urban India; the higher prevalence in urban India is in part a reflection of the higher levels of urban overweight and obesity. Another way to interpret these figures is to note that one-fifth (urban) to one-quarter (rural) of all households with an overweight mother had an underweight child, suggesting that intra-household inequality in resource allocations may be important.

Table 1.4 Cross-Tabulation of Households by Child and Mother's Anthropometric Outcomes, by Region of Residence in Richer States, 2004–2005 and 2011–2012 (% of households)

	2004–2005			2011–2012		
	Normal weight child	Under-weight Child	Total	Normal weight child	Under-weight Child	Total
Rural Areas						
Underweight Mother	18	14	32	16	10	26
Normal weight mother	35	17	53	33	14	46
Overweight/ obese mother	11	4	15	21	7	28
Total	65	35	100	69	31	100
Number of observations		3,334			1,938	
Urban Areas						
Underweight Mother	13	8	21	8	5	13
Normal weight mother	32	13	45	29	10	39
Overweight/ obese mother	27	7	33	37	10	48
Total	72	28	100	75	25	100
Number of observations		1,726			1,013	

Notes: Data refer to children aged 0 to 5 years and mothers aged 15 to 49 years. A child is defined as normal weight if weight-for-age z-score≥-2; a child is defined as underweight when weight-for-age z-score<-2. Underweight mother is defined as a mother with BMI<18.5 kilograms per meters squared (kg/m^2), normal weight mother as 18.5≤BMI<23 kg/m^2, and overweight as BMI≥ 23kg/m^2. Richer states include Karnataka, West Bengal, Maharashtra, Tamil Nadu, Haryana, Andhra Pradesh, Punjab, Himachal Pradesh, and Kerala.
Sources: 2004–2005 and 2011–2012 figures are computed from unit record data of the India Human Development Survey, Rounds 1 and 2.

Might this problem be more severe for the relatively more affluent states which saw greater increases in the proportion of overweight mothers and more modest declines in underweight children? Table 1.4 suggests that this is indeed the case in nine richer states, with 7% of rural households and 10% of urban households having a UC-OM pair in 2011–12.

The phenomenon of the coexistence of an underweight child and overweight mother has been observed in other low- and middle-income countries including Kenya, Bangladesh, Guatemala, Ghana, and Peru. In Guatemala, 6% of households had UC-OM pairs, while in Bangladesh and Kenya less than 5% did so in early 2000 (Lee et al. 2012; Barquera et al. 2007; Oddo et al. 2012; Jehn and Brewis 2009).

What are the socioeconomic factors that are associated with households with double burden? The literature suggests that prevalence of dual burden is associated with older maternal age, shorter maternal stature, and increasing family size (Oddo et al. 2012; Lee et al. 2010; Jehn and Brewis 2009). Education of the mother appears to protect against the intra-household dual burden in Indonesia, but the reverse appears to be the case in Bangladesh (Oddo et al. 2012).

Similarly, household wealth is positively associated with the prevalence of the double burden of malnutrition, suggesting that lack of access to adequate food is not a constraint (Lee et al. 2012). However, some studies do not find any association with wealth at all (see for example Lee et al. 2010). A cross-country analysis by Jehn and Brewis (2009) looked at this phenomenon in 19 lower- and middle-income countries and found it to be less prevalent in countries with lower wealth. Similarly, Garrett and Ruel (2005), analyzing data from several countries in Africa, Asia, and Latin America, find that the phenomenon increases with GDP per capita up to a point.

Leroy et al. (2014) explore the interaction between education and household wealth in explaining the prevalence of stunted child–overweight mother households in Mexico. They find that household wealth was significantly associated with increases in the prevalence of double burden pairs only among mothers who had not completed primary school. They argue that among more educated mothers, wealth is associated with both increases in child height and an absence of undesirable weight gain among mothers, and hence maternal education could mitigate the negative effect of increasing household income on dual burden households.

Some studies for the People's Republic of China, India, and Viet Nam find urban residence to be associated with the phenomenon of intra-household dual burden (Doak et al. 2000; Barnett 2011), while Lee et al. (2012) find it to be a rural phenomenon in Guatemala. However, an analysis for several countries by Garrett and Ruel (2005) finds that it is not necessarily associated with urbanization.

Analyses of the intra-household dual burden that focus on India include VanderKloet (2008) and Barnett (2011), who both use the Young Lives dataset for Andhra Pradesh. VanderKloet (2008) looks at households with an overweight mother and adolescents (11–13 years old) and finds that male, prepubescent children; un-immunized children; and those with a small maternal support network were more likely to be in UC-OM households than in households with a non-underweight child and an overweight mother. Barnett (2011) considers the prevalence of households with an overweight mother and a stunted or underweight child aged 4.5–5.5 years and finds that households living in urban areas are more likely to have these pairs, while VanderKloet (2008) finds location to have weak association. Note, however, that the Young Lives dataset oversampled poor households and may thus have underestimated the magnitude of the phenomenon.

This chapter contributes to this limited literature by examining correlates of households with an underweight child aged less than 60 months and an overweight mother (UC-OM) using a nationally representative dataset.

1.5 Factors Associated with the Intra-household Dual Burden of Malnutrition

Both binary and multinomial logit regression models are used to identify the predictors of dual burden (UC-OM) households. In the binary case, all other households are the reference group, whereas in the multinomial logit, the various socioeconomic and behavioral factors that are associated with households that have UC-OM, an underweight child and non-overweight mother (UC-NOM), and a non-underweight child and overweight mother (NUC-OM) are examined using households with a non-underweight child and non-overweight mother (NUC-NOM) as the reference category. The analysis is conducted both at the all-India level and also for a subset of nine better-off states to see whether the risk factors vary across the two.[7] Based on the review in the previous sections as well as literature that pertains to other developing countries, the following covariates are included, with some variation in alternative specifications, as noted in the tables.

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7 A likelihood ratio test of no differences in coefficients in the richer states as compared to all states was rejected.

Child characteristics: In addition to demographic characteristics of the child's age (in months) and gender, two dichotomous measures of the health of the child are used: first, whether the child had diarrhea during the month preceding the survey; and second, whether the child was fully immunized for a given age. Low birth weight is also a strong predictor of poor nutritional outcomes for children (see for example Wardlaw 2004); this is captured by a subjective assessment by the child's mother of whether the child was average or above average in size when born, in comparison to children who were born with a below-average size at birth (reference category). Although it would have been ideal to have some indicator of child-specific food intakes, this data is not currently available.

Maternal characteristics: Mother's age (and a squared term in age to capture nonlinearities) is included, as the literature suggests weight gain first increases (as metabolism slows with age and results in weight gain) and then decreases with age. There are studies showing a positive association between parity and weight gain due to pregnancy and the onset of obesity in women (Brown et al. 1992, Wolfe et al. 1997); as a proxy we include the number of children in the household.

Maternal education has been linked to child malnutrition (negatively) and also to overnutrition among women. To capture this, mother's education is categorized into four levels: none, primary education (1–5 years in school), upper primary (6–8 years), and higher secondary and above (9 or more years); no education is the reference category. Mother's occupational status is also included in the analysis under the assumption that mothers who are working in blue collar jobs (used as the reference category) would have more active lifestyles than mothers who are not working or mothers in white collar jobs.[8] Mother's height is also included as a continuous variable as better-nourished mothers have a lower probability of having malnourished children (Ferreira et al. 2009; Sichieri et al. 2003; Victora et al. 2008).

Lifestyle factors as captured by the number of hours spent on watching television are also included, with a dummy variable with value 1 if women watch more than 2 hours of television a day, and 0 if they watch for fewer hours.

Household characteristics: Household income is captured by including household expenditure quintiles as covariates. Lastly, place of residence (rural or urban) is also included.

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8 A mother is classified as working in a white collar job if she is a scientist, director, manager, economist, teacher, clerk or related worker, sales worker, merchant, shopkeeper, salesperson, etc. She is classified as working in a blue collar job if her occupation is agriculture and plantation laborer, cultivator, production laborer, bricklayer, construction worker, miner or related worker, or a service worker (maid, cook, or sweeper).

Thus, given a vector of child characteristics C_i, maternal characteristics M_i, and household characteristics H_i for household *i*, a model of the intra-household double burden of malnutrition may be specified as:

$$ln\frac{P_i^s}{P_i^t} = \beta_0 + \beta_1 C_i + \beta_2 M_i + \beta_3 H_i \text{, for } s \neq t$$

where the probability of household i having a pair s is denoted by P_i^s.

In a binary logit model s = UC-OM and t refers to all other households (that do not have a UC-OM pair). In the multinomial logit case, the probabilities refer to s = UC-OM, UC-NOM, NUC-OM, and Zt = NUC-NOM. In other words, using NUC-NOM as the reference pair, the multinomial logit regressions are estimated for the UC-OM, UC-NOM, and NUC-OM households.

The estimation sample is drawn from the IHDS2 dataset (for 2011–2012). Given that there are rural–urban differences in the magnitudes of overweight, obesity, and dual burden households, and that the factors that drive them may vary across rural and urban areas, these models were first estimated separately by region. However, a likelihood ratio test indicated that the null hypothesis of no rural–urban differences in coefficients could not be rejected across all specifications. For this reason, results are presented only for the pooled model, although as noted above, a dummy variable to represent region of residence is included. All standard errors are clustered at the primary sampling unit.

1.5.1 Regression Results

Table 1.5 presents the odds ratio of the predictors from the binary logistic model on UC-OM for both richer and all states, and for two specifications. For all states, and across both specifications, only two child-level factors—birth size and age—are significant predictors of UC-OM. A child who was large or average at the time birth has 29% lower odds of being UC-OM as compared with a child who was very small or small in size; similarly, older children are more likely to belong to a UC-OM pair. However, for the subset of richer states, none of the child-level characteristics seem to matter.

Among maternal characteristics, for all states, relative to other households, taller mothers are less likely to have an underweight child and to be overweight; this result is in line with other studies that found similar associations (Oddo et al. 2012; Lee et al. 2010). Older mothers

Table 1.5 Odds Ratios for Covariates from a Logit Regression of the Probability of an Underweight Child and Overweight Mother Household, Alternative Specifications

Dependent Variable: Probability that a Household has a UC-OM Pair	Richer States		All States	
	Specification 1	Specification 2	Specification 3	Specification 4
Child Characteristics				
Age (in months)	1.000	1.000	1.009**	1.009**
	(0.005)	(0.005)	(0.004)	(0.004)
Gender (girl)	0.937	0.936	0.999	0.996
	(0.141)	(0.141)	(0.115)	(0.115)
Diarrhea last month	0.640		1.078	
	(0.201)		(0.185)	
Fully immunized	0.980		1.091	
	(0.157)		(0.132)	
Birth size	0.839	0.855	0.713**	0.713**
	(0.169)	(0.170)	(0.101)	(0.101)
Maternal Characteristics				
Number of children	1.186**	1.187**	1.087	1.077
	(0.101)	(0.100)	(0.066)	(0.065)
Height (in meters)	0.943***	0.943***	0.950***	0.950***
	(0.012)	(0.011)	(0.009)	(0.009)
Age (in years)	1.208	1.207	1.204*	1.208*
	(0.164)	(0.163)	(0.126)	(0.126)
Age squared	0.998	0.998	0.998	0.998
	(0.002)	(0.002)	(0.002)	(0.002)
More than 2 hours of TV	1.058	1.055	1.277**	1.276**
	(0.163)	(0.161)	(0.149)	(0.150)
Primary education	1.127	1.116	1.423*	1.456*
	(0.357)	(0.352)	(0.289)	(0.296)
Upper primary	1.181	1.167	1.561**	1.614**
	(0.341)	(0.338)	(0.299)	(0.311)
Higher secondary and above	1.181	1.165	1.403	1.490*
	(0.343)	(0.339)	(0.293)	(0.309)
Not working	1.033		1.137	
	(0.218)		(0.176)	

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Table 1.5 *continued*

Dependent Variable: Probability that a Household has a UC-OM Pair	Richer States		All States	
	Specification 1	Specification 2	Specification 3	Specification 4
White collar jobs	0.990		1.446	
	(0.351)		(0.362)	
Household Characteristics				
Expenditure quintile 2	3.211***	3.202***	1.576**	1.586**
	(1.427)	(1.421)	(0.339)	(0.341)
Expenditure quintile 3	2.161*	2.164*	1.206	1.217
	(0.960)	(0.959)	(0.272)	(0.274)
Expenditure quintile 4	2.715**	2.716**	1.466*	1.496*
	(1.207)	(1.206)	(0.331)	(0.336)
Expenditure quintile 5	2.399*	2.406*	1.461	1.490*
	(1.097)	(1.097)	(0.348)	(0.353)
Urban residence	1.614**	1.634***	1.478***	1.532***
	(0.305)	(0.278)	(0.208)	(0.199)
N	2,543	2,543	5,527	5,527

UC-OM = underweight child and overweight mother.
Notes: Base categories: boy for gender, didn't have diarrhea for diarrhea last month, not fully immunized for fully immunized, very small/small for birth size, less than 2 hours of TV for hours of TV, no education for mother's education, blue collar job for mother's occupation, expenditure quintile 1 for expenditure quintile, rural for place of residence. A child is defined as underweight when weight-for-age z-score<−2; non-underweight when weight-for-age z-score≥−2. Mother is defined as overweight when BMI>=23 kilograms per meters squared (kg/m^2) and non-overweight when BMI<23 kg/m^2. Richer states include Karnataka, West Bengal, Maharashtra, Tamil Nadu, Haryana, Andhra Pradesh, Punjab, Himachal Pradesh, and Kerala. Standard errors, clustered at the primary sampling unit, in parentheses; *p<0.10, **p<0.05, ***p<0.01.
Source: Computed using India Human Development Survey, Round 2 unit record data.

and mothers who watch more than 2 hours of television are also more likely to be overweight and have an underweight child compared to other households.

The dual burden is more likely to occur in households where mothers have some formal education relative to households where mothers have no education. This apparently perverse relationship likely reflects the fact that adult overweight/obesity increases rapidly with education (as it is associated with less active lifestyles) but underweight does not fall as rapidly. These effects seem to matter, despite controls for income (proxied by household expenditure) and occupation. This is similar to findings by Oddo et al. (2012) for Bangladesh and Wong et al. (2015) for Malaysia. However, occupation does not seem to exert any independent effect on the probability of a household having a UC-OM pair. Many of these covariates are, however, insignificant when the subset of richer states is considered: only mother's height and the number of children are significant in predicting familial coexistence of underweight child and maternal overweight. This may reflect the well-known positive association of weight gain with each pregnancy and also that higher parity is associated with child undernutrition, in line with what Lee et al. (2010) have found.

Finally, households in wealthier quintiles relative to households in the lowest quintile appear to be more vulnerable to the double burden of malnutrition. For example, households in the fifth quintile have a 139% higher chance of having UC-OM pairs as compared to households in the lowest quintile in richer states, while the corresponding figure for all states is 49%, and is consistent with other studies (for example, Lee et al. 2012; Doak et al. 2005). As expected, urban residents are more likely to have UC-OM pairs relative to rural residents.

1.5.2 Multinomial Logistic Results

We examine if the covariates associated with being a UC-OM household vary if, instead of a comparison group of all other households, a multinomial approach is used, in which the factors associated with belonging to UC-OM, UC-NOM, and NUC-OM households are examined simultaneously (with the reference category of NUC-NOM household). Relative risk ratios from the multinomial logistic (MNL) using the first specification are presented in Table 1.6,[9] while Table 1.7 does the same for the more parsimonious specification. As before, variants that contain observations for all states, and a subset of the richer states, are presented separately.

Similar to the case with binary logit analysis, the MNL results for all states suggest that the child's age and birth size significantly affect the probability of being a UC-OM (relative to a NUC-NOM) household. Similarly, shorter and older mothers, and mothers who spend more time watching television, have higher chances of belonging to a UC-OM household; mothers with some formal education relative to illiterate mothers have higher odds of being UC-OM. The association with income is also the same: households in the highest quintile relative to

9 The models were tested for the validity of the independence of irrelevant alternatives (IIA) assumptions using the Hausman test, which failed to reject the null hypothesis of independence of irrelevant alternatives, suggesting that the MNL specification is appropriate.

the lowest quintile and households living in urban areas relative to rural households have higher chances of being UC-OM. These results remain unchanged in the more parsimonious specification as well. The set of significant coefficients (in terms of relative risk) is much smaller when the subset of richer states is examined, with taller mothers, mothers with more children, and households in higher-expenditure quintiles more likely to have a UC-OM than a NUC-NOM pair; this is also consistent with the results from the binary case.

Turning to the predictors of households with UC-NOM, households with older children are more likely, larger birth-weight children less likely, and those who had diarrhea recently more likely to belong to this group relative to NUC-NOM. For example, children who were large/average when they were born have 35% (all states) lower risk of being UC-NOM relative to NUC-NOM households. Maternal height and mothers' education are associated with lower probability of having UC-NOM pairs relative to NUC-NOM. Sedentary lifestyles (as captured by the number of hours spent watching television) are likely to lead to lower odds of being UC-NOM. Mothers working in blue collar jobs have more chances of being UC-NOM as compared to mothers who are not working; this variable matters even after controlling for household income quintiles. Not unexpectedly, richer households are less likely to have a UC-NOM pair compared to NUC-NOM; however, area of residence does not seem to matter. Unlike the case with UC-OM, there are no major differences in the variables that are significant across all states and the subset of richer states; they are also robust to choice of specification (see Table 1.7). These results are similar to those of Jehn and Brewis (2009), who find that households in the lowest wealth quintile and with less educated mothers have higher risk of having an underweight child and a non-overweight mother.

Finally, examining factors associated with NUC-OM households, the results in Tables 1.6 and 1.7 suggest that, relative to NUC-NOM households, taller mothers have lower chances and older mothers have higher chances of being NUC-OM. Occupation is also a significant predictor, with chances of being a NUC-OM increasing if mothers are employed in jobs that involve less physical labor or are not working (relative to mothers working in more physically strenuous jobs).

Furthermore, households with educated mothers relative to mothers with no education, and higher income quintiles relative to the lowest income quintile, have higher risk of having a NUC-OM pair than being NUC-NOM. However, for richer states, this is seen only in the highest quintile. As expected, results across both the richer and all states predict that urban relative to rural households have higher chances of

Table 1.6 Relative Risk Ratio for Covariates from a Multinomial Logit Regression of the Probability that a Household has an Underweight Child and Overweight Mother, Underweight Child and Non-Overweight Mother, or Non-Underweight Child and Overweight Mother pair (relative to Non-Underweight Child and non-Overweight Mother)

Variables	Richer States						All States					
	(1) UC-OM		(2) UC-NOM		(3) NUC-OM		(4) UC-OM		(5) UC-NOM		(6) NUC-OM	
Child Characteristics												
Age (in months)	1.006	(0.005)	1.014***	(0.004)	1.009***	(0.003)	1.015***	(0.004)	1.013***	(0.002)	1.010***	(0.002)
Gender (girl)	0.942	(0.148)	1.029	(0.121)	0.996	(0.101)	0.984	(0.117)	0.955	(0.068)	0.988	(0.073)
Diarrhea last month	0.838	(0.277)	1.760***	(0.318)	1.451**	(0.265)	1.183	(0.211)	1.469***	(0.151)	0.966	(0.120)
Fully immunized	0.986	(0.165)	0.890	(0.107)	1.075	(0.121)	1.085	(0.135)	0.894	(0.066)	1.098	(0.087)
Birth size	0.871	(0.184)	0.763*	(0.110)	1.398**	(0.215)	0.642***	(0.097)	0.651***	(0.062)	1.059	(0.118)
Maternal Characteristics												
Number of children	1.166*	(0.105)	1.017	(0.075)	0.962	(0.071)	1.032	(0.065)	0.953	(0.035)	0.906**	(0.040)
Height (in meters)	0.922***	(0.012)	0.956***	(0.009)	0.969***	(0.008)	0.930***	(0.009)	0.956***	(0.006)	0.977***	(0.006)
Age (in years)	1.234	(0.173)	0.853	(0.088)	1.305**	(0.151)	1.266**	(0.133)	0.943	(0.055)	1.382***	(0.101)
Age squared	0.998	(0.002)	1.002	(0.002)	0.997	(0.002)	0.997	(0.002)	1.001	(0.001)	0.996***	(0.001)
More than 2 hours TV	1.105	(0.176)	0.993	(0.115)	1.137	(0.119)	1.263*	(0.153)	0.871*	(0.067)	1.101	(0.085)
Primary education	1.233	(0.408)	0.949	(0.189)	1.491*	(0.350)	1.551**	(0.325)	1.062	(0.119)	1.460**	(0.221)
Upper primary	1.179	(0.351)	0.743	(0.136)	1.388	(0.295)	1.586**	(0.310)	0.780**	(0.080)	1.616***	(0.210)
Higher secondary and above	1.264	(0.377)	0.679**	(0.125)	1.703**	(0.355)	1.558**	(0.326)	0.719***	(0.079)	2.051***	(0.271)
Not working	1.048	(0.224)	0.713***	(0.086)	1.392**	(0.183)	1.152	(0.179)	0.787***	(0.061)	1.464***	(0.143)
White collar jobs	1.202	(0.450)	0.965	(0.270)	1.795***	(0.407)	1.512	(0.393)	0.740	(0.143)	1.594***	(0.265)

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Table 1.6 *continued*

Variables	Richer States						All States					
	(1) UC-OM		(2) UC-NOM		(3) NUC-OM		(4) UC-OM		(5) UC-NOM		(6) NUC-OM	
Household Characteristics												
Expenditure quintile 2	3.008**	(1.347)	0.914	(0.187)	1.000	(0.249)	1.411	(0.312)	0.833*	(0.090)	0.954	(0.149)
Expenditure quintile 3	1.981	(0.887)	0.761	(0.152)	1.093	(0.256)	1.155	(0.265)	0.802*	(0.091)	1.400**	(0.208)
Expenditure quintile 4	2.491**	(1.109)	0.603**	(0.121)	1.267	(0.287)	1.348	(0.311)	0.598***	(0.072)	1.541***	(0.229)
Expenditure quintile 5	2.538**	(1.160)	0.702*	(0.149)	1.622**	(0.383)	1.552*	(0.372)	0.610***	(0.080)	2.063***	(0.311)
Urban residence	1.916***	(0.368)	0.958	(0.135)	1.606***	(0.191)	1.716***	(0.242)	0.982	(0.085)	1.645***	(0.143)
N	2,543		2,543		2,543		5,527		5,527		5,527	

UC-OM = underweight child and overweight mother, UC-NOM = underweight child and non-overweight mother, NUC-OM = non-underweight child and overweight mother, NUC-NOM = non-underweight child and non-overweight mother.

Notes: Base categories: boy for gender, didn't have diarrhea for diarrhea last month, not fully immunized for fully immunized, very small/small for birth weight, less than 2 hours of TV for more than 2 hours of TV, no education for mother's education, blue collar jobs for mother's occupation, expenditure quintile 1 for expenditure quintile, rural for place of residence. A child is defined as underweight when weight-for-age z-score<–2; non-underweight when weight-for-age z-score≥–2. A mother is defined as overweight when BMI>=23 kilograms per meters squared (kg/m^2) and non-overweight when BMI<23 kg/m^2. Richer states include Karnataka, West Bengal, Maharashtra, Tamil Nadu, Haryana, Andhra Pradesh, Punjab, Himachal Pradesh, and Kerala. Standard errors, clustered at the primary sampling unit, in parentheses; *p<0.10, **p<0.05, ***p<0.01.

Source: Estimated using India Human Development Survey, Round 2 unit record data.

Table 1.7 Relative Risk Ratio for Covariates from a Multinomial Logit Regression of the Probability that a Household has an Underweight Child and Overweight Mother, Underweight Child and Non-Overweight Mother, or Non-Underweight Child and Overweight Mother Pair (relative to Non-Underweight Child and non-Overweight Mother), Alternate Specification

Variables	Richer States						All States					
	(1) UC-OM		(2) UC-NOM		(3) NUC-OM		(4) UC-OM		(5) UC-NOM		(6) NUC-OM	
Child Characteristics												
Age (in months)	1.010**	(0.005)	1.014***	(0.003)	1.009***	(0.003)	1.017***	(0.004)	1.012***	(0.002)	1.010***	(0.002)
Gender (girl)	1.009	(0.152)	1.011	(0.107)	1.007	(0.099)	1.072	(0.119)	0.976	(0.060)	1.013	(0.071)
Diarrhea last month	0.763	(0.243)	1.485**	(0.251)	1.351*	(0.232)	1.096	(0.183)	1.467***	(0.130)	0.949	(0.109)
Birth size	0.803	(0.165)	0.738**	(0.098)	1.375**	(0.198)	0.653***	(0.090)	0.714***	(0.059)	1.119	(0.114)
Maternal Characteristics												
Height (in meters)	0.927***	(0.012)	0.963***	(0.008)	0.970***	(0.008)	0.930***	(0.008)	0.958***	(0.005)	0.973***	(0.006)
Age (in years)	1.218	(0.155)	0.926	(0.081)	1.281**	(0.128)	1.167	(0.118)	0.892**	(0.042)	1.312***	(0.086)
Age squared	0.998	(0.002)	1.001	(0.002)	0.997*	(0.002)	0.999	(0.002)	1.002**	(0.001)	0.997***	(0.001)
Primary education	1.200	(0.354)	0.987	(0.175)	1.653**	(0.351)	1.368*	(0.251)	1.009	(0.094)	1.513***	(0.204)
Upper primary	1.136	(0.307)	0.838	(0.135)	1.526**	(0.286)	1.520**	(0.253)	0.794***	(0.066)	1.806***	(0.204)
Higher secondary and above	1.175	(0.314)	0.721**	(0.114)	1.959***	(0.355)	1.475**	(0.265)	0.675***	(0.063)	2.380***	(0.267)
Not working	1.175	(0.240)	0.741***	(0.081)	1.438***	(0.174)	1.296*	(0.182)	0.791***	(0.053)	1.521***	(0.135)
White collar jobs	1.197	(0.418)	0.843	(0.225)	1.630**	(0.344)	1.428	(0.352)	0.675**	(0.121)	1.423**	(0.221)

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Table 1.7 *continued*

Variables	Richer States						All States					
	(1) UC-OM		(2) UC-NOM		(3) NUC-OM		(4) UC-OM		(5) UC-NOM		(6) NUC-OM	
Household Characteristics												
Expenditure quintile 2	2.849***	(1.131)	0.976	(0.176)	1.169	(0.258)	1.426*	(0.268)	0.842*	(0.076)	1.019	(0.138)
Expenditure quintile 3	1.841	(0.727)	0.853	(0.150)	1.264	(0.257)	1.265	(0.245)	0.854*	(0.081)	1.470***	(0.188)
Expenditure quintile 4	2.404**	(0.934)	0.721*	(0.128)	1.497**	(0.297)	1.463*	(0.292)	0.672***	(0.069)	1.713***	(0.220)
Expenditure quintile 5	2.323**	(0.924)	0.715*	(0.138)	1.904***	(0.387)	1.616**	(0.330)	0.608***	(0.071)	2.312***	(0.299)
Urban residence	1.811***	(0.333)	1.032	(0.135)	1.604***	(0.182)	1.675***	(0.219)	0.983	(0.079)	1.689***	(0.138)
N	2,877		2,877		2,877		6,875		6,875		6,875	

UC-OM = underweight child and overweight mother, UC-NOM = underweight child and non-overweight mother, NUC-OM = non-underweight child and overweight mother, NUC-NOM = non-underweight child and non-overweight mother.

Notes: Base categories: boy for gender, didn't have diarrhea for diarrhea last month, very small/small for birth size, no education for mother's education, blue collar job for mother's occupation, expenditure quintile 1 for expenditure quintile, rural for place of residence. A child is defined as underweight when weight-for-age z-score<−2; non-underweight when weight-for-age z-score ≥−2. A mother is defined as overweight when BMI>=23 kilograms per meters squared (kg/m^2) and non-overweight when BMI<23 kg/m^2.Richer states include Karnataka, West Bengal, Maharashtra, Tamil Nadu, Haryana, Andhra Pradesh, Punjab, Himachal Pradesh, and Kerala. Standard errors, clustered at the primary sampling unit, in parentheses; *p<0.10, **p<0.05, ***p<0.01.

Source: Estimated using India Human Development Survey, Round 2 unit record data.

having a NUC-OM pair. As shown in Table 1.7, the results are unaffected when an alternate specification is considered.

To summarize, a child's birth size and age, the mother's health (as captured by her height), age, education, whether she has a sedentary lifestyle, and household expenditure significantly predict whether a household has an underweight child and overweight mother. All these are in the expected direction and are consistent with the evidence found for other developing countries including Indonesia and Bangladesh. While urban residence matters, it appears to affect only the level and not the magnitudes of the marginal effects of the covariates. These results are robust to both the choice of specification and the method of estimation (as there are no substantial differences in the set of factors that are significant across both the binary and MNL specifications). However, when a subset of the richer states is examined separately, only the mother's health, the number of children she has, and household expenditure are significant—once again, results that are robust to both choice of specification and method of estimation. Thus there appear to be strong regional differences in the principal drivers of the probability of having a dual burden household. Also, lack of access to household-level resources does not appear to explain the phenomenon, suggesting that intra-household allocation of food and other resources may be inequitable, although the lack of data on food intakes precludes a definitive statement.

1.6 Conclusions

India is far along the nutrition transition. This chapter has demonstrated that the proportion of overweight and obese adult women in India is increasing rapidly. Not surprisingly, the magnitudes of at least two of the NCDs—diabetes and hypertension—are large and have important implications for diagnosis and treatment. Given regional variations, there is a need for different intensities of intervention—with a focus on diagnosis and management in high-burden states, and prevention in regions where the magnitudes of overweight and obesity are lower. This is likely to be a particular challenge in rural areas, where health systems are weak and monitoring and managing diabetes and hypertension is challenging.

To what extent macro policy levers, especially those related to the price of food, can be used to effect better health outcomes needs further investigation. Some states subsidize the provision of edible oil and sugar through the public distribution system, potentially leading to greater consumption. Also, some have argued that the Indian National Food Security Act, with its focus on highly subsidized cereals, may act as a disincentive to make better diet choices in favor of fruits, vegetables, and dairy products—as higher-quality diets are also more expensive. However, the limited evidence (see Meenakshi 2016) suggests that quantities consumed of fats, oils, and sugars are highly inelastic with respect to price, limiting the effectiveness of price instruments, and that income effects may dominate in consumption trends. Further research is required in this area.

While the magnitude of undernutrition, especially among children, is declining in nearly all states, the phenomenon of the intra-household dual burden is increasing. The analysis suggests that among other factors, households in which children are born with a healthy weight are less likely to have a dual burden of malnutrition, underscoring the importance of current policy initiatives designed to ensure safe and healthy pregnancy outcomes. The significance of the household expenditure variable suggests that unlike the case in many developed countries (but similar to the experience of other countries undergoing the transition), overnutrition is associated with affluence; equally clearly, lifestyle choices also matter. Although this analysis could not directly address to what extent such households are characterized by inequalities in food intakes, it is reasonable to infer that a reallocation may help address the problem of the intra-household dual burden. Behavior change communication strategies that address both healthy lifestyle and diet choices for adults and appropriate feeding practices for children need greater emphasis. However, even here, there are regional differences in both trends and factors contributing to them, suggesting that a region-specific set of interventions will need to be implemented.

There are, of course, some limitations to this analysis: first, the relationships estimated here reflect associations and are not vested with causal interpretation, for familiar reasons associated with endogeneity in family health, education, and income. Also, there are some critical missing variables that are important determinants of health, including information on dietary intakes of mothers and children, and past disease history, which could not be considered for lack of data. Nonetheless, the stylized facts emerging from this analysis appear robust and can provide the basis for developing interventions as outlined above.

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2

The Obesity Pandemic in the Pacific

Jillian Wate

2.1 Introduction

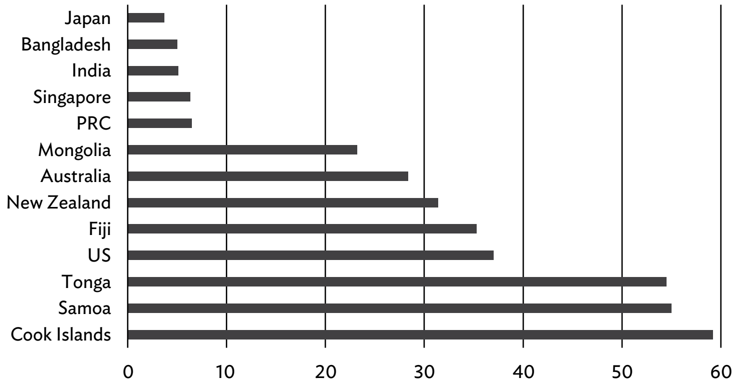
In the last 2 decades, many Pacific Island countries and territories (PICTs)[1] have experienced increasing levels of obesity. Seven out of the ten countries with the highest prevalence rates of obesity are found in this region (World Atlas 2016). While many factors contribute to this epidemic, a complex backdrop of globalization, unplanned urbanization, and rapid economic growth in PICTs have changed Pacific Islanders' consumption patterns. Another contributor has been a shift in dietary patterns from reliance on traditional low-fat diets typically based on complex carbohydrates, fresh fish, meat, and leafy greens, to increasingly modern diets based on refined starch, oils, processed meats, and confectionary (Thow et al. 2011; Snowdon, Raj et al. 2013; Estimé et al. 2014). However, dietary patterns are shaped by many interacting factors including income, prices, individual preferences and beliefs, cultural traditions, and social cultural factors (Waqanivalu 2010).

2.2 Obesity Prevalence in Adults

There are wide variations in the global prevalence of obesity. Between 1998 and 2008, more men compared to women were obese worldwide.

1 The Pacific Island region is made up of 22 island countries and territories of Polynesia, Micronesia, and Melanesia. The Polynesian island countries include American Samoa, Cook Islands, French Polynesia (Tahiti), Niue, Pitcairn, Samoa, Tonga, Tokelau, and Tuvalu. The Micronesian island countries and territories include the Federated States of Micronesia, Guam, Kiribati, Marshall Islands, Nauru, North Mariana Islands, and Palau. The Melanesian island countries include Fiji (also Polynesia), New Caledonia, Papua New Guinea, Solomon Islands, and Vanuatu. There is great cultural diversity in this region, with about 1,200 languages spoken.

Figure 2.1 Variations in Obesity Prevalence in Adult Women in Selected Countries (2016)



BMI = body mass index, PRC = People's Republic of China, US = United States.
Source: World Health Organization 2018.

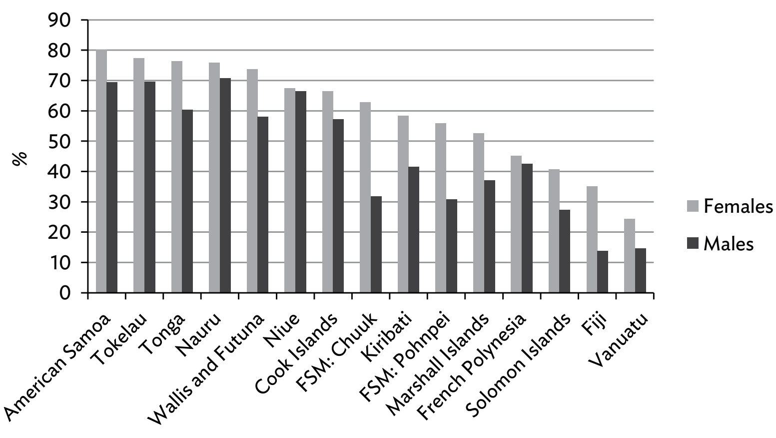
This can also be seen for adult women in selected countries; sex differences in obesity prevalence may be accounted for by economic, social, and cultural determinants (see Figure 2.1). Obesity prevalence varied from less than 2% in Bangladesh to around 30% in Australia and the United States (US) and over 80% in Tonga, a Pacific Island country. Variations in obesity prevalence can also be seen in a single country such as in New Zealand, where obesity is higher among the New Zealand Pacific Islanders compared to the Europeans (Ministry of Health 2008). In Fiji, for instance, the obesity prevalence is higher for Indigenous Fijians compared to Fijians of Indian descent (Saito 1995; Schultz et al. 2005). Despite the lower prevalence of obesity among Fijians of Indian descent, this prevalence is higher compared to that in India.

As mentioned previously, Pacific Island countries have some of the highest prevalence rates of adult obesity in the world (World Health Organization 2001; Becker et al. 2005; Gani 2009). In 2008, body mass indexes (BMIs) for males and females were highest in some Oceanian countries, reaching 33.9 kilograms per meters squared (kg/m^2) (32.8–35.0) for men and 35.0 kg/m^2 (33.6–36.3) for females in Nauru (Finucane et al. 2011). Finucane et al., in their systematic review of epidemiological studies globally, including 19 countries in Oceania, reported that between 1998 and 2008, male BMI increased in all but eight countries, with mean BMIs increasing by more than 2 kg/m² per decade in Nauru and the Cook Islands.

Although trend data are unavailable in the region due to lack of repeated surveys, obesity prevalence data is available in this region. World Health Organization has supported noncommunicable disease (NCD) risk factors STEPS surveys in a number of Pacific Island countries and territories over the last decade. The resulting data has been used for policy and program planning and implementation. To date, 17 countries and territories have completed their first NCD risk factors surveys, 3 have done STEPS-like surveys, and 8 have done two surveys. As seen in Figure 2.2, overweight (BMI ≥ 25 kg/m²) is prevalent among adults in most of the Pacific Island countries and territories, with prevalence over 70% for countries like Tonga, American Samoa, Tokelau, Wallis and Futuna, Niue, Cook Islands, Kiribati, Marshall Islands, and Pohnpei. More women are overweight compared to men.

Similarly, obesity prevalence is significant in this region, with over two-thirds of the adult population in most Pacific Island countries and territories being clinically obese, i.e., BMI ≥ 30 kg/m² (Figure 2.3). American Samoa, Tokelau, Tonga, Nauru, and Wallis and Futuna have the highest obesity prevalence in particular among women. Most of these obesity rates are higher than the global average of 13%.

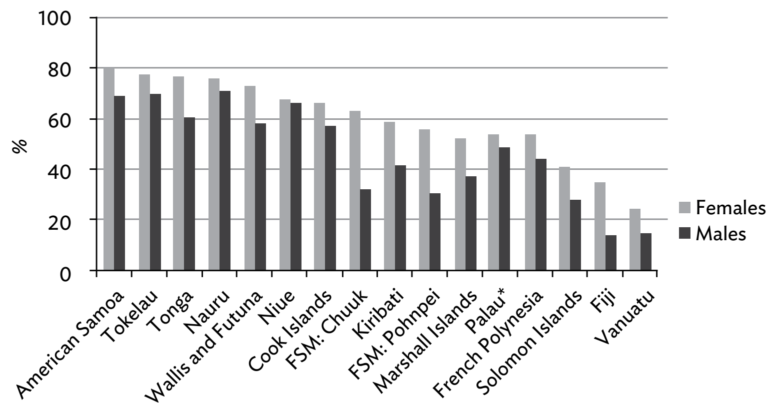
Figure 2.2 Overweight Prevalence in Adults (Aged 25–64 Years) by Sex



FSM = Federated States of Micronesia.

Sources: Kessaram et al. 2015; World Health Organization 2017.

Figure 2.3 Obesity Prevalence in Adults (Aged 25–64 Years) by Sex



FSM = Federated States of Micronesia.

Sources: Kessaram et al. 2015; World Health Organization 2017; *Watson et al. 2015.

2.3 Obesity Prevalence in Adolescents and Children

The prevalence of overweight and obesity in adolescents has been constantly increasing worldwide (Lobstein et al. 2015), including in the PICTs. As seen in Table 2.1, overweight and obesity is high among girls and boys in the Pacific. Girls are more overweight and obese than boys. In Tonga, 61.2% of boys and 58.0% of girls were overweight, with 24.7% of boys and 19.1% of girls being obese; Samoa reported 43.4% of boys and 59.1% of girls were overweight, of which 15.7% and 22.3% were obese. In Cook Islands, 58.3% of boys and 60% of girls were overweight, of which 31.6% and 23.9% were obese, while Niue reported 56.7% overall were overweight and 29.7% were obese (World Health Organization 2010). Wallis and Futuna reported 59.4% of boys and 66.0% of girls were overweight, of which 33.8% and 30.5% were obese (World Health Organization 2013) and Nauru had 40% of boys and 48.9% of girls overweight, of which 17.8% and 15.7% were obese (World Health Organization 2011). Fiji reported 17.9% of boys and 20.4% of girls were overweight, of which 5.9% and 4.5% were obese (Abbott et al. 2010).

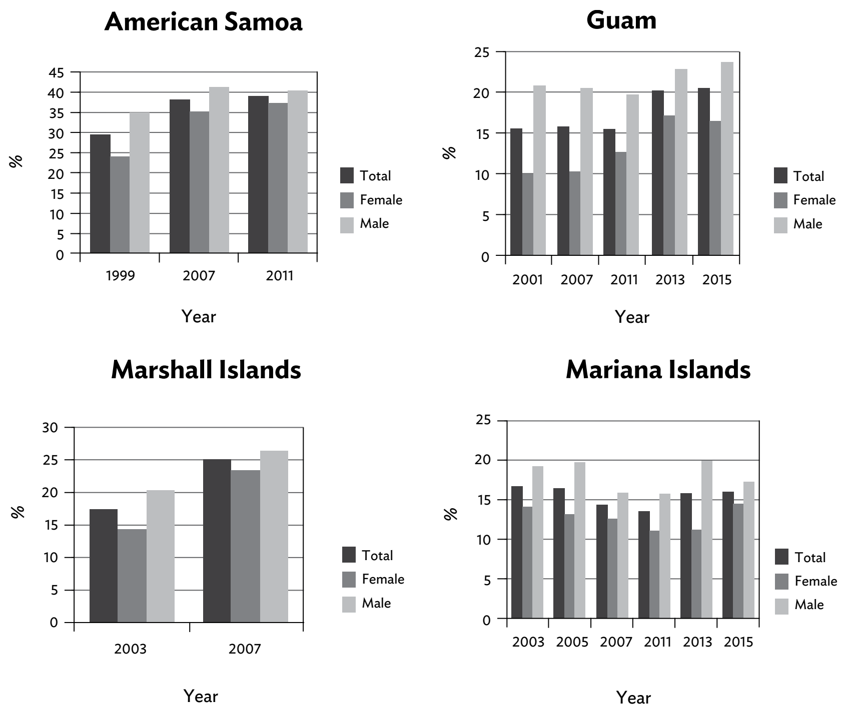
Table 2.1 Prevalence of Overweight and Obesity in Adolescents

	Overweight[a]			Obese[b]		
Country	Total	Male	Female	Total	Male	Female
American Samoa	21.3 (20.0–22.8)	20.3 (18.4–22.3)	22.5 (20.6–24.6)	38.9 (37.2–40.7)	40.4 (38.0–42.9)	37.3 (34.9–39.7)
Cook Islands*	59.1	58.3	60	27.8	31.6	23.9
Fiji	19.2 (15.6–23.4)	17.9 (13.1–24.7)	20.4 (16.1–25.4)	5.2 (4.3–6.2)	5.9 (4.0–8.8)	4.5 (3.0–6.7)
Guam	19.7 (16.7–23.1)	17.4 (13.9–21.7)	22.6 (18.4–27.4)	20.4 (17.6–23.5)	23.7 (19.8–27.9)	16.4 (13.1–20.3)
Kiribati	39.8 (36.1–43.5)	31.9 (27.1–37.1)	46.4 (41.9–51.0)	8.2 (6.3–10.5)	7.8 (5.0–12.0)	8.5 (6.8–10.5)
Marshall Islands	14.6 (12.8–16.7)	12.4 (10.1–15.1)	17.0 (14.3–20.2)	24.9 (22.6–27.3)	26.3 (23.1–29.8)	23.4 (20.2–26.9)
Nauru*	44.5	40.0	48.9	16.7	17.8	15.7
Niue*	56.7	60.3	**	29.7	39.9	**
North Mariana Islands	17.4 (16.0–18.9)	15.5 (13.7–17.4)	19.7 (17.5–21.9)	16.0 (14.7–17.4)	17.3 (15.5–19.3)	14.5 (12.7–16.5)
Palau	12.6 (11.0–14.4)	11.9 (9.7–14.5)	13.3 (11.1–15.9)	12.0 (10.5–13.8)	12.5 (10.3–15.2)	11.5 (9.4–14.0)
Samoa	51.7 (48.3–55.0)	43.4 (39.0–47.9)	59.1 (55.5–62.6)	19.2 (16.8–21.8)	15.7 (12.4–19.6)	22.3 (19.1–25.8)
Solomon Islands	20.0 (15.5–25.4)	17.6 (13.1–23.2)	22.4 (16.7–29.5)	2.2 (1.2–4.1)	1.5 (0.7–3.1)	2.9 (1.2–6.7)
Tonga	59.6 (56.7–62.5)	61.2 (57.7–64.6)	58.0 (53.8–62.0)	21.9 (19.6–24.4)	24.7 (21.9–27.7)	19.1 (15.8–22.8)
Tuvalu*	48.3	44.3	52.2	21.5	22.1	20.9
Vanuatu	11.4 (6.7–18.7)	8.9 (4.3–17.5)	13.6 (8.0–22.0)	0.1 (0.0–1.0)	0.3 (0.0–2.2)	0.0 -
Wallis and Futuna	62.9 (59.9–65.7)	59.4 (54.9–63.7)	66.0 (61.9–69.8)	32.1 (29.3–35.0)	33.8 (29.7–38.3)	30.5 (26.9–34.5)

Note: Value in parentheses reflects 95% confidence interval.
*Census Survey 95% confidence interval not provided; **low response rate.
[a] ≥1 standard deviation from the median for body mass index by age and sex.
[b] ≥2 standard deviation from the median for body mass index by age and sex.
Source: World Health Organization 2016.

Data on the trend of obesity is available for some United States-Affiliated Pacific Islands, particularly American Samoa, Guam, Marshall Islands, and North Mariana Islands during 1999–2015 (Centers for Disease Control and Prevention 2015; Figure 2.4). In general, there is an increasing trend of adolescents' obesity over the years, although it varies between islands. Analysis on statistical differences between the

Figure 2.4 Obesity in Adolescents, Selected United States-Affiliated Pacific Islands



Source: Centers for Disease Control and Prevention 2015.

first and most recent year the countries had conducted Youth Risk and Behavioral Studies, overall and by sex, showed that the North Mariana Islands has had an increase in obesity in adolescents between 2005 and 2015 overall and by sex, but differences between these years are not significant (p-values 0.63 for overall, 0.29 for female, and 0.10 for male). Similar analysis in American Samoa indicated significant differences for overall (p=0.00), female (p=0.00), and male (p=0.04) between 1999 and 2011. The finding is consistent for Guam between 2001 and 2015 for overall (p=0.02) and female (p=0.00), but there is no difference over these years for males.

There is a paucity of overweight and obesity data for younger children (11 years and below) in the Pacific region. A small number of countries are routinely measuring child health in schools, including

BMI, but this is often not reported nationally. Available data for a few Pacific Island countries indicate that overweight and obesity in younger children is also an emerging concern in this region. Based on the Cook Islands Ministry of Health Physical Health Examination data, approximately 20% of primary school children are found to be overweight, with an increasing trend. French Polynesia reports 19% overweight and 16% obese in children aged 7–9 years. Guam reports 23% overweight and 16% obese among children 4–9 years of age (Paulino et al. 2014). A systematic review by Novotny et al. (2015) reports an estimated prevalence of overweight and obesity for children aged 2–8 years in the USAPI, and finds that the prevalence increases with age. At age 2 years, the estimated prevalence of overweight and obesity is reported at 21%. At age 8 years, it increases to 39%, increasing significantly at age 5 years. Taking out the overweight children, the proportion of obese children increases from 10% at age 2 years to 23% at age 8 years, with the highest prevalence in American Samoa and Guam. Demographic health surveys conducted in some Pacific Island countries report the weight status of children under 5 years of age. Overweight and obesity rates range from 0.8% in Solomon Islands to 10.5% in Tonga (Table 2.2). Underweight and stunting remains a problem for countries like Solomon Islands and Vanuatu.

Table 2.2 Percentage of Children under Five Years Classified as Underweight, Stunted, and Obese According to Anthropometric Measures

	Kiribati	Nauru	Samoa	Solomon Islands	Tonga	Tuvalu	Vanuatu
Height-For-Age							
<-2SD	NA	24.0	4.7	32.8	8.1	10.0	28.5
<-3SD	NA	8.1	1.7	8.5	4.4	3.3	10.3
Weight-For-Age							
<-2SD	14.9	4.8	2.7	11.8	1.8	1.6	10.7
<-3SD	8.2	0.8	0.7	2.4	0.6	0.3	2.6
>+2SD	5.7	1.3	6.7	0.8	10.5	3.9	2.4
Weight-For-Height							
<-2 SD	NA	1.0	3.7	4.3	5.2	3.3	4.4
<-3 SD	NA	0.2	1.1	1.4	2.1	0.9	1.1
>+2 SD	NA	2.8	5.4	2.5	17.3	6.3	4.6

SD = standard deviation.
Source: http://prism.spc.int/reports/surveys.

2.4 Determinants of Obesity in Pacific Island Countries and Territories

Studies have been undertaken in the Pacific Islands on obesity and genetics. Duarte et al. (2003), in a study on obesity and genetics in an obese Tongan population, report that the determinants of weight gain are likely to be predisposed in utero. Another study by Dai et al. (2007) finds that specific genes influencing adiposity are present among American Samoans. A study combining samples from American Samoa and Samoa on genomic regions associated with adiposity finds some suggestive linkages with phenotypes such as BMI, % body fat, and leptin (Åberg et al. 2009; Minster et al. 2016). A more recent study on Samoans by Minster et al. (2016) finds a new genetic variant which demonstrates a significant association with body mass index, which plays a significant role in decreasing energy use and increasing fat storage in adipocytes. Furusawa et al. (2010), in their study on associations between genes and obesity comparing Pacific Islanders of Polynesian, Micronesian, and Melanesian origins, find that the certain alleles are associated significantly with higher body weight, BMI, and risk of obesity. This allele is found widely among the individuals from Polynesian and Micronesian origins. While all of these studies exhibit the potential contribution of genes to obesity, the authors highlight that the differences found in this study suggest environmental and genetic interaction, which should be taken into account in further studies. Indeed, genetic changes cannot be solely responsible for the global increase of obesity given the fact that the gene pool has not changed significantly in recent decades, but the prevalence of obesity has increased steadily during the same period (Filozof et al. 2000; Crawford et al. 2002). Thus, an obesogenic environment is a more likely explanation for the global increase of obesity (Crawford et al. 2002; Swinburn et al. 2011).

Obesity is associated with diets rich in fat and sugar, low servings of fruit and vegetables, and lack of physical activity (Brownell et al. 2009; Buijsse et al. 2009). Lim et al. (2012) report that dietary risk factors such as diets low in fruit and vegetables and high in sodium and lack of physical activity collectively contributed to 10% of disability-adjusted life years in 2010 globally. These obesogenic diets are strongly influenced by the food environment (Egger et al. 1997; Swinburn et al. 1999; Swinburn et al. 2002; Kumanyika 2008). For example, global food markets have increased the availability of unhealthy food and drink choices at cheaper prices than healthy alternatives. With the heavy promotion of processed foods high in energy, fat, sugar, and salt, there has been an increased consumption of obesogenic food and reduced fruit and vegetable consumption. The situation is commonly witnessed in the Pacific region (Snowdon, Raj, et al. 2013; Snowdon and Thow 2013).

2.5 Obesity and Health Care Costs

2.5.1 Obesity and Socioeconomic Status

Obesity is associated with socioeconomic status (SES). A systematic review by Sobal and Stunkard (1989) reports a direct relationship with SES and obesity in developing societies. Individuals of a higher SES are more likely to be obese than those of a lower SES but an inverse association is found between SES and developed societies particularly for women (while results were inconsistent for men and children). While a number of studies show similar findings, a systematic review focusing on SES and obesity in male and female population in developing countries only demonstrated that obesity is prevalent particularly among men and not limited to those of high SES; as the country's gross national product increases, the burden of obesity shifts toward the groups of lower SES.

Studies on children in Australia (O'Dea et al. 2010; O'Dea et al. 2014) demonstrate that both boys and girls of low SES are mostly found to be obese compared to those in middle and high SES, and the finding is consistent over time (O'Dea et al. 2014) across sex. There is lack of data on obesity and SES specifically in PICTs.

2.5.2 Obesity, Noncommunicable Diseases, and Health System Costs

Obesity is a significant metabolic risk factor for NCDs, which has substantial implications for health as well as social and economic development in this region. The economic cost of obesity is related to decreased life expectancy, absenteeism, and increased health care costs (Thompson et al. 2001; Swinburn et al. 2004; Withrow et al. 2011; Tin et al. 2015). In the Pacific region, the health cost of obesity is not specific but rather linked to noncommunicable diseases, particularly cardiovascular diseases, diabetes, and other complications.

NCDs have been associated to over 70% of deaths in PICTs; they are a significant contributor to morbidity in the region. In some PICTs, the cost of treating NCDs totals 39% to 58% of health expenditure (Cheng 2010). Hospital resources are insufficient to cope with increasing admission rates from NCD-related diseases. For instance, NCD cases accounted for 10.4%, 5.8%, and 8.1% of all hospital admissions in Tonga, Vanuatu, and Kiribati respectively in 2002, with increasing costs attributed to long stays (averages being 9.2 days, 7.5 days, and 13.5 days in this countries respectively) (Doran 2003). The same study reported that NCDs accounted for 19.6%, 9.0%, and 8.1% of all treatment expenditure in Tonga, Vanuatu, and Kiribati respectively. When average hospital cost was converted to 2012 prices, the costs increased considerably for Tonga and Vanuatu (Anderson 2013).

Diabetes, a chronic condition, has contributed substantially to health costs in the Pacific region in the last two decades. A study by Tin et al. (2015) reports the estimated annual national cost of diabetes to be A$2.8 million (A$281 per person per year) in Solomon Islands and A$1.2 million (A$747 per person per year) in Nauru. Rising costs of drug treatment as type 2 diabetes and hypertension progress is also noted in Vanuatu (Anderson 2013; Anderson et al. 2013). In 2012, pharmaceutical costs increased from $5.59 to $24.55 per patient per year as a diabetic individual progressed from regular testing of blood glucose to use of oral medication (metformin tablets). The cost further increased to $367 per person per year when insulin and additional drugs were required. This is consistent with treatment of hypertension, which increased twelve times as a patient advanced from the use of first-line drugs ($1.38 to $17.58 per patient per year) to additional drug therapy ($75 per patient per year). Similar findings are shown for kidney dialysis (Anderson 2013; Gibson 2014).

2.6 Current Interventions

A range of interventions has taken place over the last two decades, with increasing focus on obesity and NCD control and prevention. This has been the result of high-level regional commitment. In April 2015, in the 11th Regional Ministers of Health meeting, the Ministers re-affirmed commitment to the "Healthy Island Vision." In line, PICTs have made considerable effort to prevent and control obesity and NCDs. For example, Fiji showed strong progress towards building commitment and addressing health system constraints (Snowdon et al. 2013). This is also seen in other countries like Tonga (Asia Pacific Observatory on Health Systems and Policies 2015) and Solomon Islands (Hodge et al. 2015). However, progress remains slow in service delivery and equity, with challenges in addressing NCDs at primary, secondary, and tertiary levels.

In recent years, intervention has shifted towards policy-oriented approaches to address obesity and NCDs. In line with the global recommended "best buys" and the Pacific NCD road map (World Bank 2014), policy interventions in the region include taxation and subsides on unhealthy products (alcohol, tobacco, and certain food items) and laws restricting marketing of unhealthy food and beverages to children. French Polynesia (2002), Nauru (2007), Cook Islands (2013) and others have imposed taxes on sugar-sweetened beverages (Table 2.3).

Efforts to control the marketing of less healthy foods to children have included regulatory approaches, which have been drafted and/or endorsed in some PICTs. Additionally, at a national level, Fiji declared a National Sports Day on 23 June 2015, which is now a yearly event. Several countries have removed or reduced taxes on sporting goods and gardening/farming supplies, alongside other efforts to improve local food supply and increase physical activity.

Table 2.3 Examples of Sugar-sweetened Beverage Taxation in the Pacific Region

Country	Type of Tax	Size	Year implemented
French Polynesia	Excise and import tax on sugar-sweetened drinks, confectionaries, and ice cream	40 CFP*/liter local tax; 60 CFP*/liter imported	2002
Nauru	Sugar levy on all high-sugar foods and drinks and removal of a levy on bottled water	30%	2007
Cook Islands	Import duty on sugar-sweetened drinks	15% with a subsequent 2% rise per year	2013
		NZ$9.80 tax per kg of sugar on sugar sweetened soft drinks	2014
Fiji	Import duty on sugar-sweetened drinks Excise duty on locally manufactured products	5c/liter 5%	2006–2007
	Import duty on raw material	3%	2007
	Import duty Excise	27% 10%	2008
	Import duty Excise	32% 15%	2011
	Excise	20c/liter	2015
Samoa	Import duty Excise on local production	0.3T/liter changed to 0.4T/liter	1984, 2008
Tokelau	Import ban on carbonated drinks	All sizes	2009

Source: Author.

With regard to physical activity, a review of physical activity programs in the region by Siefken et al. (2012) indicated 84 physical activity initiatives in 20 Pacific Island countries, mostly occurring in the workplace, community, and schools.

A monitoring and accountability effort under the Pacific Monitoring Alliance for Obesity/NCD Action was also endorsed to improve access to and use of NCD data. One outcome has been an NCD dashboard with 31 indicators, which aims to track progress of key actions, recommendations, and commitments made in the region, such as controls on marketing, taxing of sugary drinks, and surveillance of obesity.

While there is progress in the region with regard to obesity and NCD preventive and control activities, a need remains to engage the whole of government in developing policies that support the prevention and control of obesity and NCDs.

2.7 Conclusion

Adult obesity prevalence in the Pacific region is high. Obesity is increasing in children. While data for childhood obesity is lacking, the high obesity prevalence in adolescents and adults is a significant warning of a future NCD burden.

Efforts to tackle obesity need to begin early and policymakers should take an approach that considers the full life course and the whole of society. Policies need to be well designed and evaluated to ensure maximum impact, and may draw on global and regional recommendations. Efforts will need focus on schools, communities, and other settings. Equally important is the need for a greater focus on policy interventions to create a healthier food and physical environment.

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3

Economic Influences on Child Growth Status, from the Children's Healthy Living Program in the United States-Affiliated Pacific Region

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3.1 Introduction

The United States-affiliated Pacific (USAP) region has some of the highest levels of adult obesity and noncommunicable diseases in the world (Hawley and McGarvey 2015). Nine of the ten countries in the world with the highest rates of adult obesity are in the Pacific. Such problems are rooted in early childhood; malnutrition in infants predisposes children to metabolic programming that results in overweight, obesity, and noncommunicable diseases in adult life, a phenomenon referred to as the "Barker hypothesis" (Barker et al. 2010). Further, there is evidence of racial disparity in obesity and health among minority groups, and among Native Hawaiians and Pacific Islanders in particular. Yet these groups are not described in United States (US) national surveys. This chapter focuses on the growth status of young Native Hawaiian and Pacific Islander children, aged 2–8 years, and addresses the following questions:

- What is the prevalence of food insecurity (household money running out for food), child stunting, child underweight, and child obesity in the USAP?
- Looking at child underweight and child obesity, what relationships exist with household money for food, household

income level, parent/caregiver education level, and jurisdiction income level, when we adjust for child sex and child age, clustering of communities, and jurisdiction strata?

3.1.1 Rates of Food Insecurity

According to the 2013 report from the United States Department of Agriculture (USDA), among households with children under age 18 years, 19.5% were food insecure (Coleman-Jensen et al. 2014). Prevalence of food insecurity was higher in households with children headed by a single woman (34.4%) or a single man (23.1%), in households headed by Black non-Hispanics (26.1%) and Hispanics (23.7%), and in households with incomes below the US poverty threshold (34.8%). Pacific Islanders were not included in this study.

3.1.2 Possible Reasons for Poor Nutrition

The USDA report showed that food insecurity was associated with higher body mass index (BMI) and rates of overweight or obesity (Coleman-Jensen et al. 2014). Food insecurity rates were positively associated with poverty (Coleman-Jensen et al. 2014; Foley et al. 2010; Chi et al. 2014; Rose 1999; Willows 2008). Poor nutrition occurs at both ends of the spectrum—with undernutrition (underweight and stunting or short height for age) and overnutrition (overweight and obesity).

The USDA report does not include data for the vast USAP region and currently there are no official figures on food insecurity rates for this region. The prevalence of food insecurity in the USAP region is likely greater than in the US mainland due to geographic isolation, low soil fertility, low household income, import and aid dependence, urbanization, reduced agricultural activity, and reduced traditional food hunting and gathering (Hughes and Lawrence 2005; Jansen et al. 1990; Ahlgren et al. 2014; Connell 2014; Kuhnlein et al. 2004; Barnett 2011; Locke 2009; Duffy 2011; Coyne 2000).

Traditionally, a "meal" in the Pacific region comprised a starchy local vegetable (e.g., yam, taro, breadfruit, pandanas) accompanied by cooked or raw seafood, a diet that is nutritious and rich in fiber, vitamins, and minerals (Parkinson 1982; Coyne 2000). The shift from a high-quality subsistence diet based on local foods to a nutrient-poor market diet with predominantly imported food has contributed to a decline in diet quality, nutritional status, and nutrition security (Nordin et al. 2013; Kuhnlein et al. 2004; Thow and Snowdon 2010; Egeland et al. 2011). The nutrition transition, along with other lifestyle changes, such as reduced agricultural activities and a more sedentary lifestyle, has contributed to the increased prevalence of obesity and obesity-related noncommunicable diseases in the region, causing health officials to declare a health emergency (Coyne 2000; Thow and Snowdon 2010).

Many Pacific islands now import much of their food. Imported foods are often of poor quality (including fatty cuts of meat like turkey tails and lamb flaps that are often considered waste in their countries of origin) and highly processed. The wide availability of these foods at very low cost means that traditionally high-status local foods are now more expensive than imported, low nutritional quality foods (Hawley and McGarvey 2015).

3.2 Policy

USAP jurisdictions have varied political affiliations with the US, which is reflected in available food assistance programs and economic policies that may have a bearing on child growth status. Affiliations include two US states (Alaska, Hawaii), two US territories (American Samoa, Guam), and one US Commonwealth (Commonwealth of the Northern Marianas). Three countries belong to a free association compact with the US (Republic of Palau, Republic of Marshall Islands, and the Federated States of Micronesia, which include Yap, Pohnpei, Kosrae, and Chuuk states) (Novotny et al. 2015). The USAP is a larger geographic area than the continental US and covers seven time zones.

A priority of US public policy, especially in the latter half of the 20th century, has been to ensure food sufficiency. Food insecurity, defined as having limited or uncertain access to enough nutritious food, is recognized as an important problem in the developed world (Coleman-Jensen et al. 2014). Nutrition security goes farther than food security, referring to access to a variety of nutritious foods and potable drinking water; knowledge, resources, and skills for healthy living; prevention, treatment, and care for diseases affecting nutrition status; and safety-net systems during crisis situations such as natural disasters or social and political events (Nordin et al. 2013).

3.3 Children's Healthy Living Program

The Children's Healthy Living (CHL) Program addressing child health for remote, underserved minority populations of the Pacific is a USDA-funded coalition among land grant colleges in the USAP to address child health. The extension (translating science for practical application), research, and training missions of these colleges were leveraged to gather research data, intervene to improve the environment for health, and build capacity in the region (Novotny et al. 2013).

Data from the CHL Program comprises data on jurisdiction, community, household and child environment, child growth status, age, sex, race/ethnicity in 11 jurisdictions of the USAP and among US-affiliated Pacific Islanders. The data, gathered in 2013, includes over 5,000 young children (n = 5,558) 2–8 years old. (Survey questions were answered by a parent or caregiver.) We specifically examined the role of the jurisdiction level and of household indicators of education and economic status on child growth status, including food insecurity, providing insight into jurisdiction economic development and the nutrition transition in the USAP.

3.4 Calculating Child Growth Status

CHL child growth analyses used survey sampling techniques (Kish et al. 1995) that weighted the sample to the child population size in each jurisdiction, based on census data, and accounted for the clustering of participants in communities within jurisdictions. Prevalence of food security and growth parameters were estimated, with 95% confidence intervals, overall and by sex, by age group (2–5 or 6–8 years old), by race/ethnicity, and by jurisdiction income level. Further details on variables are given in the appendix.

Growth for 2–8-year-olds was assessed by weight and height, and all measures were standardized to obtain regional reliability and reproducibility (Li et al. 2015). Growth data were expressed as percentile of body mass index for age (months) and sex as described by the Centers for Disease Control and Prevention (CDC 2016) using the statistical analysis system program provided by the CDC (CDC 2016). This assessment was based on US CDC reference data and cut-points for body mass index for age and sex where > 95th percentile were obese, 85th to < 95th percentile were overweight, 5th to < 85th percentile were healthy weight, and < 5th percentile were underweight. Birth weight and length data were obtained by questionnaire of caregiver. Stunting was defined as < 2 standard deviations of height for age and sex using CDC data for current (2–8-year-old) stunting and using World Health Organization data to determine stunting at birth, as recommended by the CDC (CDC 2013).

In the second half of the results section, hierarchical regression models with a logistic link of child obesity or underweight are used to assess the relationship with food insecurity (money for food), parental education, household income, and jurisdiction income level; controls are used for age group (2–5 years or 6–8 years), sex, and race/ethnicity according to the US Office of Management and Budget (OMB).

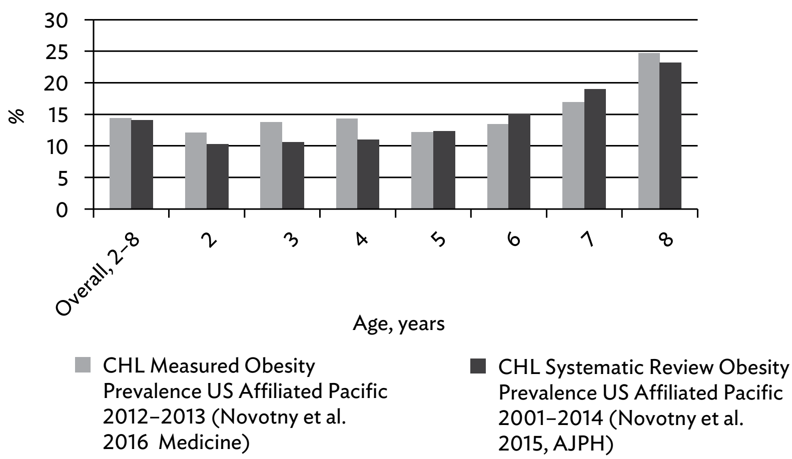
3.5 Results from Descriptive Data

3.5.1 Overview of Data

Overall, among the 2–8-year-olds in the USAP, 68% of children were of healthy weight, 15% were overweight, 14% were obese, 3% were underweight, 1% were stunted, and 7% were stunted at birth (Novotny et al. 2016; Novotny et al. 2015). US data from the contiguous US states from 2013–2014, using the same reference data and cut-points for determining obesity, showed that among 2–5-year-old US children, the rate of obesity was 10%, and among 6–11-year-old children, the rate was 17% (Ogden et al. 2016). Thus, the rate found in the USAP was comparable, on average. However, notable differences among subgroups are described below.

Obesity prevalence increased across the 2–8-year-olds (Figure 3.1), with variation among the jurisdictions: while no obesity was measured in the Republic of the Marshall Islands, American Samoa recorded 22% (Figure 3.2). Obesity and stunting prevalence also varied by income level (Figure 3.3). Stunting, an important indicator of long-term population nutrition status and well-being, decreased with increased income

Figure 3.1 Child Obesity by Age in the Children's Healthy Living Program

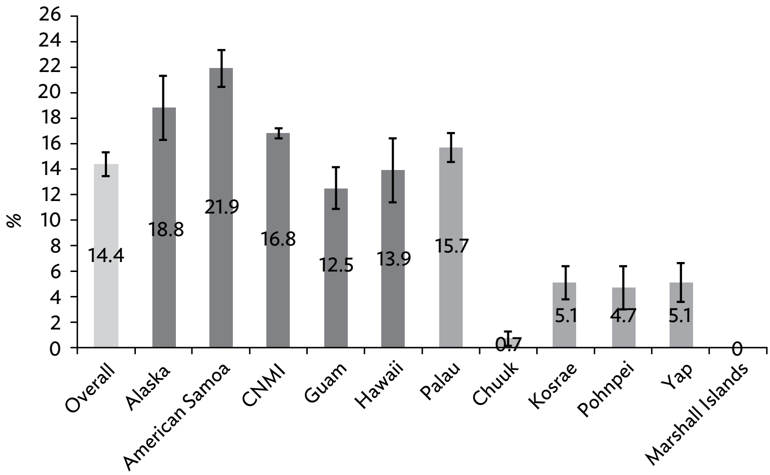


CHL = Children's Healthy Living Program, USAP = United States-affiliated Pacific.

Note: n = 5,463 CHL measured sample; n = 246 data points for CHL meta-analysis.

Sources: Novotny et al. 2015, 2016.

Figure 3.2 Obesity Prevalence (%) by United States-Affiliated Pacific Jurisdiction in the Children's Healthy Living Program

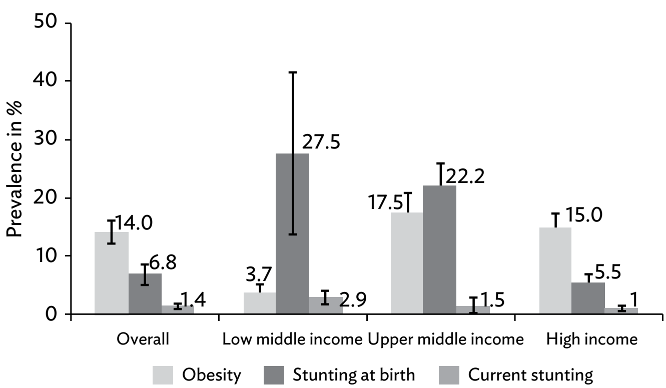


BMI = body mass index, CNMI = Commonwealth of the Northern Mariana Islands.

Notes: n = 5,461. Error bars show 95% confidence interval. BMI ≥ 95th percentile, weighted for population size and adjusted for community clustering. 14.1% overweight (85th to 94th percentile) overall.

Source: Novotny et al. 2016.

Figure 3.3 Prevalence of Obesity, Stunting at Birth, and Current Stunting by Jurisdiction Income Level in the Children's Healthy Living Program



Notes: n = 5,461. All anthropometric measures differed significantly by jurisdiction income level ($p<0.05$, Chi-square test).

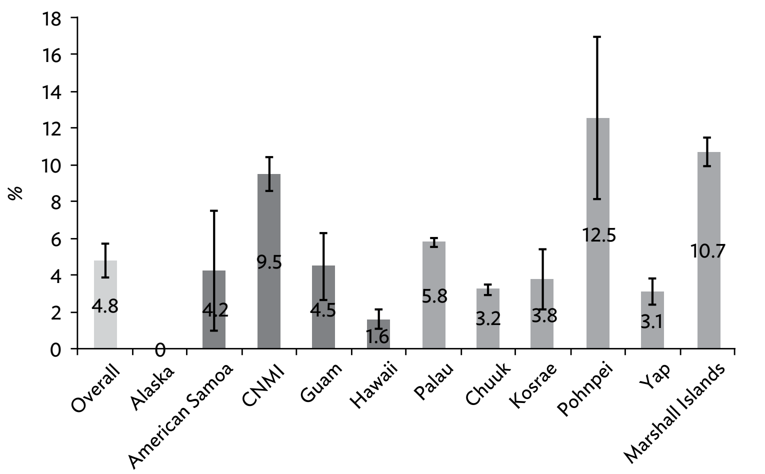
Source: Novotny et al. 2017.

level, indicating improved population growth in height with improved economic status, as would be expected. Population obesity prevalence increased from lower middle to upper middle World Bank income level, but dropped off in the high-income groups. The data reflect a shift in the nutritional and other resources available to jurisdictions and show that in the upper middle-income group, both undernutrition and overnutrition are present, whereas in the high-income group those resources have allowed for healthier growth status at both ends of the nutrition spectrum.

Prevalence or occurrence of the acanthosis nigricans condition in the population averaged 5% (Burke et al. 1999, Novotny et al. 2016, Figure 3.4) across the USAP region. Acanthosis nigricans indicates insulin mishandling and metabolic risk for diabetes, and is strongly associated with obesity (Novotny et al. 2016).

Prevalence of food insecurity (incidence of money running out for food by the end of the month) was high at 53% overall (Figure 3.5), and it was higher among households with older children. The higher level of food insecurity with older children may reflect that

Figure 3.4 Prevalence (%) of Acanthosis Nigricans in the Children's Healthy Living Program, United States-Affiliated Pacific

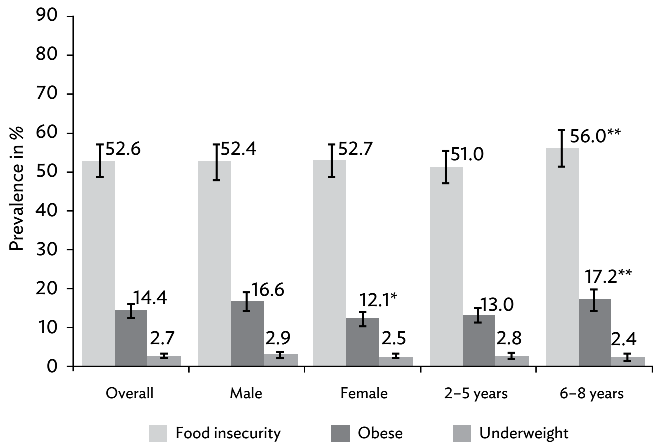


CNMI = Commonwealth of the Northern Mariana Islands.

Notes: n = 4,625. Any presence of acanthosis nigricans, weighted for population size and adjusted for community clustering.

Source: Novotny et al. 2016.

Figure 3.5 Prevalence of Food Insecurity, Obesity, and Underweight Overall, and by Sex and Age Group in the Children's Healthy Living Program



Notes: n = 5,461. Significant difference from other groups by Chi-square, $^{*}p<0.05$, $^{**}p<0.01$. Error bars show 95% confidence interval.

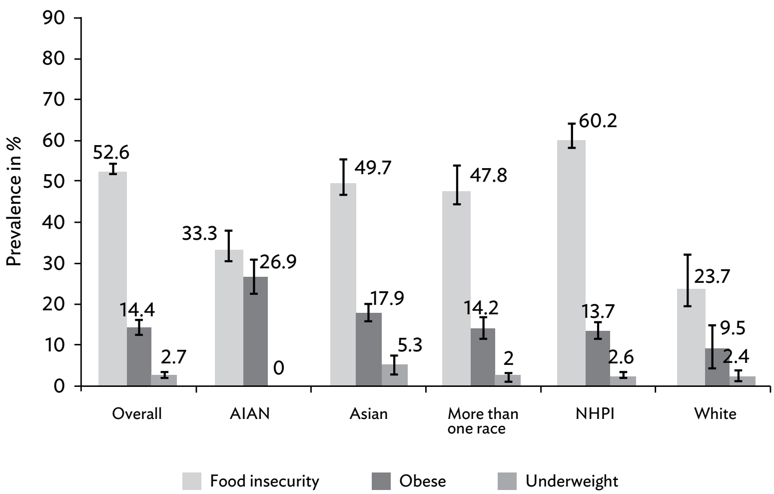
Source: Novotny et al. 2017.

fewer food assistance programs are available for this age group, as compared with the 0–5-year-old age group. The 0–5-year-old age group has early child education programs, including the Head Start program (which provides meals in Alaska, American Samoa, Hawaii, Guam, and Commonwealth of the Northern Mariana Islands) and the Supplemental Feeding Program for Women, Infants, and Children, which provides supplemental foods to take home and is available in some of the USAP jurisdictions (Alaska, Hawaii, Guam, and Commonwealth of the Northern Mariana Islands). Elementary school meal programs are also available in some jurisdictions (Alaska, Hawaii, Guam, American Samoa, and Commonwealth of the Northern Mariana Islands). Food assistance programs aim to provide healthy food and may help improve child nutritional status

Money for food was reported to have run out by the end of the month at least sometimes for 31% of households, most of the time for 11% of households, and all of the time for 6% of households. There was wide jurisdiction variability in the prevalence of food insecurity: Alaska, 31%; American Samoa, 59%; Commonwealth of the Northern Mariana

Islands, 54%; Guam, 51%; and Hawaii, 41%. Clearly food insecurity is an important issue for this region. Food insecurity also varied by race, and it was highest among Native Hawaiians and Pacific Islanders at 60% and lowest among Whites at 24% (Figure 3.6). These rates are high even for the White group, higher than the 20% found in the contiguous US (Coleman et al. 2014), though the CHL methodology, which asked only one question, may be overestimating this; additionally, CHL has estimated that food costs in the region exceed those in the contiguous US (Greenberg et al. 2015).

Figure 3.6 Food Security, Underweight, and Obesity Prevalence in the Children's Healthy Living Program



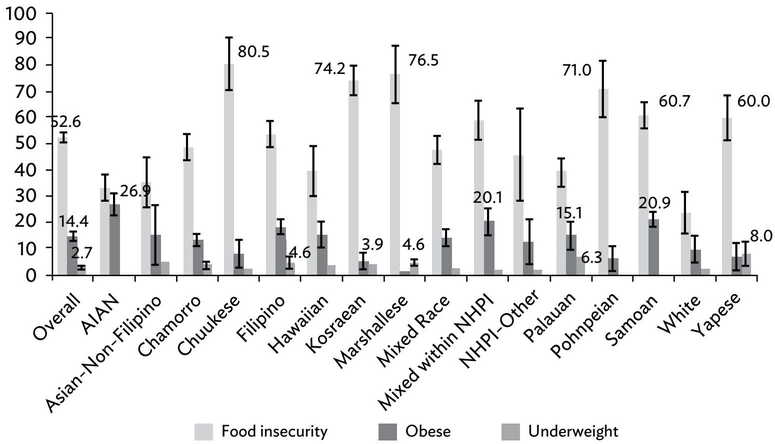
AIAN = American Indian/Alaska Native, NHPI = Native Hawaiian/Pacific Islander.

Notes: Race grouping based on United States Office of Management and Budget. n = 5,461. Significant differences in prevalence of food insecurity ($p<0.001$), obesity ($p<0.0001$), and underweight ($p = 0.02$) among the races.

Source: Novotny et al. 2017.

The highest prevalence of food insecurity was among the Chuukese (81%), Marshallese (77%), Kosraean (74%), Pohnpeian (71%), Samoan (61%), and Yapese (60%) ethnicities (Figure 3.7).

Figure 3.7 Food Insecurity, Obesity, and Underweight by Pacific Race/Ethnicity Categories in the Children's Healthy Living Program



AIAN = American Indian/Alaska Native; NHPI = Native Hawaiian/Pacific Islander.

Notes: n = 5,461. Some missing data on detailed ethnicity.

Source: Prepared by authors.

3.5.2 Results from Hierarchical Regression: Factors Influencing Child Obesity and Underweight

Hierarchical regression models (Tables 3.1–3.4) with a logistic link of child obesity or underweight assessed the relationship with food insecurity (money for food), parent/caregiver education, household income, and jurisdiction income level, controlling for age group (2–5 years or 6–8 years), sex, and race/ethnicity (OMB).[1] These models

1 Race/ethnicity was categorized into six groups according to the United States Office of Management and Budget (OMB) definition: American Indian/Alaska Native (AIAN), Black, Asian, Native Hawaiian/Other Pacific Islanders (NHPI), White, and More than One Race. Due to the diversity of and interest in specific ethnic groups among Pacific Islanders of the region, and disparities among groups, we collected additional information under each OMB race. For example, under NHPI, there were 14 ethnic groups to choose from (Chamorro, Carolinian, Chuukese, Kiribati, Kosraean, Marshallese, Native Hawaiian, Palauan, Pohnpeian, Samoan, Tongan, Tokelauan, Tahitian, and Yapese) as well as Other (please describe).

account for the community as a clustering variable and jurisdiction as a strata variable. Regression estimates, odds ratios, and 95% confidence intervals were reported from the models.

Table 3.1 shows a core model of food insecurity and risk of obesity, adjusting for OMB race, age group and sex. Food insecurity in this model is marginally negatively related to obesity. There is a positive relationship of older age, all races except Black as compared to White, and male sex, related to obesity.

Table 3.2 illustrates that economic variables added to the model further explain the relationship between food insecurity and obesity. Food insecurity is no longer significant but higher household income is marginally related to obesity and higher jurisdiction income level is highly associated with obesity. The risk of obesity drops slightly in the highest jurisdiction income group, suggesting some positive deviance or healthy adjustment to the high-income economic environment.

Table 3.1 Core Model of Food Insecurity and Risk of Obesity in the Children's Healthy Living Program

Parameter	Estimate	SE	p-value	OR	95% CI Lower	95% CI Upper
Intercept	−2.5274	0.1980	<.0001			
Food insecure vs. secure	−0.1847	0.1011	0.0677	0.831	0.682	1.014
American Indian Alaska Native vs. White	1.2809	0.3112	<.0001	3.600	1.956	6.625
Asian vs. White	0.7604	0.2323	0.0011	2.139	1.357	3.373
Black vs. White	0.9840	0.9053	0.2771	2.675	0.454	15.775
More than one race vs. White	0.5042	0.2155	0.0193	1.656	1.085	2.526
Native Hawaiian or Pacific Islander vs. White	0.4622	0.2014	0.0217	1.588	1.070	2.356
6–8 years old vs. 2–5 years old	0.3443	0.1007	0.0006	1.411	1.158	1.719
Male vs. female	0.3711	0.0986	0.0002	1.449	1.195	1.758

CI = confidence interval, OR = odds ratio, SE = standard error.
Notes: Food insecurity is defined as running out of money for food monthly, sometimes, most times, or always. n = 4,930.
Source: Prepared by authors.

Table 3.2 Core Model (Table 3.1) and Risk of Obesity Plus Jurisdiction Income Level, Household Income Level, and Education of Caregiver

					95% CI	95% CI
Parameter	**Estimate**	**SE**	**p-value**	**OR**	**Lower**	**Upper**
Intercept	−3.9775	0.3683	<.0001			
Food insecure vs. secure	−0.1433	0.1125	0.2027	0.866	0.695	1.080
American Indian Alaska Native vs. White	1.4162	0.3291	<.0001	4.121	2.162	7.855
Asian vs. White	0.6701	0.2519	0.0078	1.954	1.193	3.202
Black vs. White	1.5394	0.8793	0.0800	4.662	0.832	26.122
More than one race vs. White	0.5315	0.2297	0.0206	1.702	1.085	2.669
Native Hawaiian Pacific Islander vs. White	0.6361	0.2329	0.0063	1.889	1.197	2.982
6–8 years old vs. 2–5 years old	0.3368	0.1091	0.0020	1.400	1.131	1.734
Male vs. female	0.4112	0.1069	0.0001	1.509	1.223	1.860
High school vs. < high school	0.2864	0.1703	0.0926	1.332	0.954	1.859
College vs. high school	0.3182	0.1708	0.0624	1.375	0.984	1.921
$35,000+ vs. < $35,000	−0.1167	0.1463	0.4252	0.890	0.668	1.185
Middle vs. lower middle-income jurisdiction	1.3657	0.2537	<.0001	3.918	2.383	6.443
Upper middle vs. lower middle-income jurisdiction	1.1921	0.2541	<.0001	3.294	2.002	5.420

CI = confidence interval, OR = odds ratio, SE = standard error.
Source: Prepared by authors.

Table 3.3 illustrates that food insecurity is not related to underweight in the region. However, both Black and American Indian Alaska Native children were less likely to be underweight as compared to Whites (Table 3.3). Table 3.4 shows that household income variables were not

Table 3.3 Core Model of Food Insecurity and Risk of Underweight in the Children's Healthy Living Program

					95% CI	95% CI
Parameter	**Estimate**	**SE**	**p-value**	**OR**	**Lower**	**Upper**
Intercept	−3.7025	0.4463	<.0001			
Food insecure vs. secure	−0.1261	0.2141	0.5558	0.882	0.579	1.341
American Indian Alaska Native vs. White	−13.9113	0.4552	<.0001	<0.001	<0.001	<0.001
Asian vs. White	0.8508	0.5035	0.0911	2.342	0.873	6.282
Black vs. White	−13.9554	0.5544	<.0001	<0.001	<0.001	<0.001
More than one race vs. White	−0.1327	0.5035	0.7921	0.876	0.326	2.349
Native Hawaiian Pacific Islander vs. White	0.1505	0.4801	0.7540	1.162	0.454	2.979
6–8 years old vs. 2–5 years old	−0.1906	0.2236	0.3941	0.826	0.533	1.281
Male vs. female	0.1378	0.2061	0.5038	1.148	0.766	1.719

CI = confidence interval, OR = odds ratio, SE = standard error.
Note: n = 4,930.
Source: Prepared by authors.

Table 3.4 Core Model and Risk of Underweight Plus Education, Household Income, Jurisdiction Income, and Education of Caregiver

					95% CI	95% CI
Parameter	**Estimate**	**SE**	**p-value**	**OR**	**Lower**	**Upper**
Intercept	−3.1468	0.6258	<.0001			
Food insecure vs. secure	−0.0283	0.2403	0.9062	0.972	0.607	1.557
American Indian Alaska Native vs. White	−14.1030	0.4717	<.0001	<0.001	<0.001	<0.001
Asian vs. White	0.7230	0.5439	0.1837	2.061	0.710	5.983
Black vs. White	−14.2320	0.6178	<.0001	<0.001	<0.001	<0.001
More than one race vs. White	−0.3631	0.5368	0.4988	0.696	0.243	1.992

continued on next page

Table 3.4 *continued*

Parameter	Estimate	SE	p-value	OR	95% CI Lower	95% CI Upper
Native Hawaiian Pacific Islander vs. White	−0.0643	0.5356	0.9045	0.938	0.328	2.679
6–8 years old vs. 2–5 years old	−0.1558	0.2636	0.5543	0.856	0.510	1.434
Male vs. female	0.2698	0.2337	0.2483	1.310	0.828	2.071
High school vs. < high school caregiver	0.2157	0.3475	0.5348	1.241	0.628	2.452
College vs. < high school caregiver	−0.0282	0.3394	0.9337	0.972	0.500	1.891
$35K + vs. < $35K	−0.2541	0.3473	0.4644	0.776	0.393	1.532
Middle vs. lower middle-income jurisdiction	−1.5833	0.4519	0.0005	0.205	0.085	0.498
Upper middle vs. lower middle-income jurisdiction	−0.5021	0.3725	0.1776	0.605	0.292	1.256

CI = confidence interval, OR = odds ratio, SE = standard error.
Source: Prepared by authors.

related to underweight but that middle-income jurisdictions had less underweight than lower middle-income jurisdictions.

Overall these results show that jurisdiction-level economic development improves underweight conditions but is associated with a higher risk of obesity in middle-income jurisdictions. This suggests economic advancement creates a context where obesity can begin to be contained.

3.6 Discussion and Conclusions

Household income was not significantly related to obesity in regression analyses, but jurisdiction income level was strongly related. Household income has been shown to be important at both ends of the distribution of income (Jolliffe 2011). Within the upper middle-income jurisdictions, income may be an important predictor of obesity among those at the ends of the income distribution, yet overall other factors related to use of income (for example, purchase of imported processed foods) are likely better indicators. This implies jurisdiction-level approaches can be vital in changing nutrition and health status.

Several of the jurisdictions are in free association compacts with the US (Federated States of Micronesia, the Republic of the Marshall Islands, and Palau); the compact agreement is currently being renegotiated in Palau, and will be up for renegotiation in the Republic of the Marshall Islands and the Federated States of Micronesia in 2023 (GAO 2016). This is a key opportunity to implement policies that will support healthy growth of children, which will impact future health outcomes.

Strategies for economic development of jurisdictions in the USAP should consider the food and physical activity environment. Strategies that protect the local food system and active living are vital (Sunguya et al. 2014). Advancing programs that support local foods may be helpful since local food production (i) provides incentives for entrepreneurship and innovation, (ii) expands consumer choice and fresh food access, (iii) improves negotiating power to local producers, (iv) supports rural economic revitalization, and (v) protects the food system against severe shocks, through decentralization of production (McFadden et al. 2016). This latter point is especially important in island settings where frequent cyclones devastate agriculture, requiring a planned agricultural response to avoid dependency on outside food sources. For example, Snowdon et al. found that approximately 67% of Guam's food supply is imported from the US, the Philippines, and Japan (Snowdon et al. 2013); such terms of the free association compacts will likely play a key role in determining the economic environment for promoting healthy child growth in the USAP.

Other approaches for food companies include the following: (i) align core business practices with population health goals, (ii) pledge to support a level playing field for those attempting to make the food environment healthier, (iii) share proprietary data with independent evaluators, and (iv) invest in creating a consumer base for healthy food and beverage products (Huang et al. 2015) including taxes on sugar-sweetened beverages, restricting sale or availability of such beverages in and around schools, and prohibiting the purchase of such beverages in the Supplemental Food Assistance Programs.

The USAP region is highly diverse in economic development, food security, and child growth status, with a dual burden of over and undernutrition. Jurisdiction-level policies promoting a healthy local environment and healthy child development are urgently needed.

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Appendix 3

Table A3.1 displays Children's Healthy Living (CHL) Program race/ethnicity distribution according to the United States Office of Management and Budget (OMB).[2] Using the OMB categories, 61% of the sample was Native Hawaiian or Pacific Islander. Of the population, 9% was Asian and 2% was American Indian or Alaska Native. The African American/Black population was a mere 0.3%.

Table A3.1 Race/Ethnicity of Child Participants (2–8 Years) in the Children's Healthy Living Program According to the United States Office of Management and Budget Categories

Race/Ethnicity	n	%
American Indian/Alaska Native	124	2.2
Asian	489	8.8
Black	16	0.3
Native Hawaiian/Pacific Islander	3,389	61.2
White	419	7.6
More than one race	1,102	19.9

Notes: n = 5,539. Race/ethnic information missing on some participants.

Other demographic characteristics are described in Table A3.2. The sample was 51% male. There were more children in the 2–5-year-old age group than the 6–8-year-old age group; age is therefore adjusted for in analyses.

Differences in CHL program activities occurred in the different jurisdictions, accounting for different sample sizes across the jurisdictions; yet the sampling methods were similar, and measurement methods were identical in all jurisdictions (Wilken et al. 2013). To account for differences in sample size, population size is weighted in prevalence analyses.

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2 Since there is a high correlation between Pacific race and jurisdiction, for the purposes of this chapter, we focused on jurisdiction rather than race/ethnic difference. When important for interpretation, we use the OMB race variable in regression models.

Jurisdiction Income

Lower middle-income (LMI) jurisdictions participating in CHL included the states of the Federated States of Micronesia (Yap, Chuuk, Pohnpei, and Kosrae) while upper middle-income (UMI) jurisdictions included American Samoa, the Republic of the Marshall Islands, and Palau. Guam, the Commonwealth of the Northern Mariana Islands, and the US states of Hawaii and Alaska were classified as high-income (HI). This classification of the world's economies was based on estimates of gross national income (GNI) per capita for the previous year. Lower middle-income economies were those with a GNI per capita between $1,026 and $4,035; upper middle-income economies were those with a GNI per capita between $4,036 and $12,475; high-income economies were those with a GNI per capita of $12,476 or more (World Bank 2016).

Table A3.2 Characteristics of Child Participants with Anthropometric Measurements in the Children's Healthy Living Program

Child Characteristics	n	%
Sex (n = 5,523)		
Male	2,825	51.1
Female	2,698	48.9
Age (n = 5,558)		
2–5 years old	3,659	65.8
6–8 years old	1,899	34.2
Jurisdiction and Jurisdiction Income Classification		
Alaska – HI	666	12.0
American Samoa – UMI	972	17.5
CNMI – HI	911	16.4
Guam – HI	865	15.6
Hawaii – HI	944	17.0
Republic of Palau – UMI	193	3.5
Republic of Marshall Islands – UMI	214	3.9
Chuuk – LMI	197	3.5
Pohnpei – LMI	200	3.6
Kosrae – LMI	193	3.5
Yap – LMI	203	3.6

CNMI = Commonwealth of the Northern Mariana Islands, HI = high-income, LMI = lower middle-income, UMI = upper middle-income.

Notes: n = 5,558. Based on participants with age reported by caregiver. Sex information missing on some child participants. Income classification based on World Bank classification (World Bank 2016).

Education of Caregivers

Caregiver self-reported education level is shown in Table A3.3. The largest number had a high school education, 22% had less than a high school education, and 39% had more than a high school education.

Table A3.3 Education Level of Caregiver of the Child Participant, Children's Healthy Living Program

Education Level	Frequency	%
Never attended school or only attended kindergarten	105	1.9
Grades 1 to 8 (elementary to middle school)	344	6.2
Grades 9 to 11 (some high school)	790	14.3
Grade 12 or GED (high school graduate)	2,131	38.4
College or technical school (1 year to 3 years)	1,349	24.3
College 4 years or more	826	14.9
Total	5,545	100.0

GED = general equivalency diploma.
Note: n = 5,545.

Household Economic Measures (Income and Food Insecurity)

Household food security was assessed by one question from the United States (US) Department of Agriculture's Core Food Security Module: "In the past 12 months how often does money for food run out before the end of the month?" (Coleman et al. 2014; Centers for Disease Control 2011). The respondent, the child's parent or caregiver, chose one from the seven options: Never, Seldom, Sometimes, Most Times, Always, Don't Know, or No Response. Household food insecurity was defined as present if the respondent answered that money for food runs out sometimes, most times, or always before the end of the month. This method may have overestimated the prevalence of food insecurity as we used only one question modified from the USDA Core Food Security Module. It also does not assess other food resources such as subsistence living, which is common in some of the Pacific jurisdictions, like the Federated States of Micronesia. Additional metrics are needed to quantify the economic contribution of subsistence living to child growth status, risk for disease, and health.

Household income was measured by a questionnaire of caregivers, which provided for six categories of household income. The United States-Affiliated Pacific household income distribution is found in Table A3.4, where 25% of households earned less than $10,000 per year. Even if there was only one person in the household, this income level would be below poverty level in the US in 2013 (US Census 2013). Median household income for the US in 2013 was $53,718 (Proctor et al. 2016).

Table A3.4 Annual Household Income in the United States-Affiliated Region, Adjusted for Clustering in 51 Communities and 11 Jurisdictions in the Children's Healthy Living Program

Annual Household Income (US $)	n (%)
<$10K	1,818 (25.0%)
$10K–<$20K	866 (16.6%)
$20K–<$35K	633 (17.4%)
$35K–<$60K	501 (19.1%)
$60K–<$75K	171 (7.9%)
$75K or more	339 (14.0%)

Note: n = 4,328.

4

Socioeconomic Inequality in Excessive Weight: The Case of Indonesia

Toshiaki Aizawa and Matthias Helble

Introduction

Growing overweight and obesity is one of the most pressing public health issues, particularly in developing countries, where almost two-thirds of obese people in the world live. Studying developing countries is important because the growth of obesity is expected to continue to increase, even while the rate has slowed in developed countries (Ng et al. 2014). Numerous factors contribute to overweight and obesity. As an economy develops, people typically shift from the agricultural sector to manufacturing and eventually service industries, so work becomes more sedentary. Economic development allows more income to be spent on food; this is frequently accompanied by a shift toward the intake of energy-dense foods with high fat content (Popkin and Du 2003). Urbanization has also been found to contribute to the acceleration of the change in lifestyles and subsequently health conditions (Popkin 2001; Van de Poel et al. 2007, 2009, 2012). Meanwhile, those remaining in poverty face the challenge of buying sufficient and adequate food. Several low- and middle-income countries are thus confronted with a "double burden" of both infectious and non-infectious illnesses.

The growth of overweight and obesity prevalence is widely observed throughout the world, but the distribution across income groups varies by country. Over the past 5 decades, many studies have showed the relationship between income and overweight and obesity. An exhaustive and seminal review by Sobal and Stunkard (1989) describes 144 published studies on the relationship between socioeconomic status and obesity, in both developed and developing countries. They observe a consistent inverse association in obesity and income in developed countries particularly for women. That is, the poor are more likely to be obese. In developing countries, on the other hand, a strong direct relationship was revealed among men, women, and children. In other words, people of a more privileged socioeconomic status are more likely to become overweight and obese. McLaren (2007) updates their review with research on 333 published studies. Their results are more or less consistent with the findings by Sobal and Stunkard (1989) and show that as a country moves from low- and middle-income to high-income status, the relationship between socioeconomic status and obesity is reversed. In other words, in more advanced economies, the less wealthy are more likely to be exposed to the risk of obesity than people with a higher socioeconomic status. Other studies on this relation show largely similar results (e.g., Reynolds et al. 2007 and Monteiro et al. 2004). As an example from a developing country, Monteiro et al. (2000) and Monteiro et al. (2001) examine the case for Brazil and show that as the country advanced, obesity grew faster among the group with a lower socioeconomic status.

While much effort has been made in the literature on inequalities in health including overweight and obesity, there are no studies on changes over time using a panel dataset of a household survey. This chapter fills the gap in the literature by exploring the change in the trend of overweight and obesity.

We employ the concentration index and measure the disparity of excessive weight from 1993 to 2014. We then trace the change in these disparities between 2000 and 2014, when a large reduction of the concentration index was observed, and attempt to decompose the change in inequality into several potential contributing factors. The case of a Southeast Asian developing country is intriguing not only from a public health perspective, but also from an economic viewpoint. Indonesia has shown high economic growth in recent years and has the largest population in Southeast Asia. Indonesia thus represents an excellent case study among the emerging economies of Southeast Asia. Better understanding the transition in Indonesia can provide important guidance for the design of appropriate policies to tackle the problem of overweight and obesity in Indonesia and beyond. To the best of our knowledge, this study is the first attempt to explain factors that contribute to the change in the disparity of overweight and obesity among groups of different wealth in Indonesia.

The structure of this chapter is as follows. The next section introduces the data and discusses descriptive statistics. In Section 4.3 we explain the econometric methods used to measure the inequality in health. Section 4.4 presents the results of the analysis and provides interpretation. Finally, in Section 4.5, we discuss policy implications and conclude.

4.1 Data

The Indonesian Family Life Survey is an ongoing, multipurpose household longitudinal survey that was launched in 1993/94. The Indonesian Family Life Survey currently has five waves (as of 2016) and the latest one was completed in 2014. Each wave covers around 30,000 individuals living in 13 of the 27 provinces in the country. We use all five waves in this chapter. From measurements of the heights and weights of the respondents, we calculate the body mass index (BMI), defined as an individual's weight divided by the square of their height and expressed internationally in units of kilograms per meters squared. We use the BMI to assess the overweight and obesity status. The threshold points for overweight and obesity are 25 and 30 , respectively, and corresponding to WHO definitions of overweight and obesity. We do not include children and adolescents in the samples due to difficulty in judging overweight conditions for these groups under the same criteria as those applied for adults. Therefore, our sample is composed of people aged over 20. Furthermore, in this chapter, excess weight is defined as the difference between a respondent's weight minus his/her optimal weight.[1] Excess weight is nonnegative and set to be equal to 0 if a respondent's weight is below his/her optimal weight.

Figure 4.1 shows the prevalence rate of overweight and obesity in the five waves of our sample. The figure illustrates that the number of overweight and obese people grew during the period. In 1993, approximately 13% of the sample was overweight or obese, but in 2014 the number reached 25%. As well as the continuing increase in the prevalence rate of overweight and obesity, we find that the average BMI of Indonesians increased during the period. Figure 4.2 and Figure 4.3 illustrate the cumulative distribution functions of BMI for men and women. We find a relatively large increase after 2000 both for men and women. Overall, our BMI numbers are consistent with another study (Witoelar et al. 2009) on overweight in Indonesia.

Next we look into the relationship between socioeconomic status and overweight/obesity. Various studies approximate socioeconomic status using different measurements, such as income, expenditure, education level, and wealth. One can use one or several of these variables to rank people from low to high socioeconomic status, but different indicators generally give different results and the choice depends fundamentally on researchers' interests (Fleurbaey and Schokkaert 2012). In this

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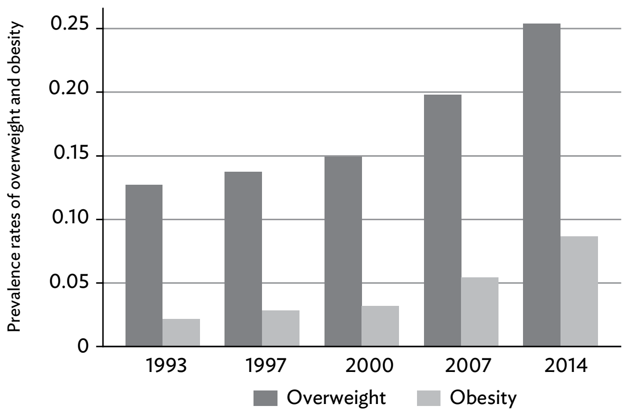
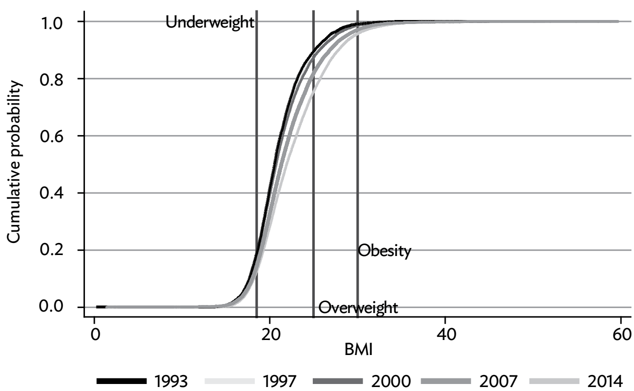
1 *Optimal weight* = 22 * $\{(height/100)^2\}$.

Figure 4.1 Prevalence Rate of Overweight and Obesity, 1993–2014 (%)



Source: Authors' calculation.

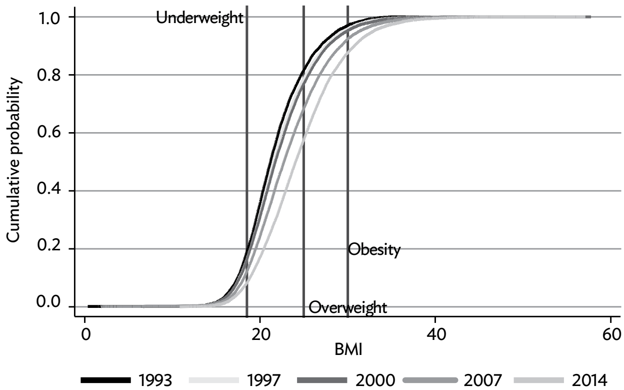
Figure 4.2 Empirical Cumulative Distribution Function of Body Mass Index for Men



BMI = body mass index.

Source: Authors' calculation.

Figure 4.3 Empirical Cumulative Distribution Function of Body Mass Index for Women



BMI = body mass index.
Source: Authors' calculation.

chapter we use family-size adjusted household wealth.[2] Using wealth has advantages over other options as it includes the monetary values of various items commonly found in household. The reason we do not use income for socioeconomic status is that we may not be able to correctly observe employment income if households make their living from family-owned businesses, such as farming. Furthermore, it would be difficult to rank retired people as they typically have very little or no employment income. We also consider educational levels unsuitable for this study because of the difficulty in capturing a respondent's educational qualifications or achievement as a continuous number, which would be needed to rank people.

Figure 4.4 shows the prevalence rate of overweight and obesity over time and conveys a few important points. First, wealthy people tend to be overweight and obese in every period of time, and in this regard,

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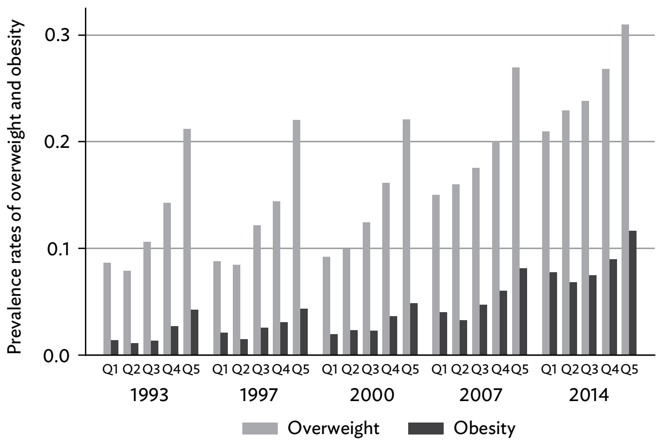
2 Wealth is defined as the aggregated total value of the following assets: (i) House and land occupied by a household; (ii) Other house/building (including land); (iii) Land (not used for farm); (iv) Poultry; (v) Livestock/fishpond; (vi) Hard stem plant not used for farm or non-farm business; (vii) Vehicles (cars, boats, bicycles, motorbikes); (viii) Household appliances (radio, tape recorder, television, fridge, sewing or washing machine, video and CD player, cell phone, etc.); (ix) Savings/certificates of deposits/stocks; (x) Receivables; (xi) Jewelry; (xii) Household furniture and utensils; and (xiii) Others. The value is divided by the number of family members.

Figure 4.4 Prevalence Rate of Overweight and Obesity across Different Wealth Groups in 1993, 1997, 2000, 2007, and 2014



Q = quintile.

Source: Authors' calculation.

the prevalence of overweight and obesity in Indonesia corresponds to the case typically found in low- and middle-income countries (Sobal and Stunkard 1989; McLaren 2007). Second, the prevalence rates of the first (the least wealthy) and second (the second-least wealthy) quintile groups show a large increase between the years 2000 and 2007, resulting in the smaller gap between the lowest and top quintile groups in 2007, compared with other years in the survey. More detailed analysis will be conducted in Section 4.4, where we will quantify the degree of disparity of overweight, obesity, and excess weight across the population.

4.3 Methodology

4.3.1 The Concentration Curve and the Concentration Index

The measurement of disparity of the distribution of overweight/obesity and excess weight in this chapter is based on the concentration curve.[3]

[3] The concentration curve is also known as a generalized Lorenz curve. Its main difference from the Lorenz curve is that the concentration curve ranks people by their socioeconomic status, not their health status.

The concentration curve plots the cumulative percentage of the health variable against the cumulative percentage of the population ranked from poorest to richest (Kakwani 1977; Kakwani et al. 1997).

The concentration index corresponds to twice the area between the concentration curve and the perfect equality 45-degree line (Kakwani et al. 1997). Differences between the Lorenz curve and the concentration curve, and between the Gini coefficient and the concentration index, are succinctly explained by Carr-Hill and Chalmers-Dixon (2005). While the Gini coefficient ranges from 0 to 1 (0 means perfect equality and 1 represents perfect inequality), the concentration index ranges from −1 to 1. If health is equally distributed, the concentration curve coincides with the 45-degree line and the index becomes 0. If the index for overweight is positive, it means overweight is more concentrated among the rich, and vice versa.

The concentration index can be calculated using the following equation:

$$CI = \frac{2}{N\mu}\sum_{i=1}^{n} h_i\, r_i - 1 - \frac{1}{N} \qquad (1)$$

where h_i is the health outcome index of individual i and μ is its mean. $r_i = {}^{i}/_{N}$ is the fractional rank of individual i in the economic status based on household wealth.

The concentration index can be alternatively obtained from the coefficient of the regression of equation (2):[4]

$$2\sigma_r^2\left(\frac{h_i}{\mu}\right) = \alpha + CIr_i + \varepsilon_i \qquad (2)$$

where σ_r^2 is the variance of the fractional rank. The coefficient of the rank is an estimate of the concentration index, which is numerically equivalent to the value from equation (1) (for more details, see O'Donnell et al. 2008).

When the health outcome is a binary variable, the minimum and maximum possible values of the concentration index become $\mu - 1$ and $1 - \mu$ and therefore the feasible range of values the index can take shrinks as the mean of the outcome value increases (Wagstaff 2005). Following the normalization method suggested by Wagstaff (2005), we provide both the original concentration index and the normalized concentration

4 For the derivation of equation (2), see Wagstaff et al. (2003); Kakwani et al. (1997).

index in this chapter. The normalization index, introduced by Wagstaff (2005), is calculated as:

$$\widetilde{CI} = \frac{1}{1-\mu} CI \qquad (3)$$

4.3.2 The Achievement Index

Wagstaff (2002) proposes a measurement of the average level of health including equity aspects. His measurement gauges the average health level ("achievement") taking into account the different health conditions and income levels within the sample. It is defined as a weighted average of the health conditions of all persons in the sample, and imposes higher weights on persons with lower incomes. Wagstaff (2002) introduces equation (4) to calculate the achievement index, AI. If the health variable measures excess weight, for example, the index should be interpreted as a "disachievement" index because excess weight is considered undesirable for health. When ill health is more concentrated among the poor, i.e., CI<0, the "disachievement" index is inflated and shows a larger weighted mean. If the bad health is seen more among the rich, namely CI>0, the achievement index indicates a smaller value than the unweighted sample mean.

$$AI = \frac{1}{n} \sum_{i=1}^{n} h_i (1 - r_i) = \mu(1 - CI) \qquad (4)$$

4.3.3 Decomposition Method

Inequalities in health across the socioeconomic-related distribution can be decomposed into their contributors (Wagstaff et al. 2003). The basic idea is based on the assumption that the inequality in health stems from inequalities in the determinants of the health variable. The decomposition allows us to answer the following type of question: how much can the inequity in education explain the inequality in health? The decomposition thus helps us to identify policy areas for intervention.

Assume any additive linear regression model of health outcome h_i, such that

$$h_i = \alpha + \sum_k \beta_k x_{ki} + \varepsilon_i \qquad (5)$$

where x_{ki} is a determinant of health variable h_i, Wagstaff et al. (2003) introduce a decomposition method (equation 6):

$$CI = \sum_k \frac{\beta_k \bar{x}_k}{\mu} CI_k + \frac{GCI_\varepsilon}{\mu} \tag{4}$$

In equation (6), the concentration index is decomposed into two parts. The first part is the deterministic components, which are equal to the weighted sum of the concentration indices of the explanatory variables $x_k (CI_k)$. The weight is the elasticity of the health index with respect to each factor x_k, which measures the share of variables explaining the concentration index of interest. The product of the elasticity and CI_k reflects the contribution made by x_k. The second part is called the generalized concentration index for the residual component (GCI_k) (O'Donnell et al. 2008). This second part captures the inequality that cannot be explained by x_k. The percentage of the contribution of the inequality in x_k to the inequality in h_i can be calculated as below (equation 7).

$$\% \text{ contribution}_{x_k} = \left\{ \frac{\beta_k \bar{x}_k}{\mu} CI_k / CI \right\} \tag{7}$$

4.4 Results and Discussion

4.4.1 Regression Analysis

We first conduct a regression analysis to unveil the social determinants of overweight, obesity, and excess weight. The estimation results are listed in Table 4.1. As the dependent variables are dichotomous for columns (1) and (2), we perform a probit estimation with a cluster-robust covariance estimator. As excess weight is defined to be non-negative, we perform the negative binomial estimation with a cluster-robust covariance estimator. The null hypothesis of equidispersion assumed under the Poisson distribution is rejected ($p<0.01$). Columns (1), (2), and (3) show the estimated average marginal effects.

The results show that firstly, the elderly and women are more likely to be overweight and obese ($p<0.01$). Earlier studies, such as Ng et al. (2014), have found similar results for women in developing countries. Living in urban areas increases the probability of being overweight and obese ($p<0.01$), which could be due to an urban lifestyle typified by high exposure to fast food, sedentary working conditions, and physical inactivity (Popkin 2001). Furthermore, married people and people living in a large family have a higher probability of being obese ($p<0.01$). Secondly, we see a significant association between wealth and overweight, obesity, and excess weight ($p<0.01$), which implies that being rich is significantly more likely to lead to a higher BMI and excess weight. Thirdly, although we cannot find a significant relation between higher educational achievement and obesity, the regression results show strong evidence that more educated people have a higher likelihood of being overweight and having excess weight ($p<0.01$). Finally, regression results indicate that higher expenditure on meat, fish, oil, soft drinks, and prepared foods is significantly associated with higher levels of overweight and obesity. Alcohol does not show significance, but this may be because many Indonesians are Muslim and do not drink alcoholic beverages.

Overall, our regression analysis shows strong evidence that overweight and obesity are influenced by social determinants as well as dietary choices. In Indonesia, more affluent people are more prone to being overweight or obese and having excess weight. These findings are consistent with other studies in developing countries (Monteiro et al. 2000; Monteiro et al. 2001) and our a priori expectation.

Table 4.1 Regression Analysis

	(1) Overweight and Obesity	(2) Obesity	(3) Excess Weight
Age	0.000703***	0.0000620	−0.00288
	(0.000135)	(0.0000676)	(0.00329)
Male	−0.148***	−0.0563***	−2.729***
	(0.00372)	(0.00222)	(0.0873)
Urban	0.0796***	0.0261***	1.851***
	(0.00434)	(0.00230)	(0.0926)
Married	0.123***	0.0319***	2.355***
	(0.00469)	(0.00271)	(0.110)
Family size	−0.000991	0.00106**	−0.0276
	(0.000987)	(0.000484)	(0.0211)
ln(Wealth)	0.0292***	0.00930***	0.538***
	(0.00127)	(0.000696)	(0.0302)
Car	0.0318***	0.00310	0.663***
	(0.00388)	(0.00202)	(0.0828)

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Table 4.1 *continued*

	(1) Overweight and Obesity	(2) Obesity	(3) Excess Weight
University	0.0413***	0.00437	1.262***
	(0.00711)	(0.00348)	(0.141)
High school	0.0258***	0.00181	0.879***
	(0.00523)	(0.00269)	(0.117)
Junior high school	0.0214***	–0.00196	0.507***
	(0.00472)	(0.00246)	(0.106)
Primary school	0.0292***	0.00463*	0.635***
	(0.00509)	(0.00264)	(0.119)
ln(Staple food)	0.000386	0.000363	–0.00436
	(0.000751)	(0.000404)	(0.0153)
ln(Beef)	0.000659	–0.000159	0.00325
	(0.000517)	(0.000264)	(0.00984)
ln(Chicken)	0.00327***	0.000755***	0.0619***
	(0.000438)	(0.000234)	(0.00877)
ln(Fish)	0.00270***	0.000606**	0.0620***
	(0.000480)	(0.000251)	(0.00977)
ln(Oil)	0.00298***	0.000804**	0.0578***
	(0.000661)	(0.000357)	(0.0126)
ln(Soft drink)	0.00394***	0.00125***	0.0899***
	(0.000543)	(0.000280)	(0.0107)
ln(Alcohol)	–0.001000	–0.00151	0.0128
	(0.00173)	(0.000990)	(0.0328)
ln(Prepared food)	0.00421***	0.00188***	0.106***
	(0.000464)	(0.000266)	(0.00956)
Observations	**78,133**	**78,133**	**78,133**

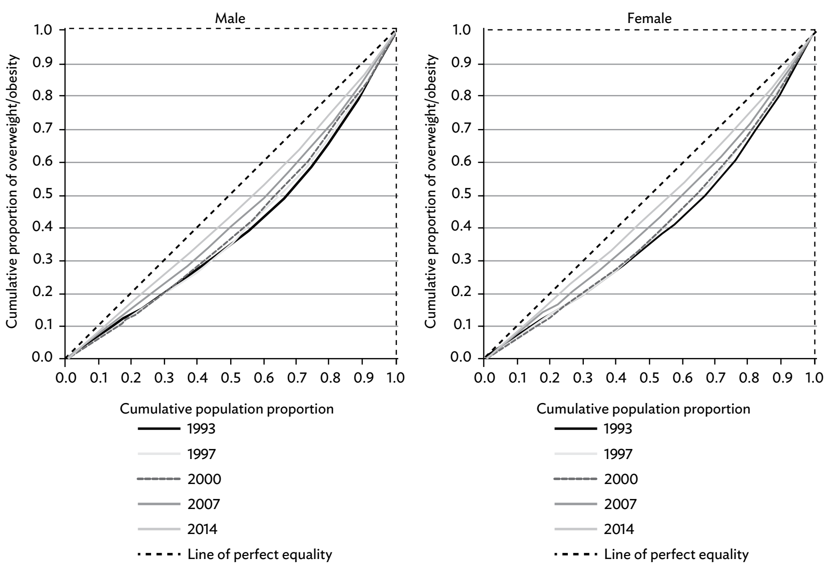
Notes: Standard errors are in parentheses. Standard errors are cluster-robust to arbitrary heteroskedasticity and serial correlations.
Clusters are defined by household units.
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.
Age: age of the respondent; Male: a sex dummy; Urban: a dummy that is 1 if a respondent lives in an urban district; Married: a marital status dummy equal to 1 if a respondent is married; Family size: the number of family members in the household; ln(Wealth): the logarithmic amount of the family-size adjusted wealth of a household; Car: a dummy equal to 1 if a respondent has a car; University, high school, junior high school, and primary school: educational background dummies that equal 1 if a respondent has completed the respective schooling levels as his/her highest education level; ln(Staple foods), ln(Beef), ln(Chicken), ln(Fish), ln(Oil), ln(Soft drink), ln(Alcohol), ln(Prepared food): the logarithmic amount of family-size adjusted expenditure on foods.
Source: Authors.

4.4.2 Concentration Curve

Figure 4.5 shows the concentration curves at five points in time of the survey for overweight and obesity for both men and women. The wealth-related disparity of overweight/obesity is shrinking in each year for both sexes, meaning more and more people are becoming overweight/obese irrespective of their different socioeconomic statuses. Combined with Figure 4.4, Figure 4.5 suggests that the lower socioeconomic groups are steadily catching up with the higher socioeconomic groups in each period. The shrinking gap between rich and poor could be a possible sign of the gradual transition of Indonesia from a low-income country to a middle-income country. During this transition process, higher-income groups stop having higher rates of overweight, while the prevalence among lower-income groups continues to increase. This tipping point has not yet been reached in Indonesia. Figure 4.6 shows the concentration curves for excess weight, illustrating a similar trend as we observed in Figure 4.5. The disparity between poor and rich shrank over time, particularly between 2000 and 2014.

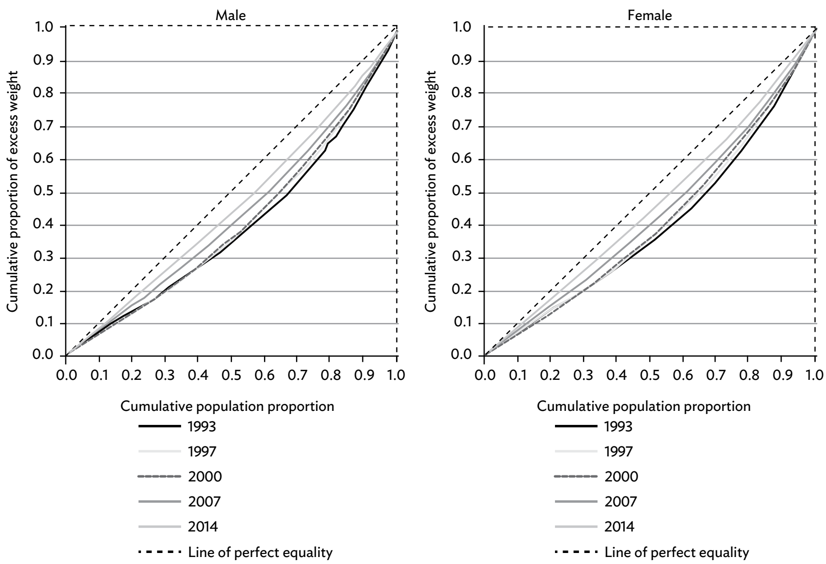
The catching up of the lower wealth groups is also prominent in Table 4.2, which shows the annual growth rate of the prevalence of overweight/obesity from 1993 to 2014 across different wealth quintile

Figure 4.5 The Concentration Curve for Overweight and Obesity



Source: Authors.

Figure 4.6 The Concentration Curve for Excess Weight for Men and Women



Source: Authors.

groups. During the period, the growth rates of the lowest and lower-middle wealth groups are by far larger than those of the upper-middle and highest groups, resulting in a shrinking of the gap of the overweight and obesity rates between the poor and the rich.

Table 4.2 Annual Growth Rates of the Prevalence of Overweight, Obesity, and Excess Weight across Different Wealth Quintile Groups from 1993 to 2014 (%)

Wealth Quintile Level	Overweight or Obese	Obese	Excess Weight
Quintile 1	5.14	8.56	5.33
Quintile 2	5.89	9.19	5.69
Quintile 3	4.70	8.62	5.03
Quintile 4	3.62	5.93	3.90
Quintile 5	2.48	4.92	2.89

Note: The lowest wealth group is Quintile 1 and the highest wealth group is Quintile 5.
Source: Authors' calculation.

4.4.3 Concentration Index

We measure the degree of socioeconomic-related disparity in each period of time by calculating the concentration indices. The results are shown in Table 4.3. The concentration indices decline consistently over time, with the greatest fall found after 2000, as we already inferred by analyzing the concentration curves above. The concentration index for men is consistently higher than that for women.

Table 4.3 Concentration Index

		Overweight or Obese		Obese		Excess Weight
	Year	CI	Adjusted CI	CI	Adjusted CI	CI
All	1993	0.224 (0.012)	0.263 (0.014)	0.288 (0.034)	0.294 (0.035)	0.208 (0.010)
	1997	0.205 (0.011)	0.245 (0.013)	0.196 (0.029)	0.202 (0.030)	0.191 (0.009)
	2000	0.188 (0.009)	0.230 (0.011)	0.196 (0.023)	0.202 (0.024)	0.182 (0.008)
	2007	0.134 (0.007)	0.179 (0.009)	0.181 (0.016)	0.191 (0.017)	0.135 (0.006)
	2014	0.086 (0.005)	0.117 (0.007)	0.102 (0.012)	0.035 (0.004)	0.086 (0.005)
Male	1993	0.324 (0.021)	0.362 (0.024)	0.463 (0.070)	0.467 (0.071)	0.285 (0.016)
	1997	0.344 (0.020)	0.386 (0.023)	0.345 (0.071)	0.349 (0.072)	0.300 (0.015)
	2000	0.283 (0.015)	0.324 (0.018)	0.302 (0.046)	0.306 (0.047)	0.256 (0.012)
	2007	0.211 (0.012)	0.258 (0.015)	0.319 (0.031)	0.329 (0.032)	0.205 (0.010)
	2014	0.175 (0.009)	0.171 (0.009)	0.234 (0.025)	0.041 (0.004)	0.160 (0.008)

continued on next page

Table 4.3 *continued*

	Year	Overweight or Obese CI	Overweight or Obese Adjusted CI	Obese CI	Obese Adjusted CI	Excess Weight CI
Female	1993	0.178	0.218	0.244	0.252	0.167
		(0.015)	(0.018)	(0.038)	(0.040)	(0.012)
	1997	0.147	0.186	0.162	0.169	0.135
		(0.013)	(0.016)	(0.032)	(0.033)	(0.011)
	2000	0.139	0.180	0.163	0.172	0.136
		(0.011)	(0.014)	(0.026)	(0.028)	(0.010)
	2007	0.090	0.132	0.128	0.138	0.089
		(0.008)	(0.012)	(0.019)	(0.021)	(0.008)
	2014	0.038	0.064	0.058	0.029	0.041
		(0.006)	(0.010)	(0.014)	(0.007)	(0.006)

CI = concentration index.
Note: Standard errors are in parentheses.
Source: Authors' calculation.

4.4.4 Achievement Index

Table 4.4 shows the mean and the achievement index of the three conditions. As the health conditions measured are overweight, obesity, and excess weight, it becomes more intuitive if we call it the "disachievement" index. As we have seen before, the means of the prevalence of excess weight, overweight, and obesity show an increase over time. The "disachievement" indices taking account of the change in the distribution of health show even larger growth rates, because the inequalities in overweight, obesity, and excess weight become smaller over the period. In other words, the process of the poor catching up with the rich leads to higher "disachievement" indices as more weight is attached to the poorer people when calculating the averages of the health condition variables in the sample.

4.4.5 Decomposition Analysis

Finally, we decompose the aforementioned relatively large change between 2000 and 2014 in the concentration index of excess weight. As a first step, we calculate the inequalities in each individual potential

Table 4.4 Achievement Index

	Year	Overweight or Obese		Obese		Excess Weight	
		Mean	AI	Mean	AI	Mean	AI
All	1993	0.149	0.115	0.022	0.015	2.603	2.060
	1997	0.166	0.132	0.028	0.023	2.988	2.419
	2000	0.181	0.147	0.032	0.026	3.296	2.697
	2007	0.252	0.219	0.054	0.044	4.621	3.999
	2014	0.341	0.311	0.087	0.078	6.291	5.752
Male	1993	0.105	0.071	0.010	0.005	2.056	1.469
	1997	0.108	0.071	0.011	0.008	2.230	1.561
	2000	0.125	0.090	0.014	0.010	2.551	1.897
	2007	0.181	0.143	0.030	0.020	3.653	2.906
	2014	0.245	0.203	0.043	0.033	4.853	4.077
Female	1993	0.183	0.151	0.031	0.024	3.042	2.535
	1997	0.211	0.180	0.042	0.035	3.596	3.109
	2000	0.230	0.198	0.048	0.040	3.952	3.415
	2007	0.316	0.288	0.076	0.066	5.480	4.990
	2014	0.424	0.408	0.124	0.117	7.548	7.237

AI = achievement (disachievement) index.
Source: Authors' calculation.

contributing factor (Table 4.5). University education achievement, gas stove possession, refrigerator use, and expenditure on beef show higher values, which means that they are particularly commonly seen among the rich. The elasticity measures the share of the factors explaining the inequality in health (in our case excess weight) in the respective year. Positive elasticity means a positive link between the inequality in a factor and the health inequality. The larger the absolute elasticity, the stronger the connection.

The products of the elasticity and the concentration indices of the individual factors produce the contributions to the inequality in health, illustrated in Figure 4.7. During the period, our data shows an alleviation of educational inequality in Indonesia. Table 4.5 indicates that the concentration index of university education decreased by 0.09 (=0.44–0.35), a decrease that applied to both sexes. However, more equal access to education did not lead to consistent results in terms of lowering excess weight disparities for both men and women. For men, the inequality in

Table 4.5 Decomposition of the Concentration Index of Excess Weight in 2000 and 2014

Individual Contributing Factors	All				Male				Female			
	2014		2000		2014		2000		2014		2000	
	E	CI	E	CI	E	CI	E	CI	E	CI	E	CI
High school education	−0.01	0.04	−0.04	0.26	0.06	0.05	0.08	0.25	−0.02	0.02	−0.07	0.26
University education	0.01	0.35	0.00	0.44	0.07	0.36	0.03	0.45	−0.02	0.33	−0.01	0.43
Electricity	0.14	0.00	0.16	0.04	0.22	0.00	0.06	0.04	0.06	0.00	0.21	0.04
Electric stove	0.00	−0.10	0.00	0.23	0.00	−0.10	0.00	0.23	0.00	−0.09	0.00	0.23
Gas stove	0.18	0.07	0.03	0.47	0.18	0.07	0.04	0.48	0.16	0.07	0.02	0.47
Clean water	0.04	0.04	0.05	0.14	0.04	0.04	0.06	0.13	0.04	0.05	0.05	0.15
Own toilet	0.07	0.07	0.09	0.15	0.14	0.07	0.13	0.15	0.02	0.07	0.05	0.15
Sanitation	0.06	0.09	0.07	0.21	0.08	0.09	0.09	0.20	0.05	0.09	0.06	0.23
Vehicle	0.06	0.08	0.05	0.16	0.10	0.08	0.07	0.16	0.05	0.07	0.03	0.16
Appliances	0.10	0.01	0.04	0.09	0.06	0.01	0.03	0.08	0.17	0.01	0.06	0.09
Fridge use	0.04	0.17	0.05	0.46	0.06	0.18	0.06	0.46	0.02	0.17	0.04	0.46
Television	0.15	0.03	0.21	0.18	0.13	0.03	0.19	0.18	0.15	0.03	0.21	0.18
Staple foods	0.00	0.01	−0.01	0.02	−0.01	0.02	−0.02	0.02	0.00	0.01	−0.01	0.02
Beef	0.01	0.18	0.00	0.30	0.00	0.17	0.00	0.31	0.01	0.19	0.01	0.30
Chicken	0.02	0.15	0.01	0.22	0.02	0.15	0.02	0.22	0.01	0.15	0.00	0.23
Fish	0.02	0.12	0.02	0.12	0.04	0.12	0.03	0.11	0.01	0.13	0.01	0.13
Oil	0.01	0.06	0.03	0.11	0.00	0.06	0.03	0.11	0.02	0.06	0.03	0.11
Soft drink	0.00	0.17	0.01	0.33	0.01	0.17	0.01	0.33	0.00	0.16	0.00	0.33
Prepared food	0.03	0.17	0.01	0.21	0.05	0.16	0.02	0.21	0.02	0.18	0.00	0.21

CI = concentration index, E = elasticity.
Source: Authors' calculation.

education is correlated with the inequality in the distribution of excess weight, but we cannot see the positive correlation for women. This difference comes from the opposite sign of the elasticity of education.

4.5 Conclusion

This chapter studies the socioeconomic disparities of overweight, obesity, and excess weight in Indonesia from 1993 to 2014 and their changes during the period. First, we showed that the proportion of overweight and obese people grew rapidly in the country and overweight and obesity were swiftly becoming more prevalent among less wealthy groups. Although the overweight and obesity prevalence rate was still higher among the wealthy, the growth of the prevalence rate among less wealthy groups was higher than that of the rich. Second, from the concentration index in each year of the survey, we found that the socioeconomic-related disparity decreased over time. The largest fall was found after 2000 for both women and men, suggesting that all findings considered, overweight and obesity are no longer problems only for the rich but increasingly for the poor.

The rapid growth of people with excess weight in the lower income quintiles is a worrisome development. Overweight is one of the main risk factors for developing chronic diseases, which require substantive medical expenditures often borne by the patient in developing countries. Lower-income groups are particularly ill prepared for such high expenditures. The question is what policies could help to dampen the rapid increase of weight in lower income quintiles, while at the same time reducing undernutrition.

This chapter presented new evidence that the socioeconomic disparity of overweight and obesity in Indonesia has been rapidly changing over the past 2 decades. Hand in hand with economic growth, lower income groups increased body weight faster than higher income groups. Overall, overweight in Indonesia is no longer affecting only the wealthier segments of the population, but the entire socioeconomic spectrum. This also implies that population groups that are less well prepared for the incidence of noncommunicable diseases are now running a higher risk of developing them. Policy makers in Indonesia need to think about policies to slow down the increasing speed of the prevalence of obesity, especially among poorer households. One option is targeted educational efforts. Another option might be introducing taxes on unhealthy foods, such as soft drinks. These tax measures need to be well designed in order to make sure they achieve their policy objectives while maintaining enough healthy and affordable food choices. Given the sharp increase in overweight and obesity in Southeast Asia, more research is needed to better understand the problem and to be able to design appropriate responses that take into account strong socioeconomic disparities.

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PART II

Cost and Policy Implications of Obesity and Overweight

5

Economic Impact of Obesity in the Republic of Korea

Wankyo Chung

5.1 Introduction

Obesity has a clear impact on health-related quality of life, and generates considerable direct and indirect costs (Dixon 2010). In 2014, more than 1.9 billion adults (39% of the world's adults) aged 18 years and older were overweight (body mass index [BMI]>=25 kilograms per meters squared [kg/m^2]) and over 600 million adults (13%) were obese (BMI>=30 kg/m^2) (World Health Organization 2016a). Compared to other countries, the Republic of Korea has lower rates of overweight and obesity: in 2014, the Republic of Korea ranked 55^{th} out of 192 countries, and 33.5% of adults aged 18 years and older were overweight (BMI>=25 kg/m^2, age-standardized estimate) (World Health Organization 2016b). However, the Republic of Korea's prevalence of overweight and obesity has been rising, from 25.8% in 1998 to 31.5% in 2014 for adults aged 19 and over, which contributes significantly to rising medical costs.

Many studies have estimated the economic burden of obesity (Finkelstein et al. 2009; Thorpe et al. 2004; Cawley and Meyerhoefer 2012). One recent paper used an instrumental variable estimation to address both the endogeneity of weight and measurement error in weight, and showed that the effect of obesity on medical care costs is much greater than previously estimated (Cawley and Meyerhoefer 2012). For example, while Finkelstein et al. (2009) estimated that annual medical spending of the obese was $1,429 (in 2008 dollars or 41.5%) higher than that of healthy weight individuals, Cawley and Meyerhoefer (2012) showed that obesity increased annual medical costs by $2,741 (in 2005 dollars).

Four studies are key to understanding costs of obesity in the Republic of Korea. Jee et al. (2006) showed that the relative risk of death is higher for those with a higher BMI, especially deaths from atherosclerotic cardiovascular disease or cancer. Similarly, Hong et al. (2015) showed that higher BMI increased the hazard ratio of death, especially vascular mortality. Lee et al. (2012) estimated that medical cost due to 16 obesity-related diseases was ₩2,128 billion[1] in the Republic of Korea, 4.6% of the total medical cost of national health insurance in 2011. Lee et al. (2015) estimated obesity-related medical cost to be ₩1,142 billion (in 2013 won) for males and ₩1,952 billion (in 2013 won) for females.

This study builds on the previous research by examining evidence on obesity, estimating obesity-related medical cost using more representative and reliable data, and estimating the obesity-related risk of disability. The following section describes trends in obesity for children and adults in the Republic of Korea. Section 5.3 explains risk factors. Section 5.4 describes the data, while section 5.5 presents the model. Section 5.6 discusses the results and Section 5.7 concludes.

5.2 Trends in Obesity for Children and Adults

5.2.1 Childhood Obesity

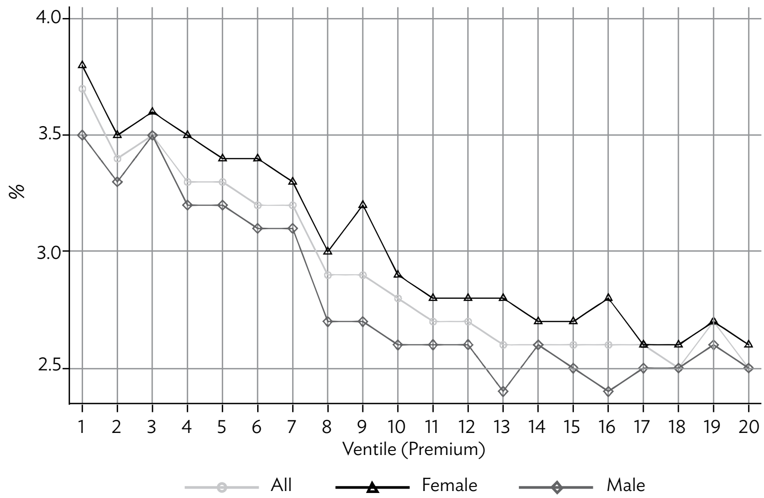
The obesity of infants aged 4–71 months was calculated based on those examined between 2012 and 2015 (total of 1.64–2.04 million infants for each year). For infants aged from 4 to 24 months (three groups of 4–6, 9–12, and 18–24 months), overweight was defined as being greater or equal to 95 percentile of weight-for-height. For infants aged from 30–71 months (4 groups of 30–36, 42–48, 54–60, and 66–71 months), overweight was defined by (1.04<=BMI z-score<1.65) and obesity was defined by (1.65<=BMI z-score) (National Health Insurance Service [NHIS] 2016).

Overweight rates were 8.8, 9.0, 8.9, and 8.6% and obesity rates were 2.8, 2.7, 2.8, and 2.8% for each year from 2012 to 2015, respectively. When infants were categorized by gender, overweight and obesity rates were higher for female than male infants. For male infants, overweight rates were 8.0, 8.2, 8.1, and 8.4% and obesity rates were 2.6, 2.5, 2.6, and 2.7% for the respective years. For female infants, overweight rates were 9.8, 9.8, 9.6, and 8.9% and obesity rates were 2.9, 2.9, 3.1, and 2.9% (NHIS 2016).

Obesity rates increased with age of infants, for example, from 3.0% (30–36 months) to 5.1% (42–48 months), 5.9% (54–60 months) and 6.9% (66–71 months) in 2015, and declined with household income, proxied by ventiles of insurance premium (see Figure 5.1 and Table A5.1). The obesity rates were 3.7% at the first ventile but declined sharply to 2.6% at the 13th ventile and further decreased to 2.5% at the 20th ventile.

1 Conversion as of December 2017 is $1 = ₩1,080.

Figure 5.1 Distribution of Infant (30–71 Months) Obesity across Income, 2015



Source: National Health Insurance Service (2016).

When infants were divided by gender, the same declining pattern showed, while obesity rates of female infants were higher than those of male infants by about 0.1–0.3 percentage points across the ventiles of insurance premium.

Obesity for children aged 6–18 years was defined by BMI (>=95 percentiles for each age or >=25 kg/m^2) and calculated based on data from examinations at primary, junior high, and high schools (see Table 5.1).[2] Obesity rates of students at primary schools (6 years of education) increased by 1 percentage point from 8.0% in 2009 to 9.0% in 2015. Obesity rates of students at junior high schools (3 years of education) increased by 1.2 percentage points from 12.7% to 13.9% and that of students at high schools (3 years of education) increased by 3.8 percentage points from 15.7% to 19.5% during the same period. In each year, obesity rates increased with ageing from students at primary schools to those at junior high schools and high schools. In 2015, for example, the respective rates were 9.0%, 13.9% and 19.5%. Male students showed higher obesity rates than females. In 2015, male versus female

2 Size of sample ranges from 82,581 (756 schools) to 194,065 students (749 schools).

Table 5.1 Child Obesity Rate by School Level, 2009–2015 (%)

Year	Primary School	Junior High School	High School
2009	8.0	12.7	15.7
2010	8.3	12.6	16.3
2011	8.5	12.6	15.8
2012	9.0	13.2	16.5
2013	9.0	13.7	17.5
2014	8.9	13.5	18.2
2015	9.0	13.9	19.5

Note: Age = 6–18.
Source: Students Physical Development Survey, Ministry of Education, the Republic of Korea.

obesity rates were 9.5% to 8.5% for students in primary schools, 17.0% to 10.5% for those in junior high schools, and 23.3% to 15.3% for those in high schools.

5.2.2 Adult Obesity

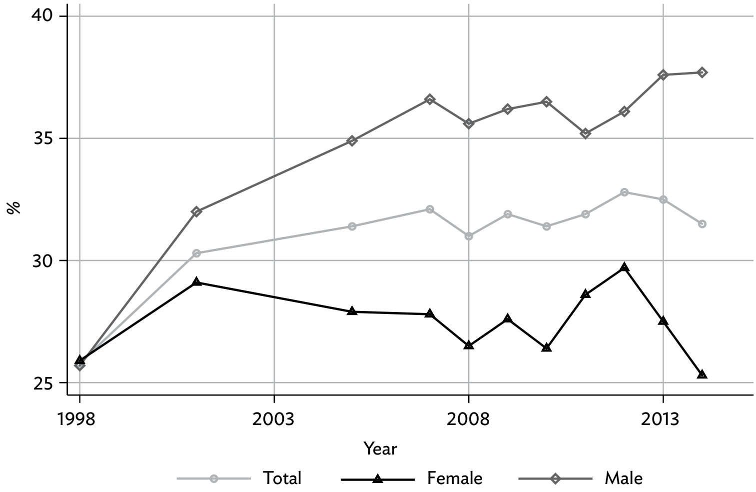
In 2014, 31.5% of adults aged 19 and over were obese (BMI>=25 kg/m^2). Males showed a higher obesity rate of 37.7% than females, measured at 25.3%. Obesity increased with age from 23.9% for ages 19–29, to 31.8% for ages 30–39, 31.1% for ages 40–49, 35.4% for ages 50–59, 36.8% for ages 60–69, and 32.1% for 70 and over.

Figure 5.2 shows that adult obesity increased over time from 25.8% in 1998 to 31.5% in 2014 (see Table A5.2). This increase is driven by males; while male obesity increased from 25.7% to 37.7%, female obesity fluctuated from 25.9% to 25.3%. When the sample is limited to younger adults from 19 to 29 years old in Figure 5.3 (see Table A5.3), both males and females show an increasing trend during the period. Younger adults' obesity increased from 15.2% in 1998 to 23.9% in 2014, with both males' obesity increasing from 19.3% to 32.0% and females' obesity increasing from 11.6% to 15.0% during the period.

5.3 Risk Factors

Lee, H. S. et al. (2014) used dietary intake data of 33,745 subjects aged over one from the Korea National Health and Nutrition Examination Survey (KNHANES) 2008–2011 to estimate total sugar intake. Their results showed that mean total sugar intake was 61.4 grams/person/day, corresponding to 12.8% of total daily energy intake and more than half of this amount (35.0 grams/day) was from processed foods. The top

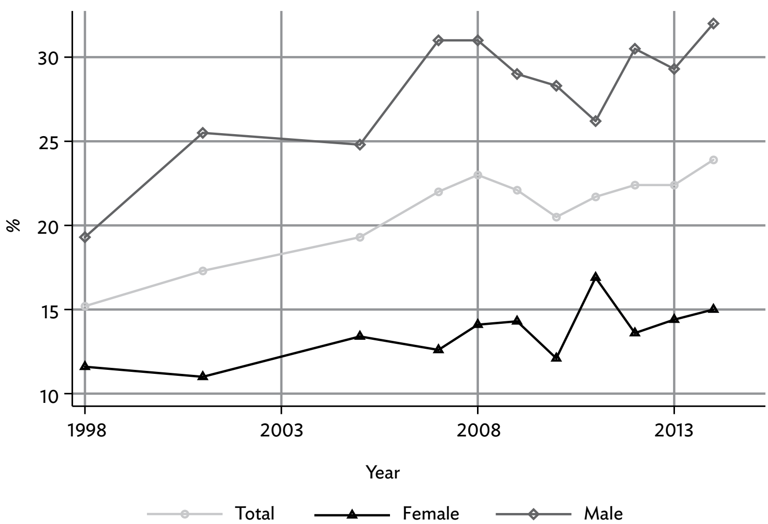
Figure 5.2 Trends of Adult Obesity, 1998–2014



Note: Age>=19, body mass index>=25.

Source: Korea National Health and Nutrition Examination Survey, Ministry of Health, Welfare and Family Affairs, the Republic of Korea.

Figure 5.3 Trends of Young Adult Obesity, 1998–2014



Note: Age=19–29 years, BMI>=25.

Source: Korea National Health and Nutrition Examination Survey, Ministry of Health, Welfare and Family Affairs, the Republic of Korea.

five processed food sources of total sugar intake were: granulated sugar, carbonated beverages, coffee, breads, and fruit and vegetable drinks. Across age groups, total sugar intake showed an inverted U shape, highest for adolescents (12 to 18 years, 69.6 grams/day) and second-highest for young adults (19 to 29 years, 68.4 grams/day) with higher beverage intake but lowest for seniors aged 65 and over (39.1 grams/day) and second-lowest for children 1 to 2 years old (50.7 grams/day).

Ma et al. (2015) studied the association between family meals and childhood obesity using 247 elementary students in one province, Gyeonggi-do, in the Republic of Korea. The results showed that no breakfast, less frequent family breakfast meals, or more dining out were positively associated with body mass index-standard deviation score.

Another study examined the association between dairy products and calcium intake and obesity for adults aged 19–64 from KNHANES 2007–209 (Lee, H. J. et al. 2014). It showed that a higher frequency of dairy product intake was associated with reduced prevalence of obesity (odds ratio [OR]=0.63; 95% confidence interval [CI]=0.45–0.89 for ≥2 times/day vs. ≤1 time/month). Similarly, higher calcium intake from dairy products as well as total dietary calcium intake was associated with a decreased prevalence of obesity (OR=0.83; 95% CI=0.71–0.98 for highest vs. lowest quintile of dairy calcium intake; OR=0.78; 95% CI=0.64–0.94 for highest vs. lowest quintile of total calcium intake). Their results suggest that calcium in dairy products may be one component contributing to the association. Meanwhile, Oh et al. (2017) showed that the prevalence of obesity increased with a diet deficiency in protein for those aged 60 and over in the Republic of Korea.

Kong et al. (2015) studied the association between physical activity and obesity using data from the 2013 Korea Youth Risk Behavior Web-based Survey. The results showed that low physical activity was positively associated with obesity (OR 1.12; 95% CI=1.01–1.25). Finally, You and Choo (2016) studied the association between socioeconomic status and adolescent overweight/obesity and the mediating effect of fruit and vegetable intake. They used data of 63,111 adolescents from the 2013 Korea Youth Risk Behavior Web-based Survey. They defined overweight/obesity as body mass index >=85th percentile and high intake of fruit and vegetable as >=1 fruit serving and >=3 vegetable servings per day. Their results showed that low socioeconomic status was significantly associated with overweight/obesity among girls only, which was significantly mediated by fruit and vegetable intake. Therefore, they suggest that promoting fruit and vegetable intakes for socially disadvantaged girls should be prioritized to prevent adolescent overweight/obesity.

5.4 Data

Although KNHANES is useful to describe obesity trends, given its small sample size, we draw upon the National Health Insurance Service-National Sample Cohort (NHIS-NSC) database. NHIS-NSC has a representative sample of 1,025,340 individuals, which is 2.2% of the total eligible Korean population in 2002 (Lee et al. 2016). We use data only from 2009 to 2013 (study sample consists of 416,330 people) because the sample who took health examinations for variables measuring obesity changed considerably in 2008 and the questionnaire on health examination changed in 2009. We limit the study sample to adults aged from 20 to 64, as weight and medical cost can fluctuate considerably for those outside this age group.

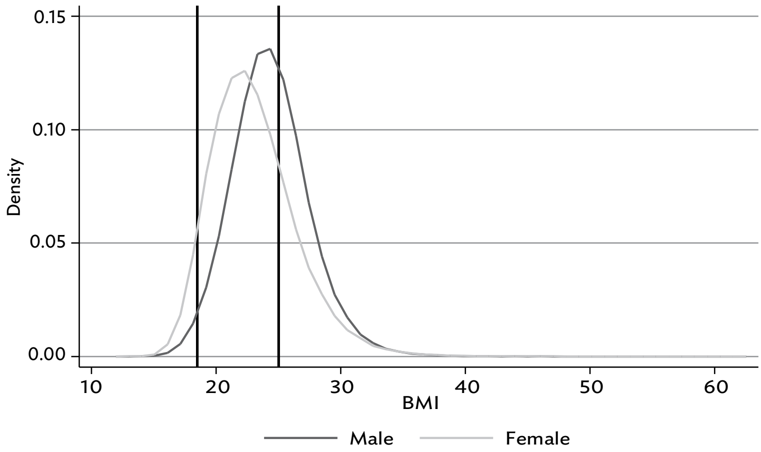
5.4.1 Data Description: Obesity Rates

The NHIS-NSC database contains variables to measure obesity from nationwide health examinations. The number of individuals who took the health examinations ranges from 211,541 to 241,397 from 2009 to 2013 and represents 21–24% of individuals in the sample cohort. Some individuals took health examinations more than once (up to five times) from 2009 to 2013. We limited the study sample to those who took a health examination once and randomly selected one health examination for others who took it more than once. The study sample is 416,330 individuals, distributed 17.6–22.4% from 2009 to 2013. Details of the study sample are provided in the following section.

The NHIS-NSC database shows an obesity rate of 39.7% for males and 24.6% for females, higher than that from KNHANES for males but lower than that from KNHANES for females. Its large sample size enables us to examine the distribution of BMI in detail. To begin with, kernel density functions of BMI are estimated separately for males (209,403) and females (206,927) and overlaid for comparison in Figure 5.4. The density shifts to the right for males with a greater peak at a higher value of BMI. Male average BMI is 24.4 kg/m^2 (ranging from 12.8 to 62.3 kg/m^2) and the female average BMI is 23.0 kg/m^2 (ranging from 12.2 to 50.8 kg/m^2). Two vertical lines are drawn, one at 18.5 kg/m^2 to divide underweight from normal weight and the other at 25 kg/m^2 to divide obesity from normal weight.

Figure 5.5 shows an interesting distribution of obesity across income (see Table A5.4). We divided the sample between males and females because of their difference in obesity and regulation of energy homeostasis (Lovejoy et al. 2009). We also divided the sample with respect to working status between self-employed workers and

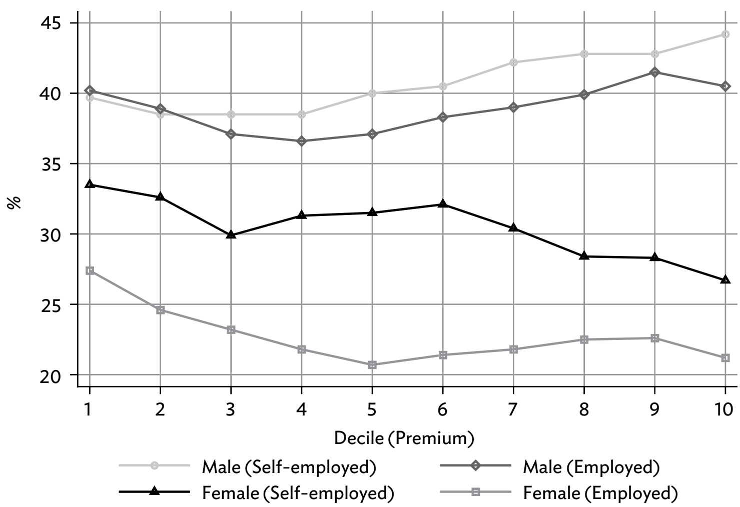
Figure 5.4 Density of Adult Obesity, 2009–2013



Note: Age = 20–64 years.

Source: National Health Insurance Service-National Sample Cohort database.

Figure 5.5 Distribution of Adult Obesity across Income, 2009–2013



Note: Age = 20–64 years.

Source: National Health Insurance Service-National Sample Cohort database.

employed workers because the health insurance premium, a proxy for income (income is not directly available in the NHIS-NSC database), is calculated differently between the two. The health insurance premium is calculated based on the monthly income for the employed workers but it is calculated based on income, standard of living, and property for self-employed workers.[3] Thus, a higher insurance premium (higher deciles in the figure) means higher income or wealth.

For males, the self-employed (45,431 individuals) show higher obesity rates than the employed (163,972 individuals) except for the first and second deciles. The obesity rate for the self-employed males declines from 39.7% at the 1st decile to 38.5% at the 2nd decile and then steadily increases to 44.2% in the 10th decile. The obesity rate for employed males declines from 40.2% at the 1st decile to 36.6% at the 4th decile, increases to 41.5% at the 9th decile, and then declines to 40.5% at the 10th decile.

For females, the gap between the self-employed (54,984 individuals) and the employed (151,943 individuals) is wider. The obesity rate for the self-employed females declines from 33.5% at the 1st decile to 29.9% at the 3rd decile, increases to 32.1% at the 6th decile, and then declines to 26.7% at the 10th decile. The obesity rate for the employed females declines from 27.4% at the 1st decile to 20.7% at the 5th decile, increases to 22.6% at the 9th decile, and then declines to 21.2% at the 10th decile. Overall, the obesity rate shows a weak U-shaped pattern for both male and female employed workers.

Table 5.2 shows the distribution of obesity by 17 areas, grouped by metropolitan cities and large administrative districts. Male obesity rates range from 36.5% for Ulsan to 47.9% for Jeju-do while the female obesity rates range from 20.8% for Daegu to 32.2% for Gangwon-do. Male obesity rates are positively correlated with female obesity rates (r=0.59, p=0.014) across the 17 areas.

5.4.2 Data Description: Obesity-related Medical Cost

We estimate obesity-related medical cost for males and females separately as there are gender differences in obesity rates and regulation

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3 When yearly household income is ₩5 million or less for the self-employed workers, the premium is calculated based on living standard and economic activity, value of property, and ownership of a motor vehicle. When yearly income is greater than ₩5 million, the premium is calculated based on income, value of property, and ownership of a motor vehicle. A 50% reduction of the premium applies to those living on islands or remote rural areas. Those living in rural areas receive a 22% reduction, and those who are disabled, single parents, or living with the elderly receive a reduction of 10–30% (www.nhis.or.kr).

Table 5.2 Adult Obesity Rate by Area, 2009–2013 (%)

Area	Population (2013)	Male	Female
Seoul	10,012,712	39.7	21.9
Busan	3,493,213	38.6	23.1
Daegu	2,483,045	36.6	20.8
Incheon	2,833,205	40.6	26.3
Gwangju	1,461,796	38.5	22.7
Daejeon	1,517,299	39.2	23.1
Ulsan	1,144,912	36.5	24.8
Sejong	116,753	45.8	29.1
Gyeonggi-do	12,061,219	41.0	24.6
Gangwon-do	1,526,532	43.7	32.2
Chungcheongbuk-do	1,558,806	39.4	28.1
Chungcheongnam-do	2,024,419	39.4	28.3
Jeollabuk-do	1,860,621	40.3	28.2
Jeollanam-do	1,894,700	40.5	30.9
Gyeongsangbuk-do	2,680,890	37.9	26.4
Gyeongsangnam-do	3,304,756	37.8	24.0
Jeju-do	584,078	47.9	27.9

Note: Age = 20–64 years.
Sources: Vital Statistics, Statistics Korea, the Republic of Korea for population and National Health Insurance Service-National Sample Cohort database for obesity.

of energy homeostasis (Lovejoy et al. 2009) and labor force participation, which is related to health care use.

Table 5.3 shows descriptive statistics for male adults (209,403 individuals). Average medical cost (including 0 medical cost) was ₩514,000 in 2010.[4] Average BMI was 24.39 kg/m^2 and 39.7% of adult males were obese (defined as BMI>=25 kg/m^2) and 4.5% were severely obese (defined as BMI>=30 kg/m^2). The average weight was 71.22 kilograms and height was 1.71 meters, and they are correlated by 0.51 (p=0.00). As for health-related habits, 70.8% of adult males were current or former smokers, 43.8% were drinking alcohol more than 2 times per week, and 29.6% were exercising more than 2 days per

4 Each year's values of medical cost were deflated to 2010 won using the medical component of Consumer Price Index. One dollar was 1,134.8 Korean won in 2010.

Table 5.3 Descriptive Statistics of Male Adults, 2009–2013

	Mean	Standard Deviation	Min	Max
Cost (1,000 won, 2010=100)	514.2	1,834.6	0	114,213.3
Cost>0	0.996	0.065	0	1
Disability (grade 1–6)	0.053	0.224	0	1
BMI	24.39	3.115	12.76	62.3
Obese (=1 if BMI>=25)	0.397	0.489	0	1
Severely obese (=1 if BMI>=30)	0.045	0.207	0	1
Weight (kilograms)	71.22	10.667	30	162
Height (meters)	1.71	0.063	1.06	1.99
Smoking (currently or previously)	0.708	0.455	0	1
Drinking (>=2 days per week)	0.438	0.496	0	1
Exercise (>=2 days per week, >=20 minutes)	0.296	0.457	0	1
Age (20–24)	0.022	0.148	0	1
Age (25–29)	0.087	0.282	0	1
Age (30–34)	0.118	0.323	0	1
Age (35–39)	0.111	0.314	0	1
Age (40–44)	0.166	0.372	0	1
Age (45–49)	0.130	0.336	0	1
Age (50–54)	0.152	0.359	0	1
Age (55–59)	0.103	0.304	0	1
Age (60–64)	0.111	0.314	0	1
Number of Observations	209,403			

BMI = body mass index.
Note: Age = 20–64 years.
Source: National Health Insurance Service-National Sample Cohort database.

week and more than 20 minutes per day. There were more males aged 40–54 (44.7%), but fewer males aged 20–29 (10.9%) among the 20–64 age group.

Similarly, Table 5.4 presents descriptive statistics for female adults (206,927 individuals). Their medical cost (including 0 medical cost)

Table 5.4 Descriptive Statistics of Female Adults, 2009–2013

	Mean	Standard Deviation	Min	Max
Cost (1,000 won, 2010=100)	596.6	1,689	0	95,196
Cost>0	0.998	0.041	0	1
Disability (grade 1–6)	0.03	0.17	0	1
BMI	23.02	3.391292	12.19	50.84
Obese (=1 if BMI>=25)	0.246	0.431	0	1
Severely obese (=1 if BMI>=30)	0.035	0.183	0	1
Weight (kilograms)	57.29	8.617	26	141
Height (meters)	1.58	0.057	1.1	1.91
Smoking (currently or previously)	0.064	0.244	0	1
Drinking (>=2 days per week)	0.12	0.325	0	1
Exercise (>=2 days per week, >=20 minutes)	0.209	0.406	0	1
Age (20–24)	0.045	0.208	0	1
Age (25–29)	0.091	0.287	0	1
Age (30–34)	0.074	0.262	0	1
Age (35–39)	0.059	0.237	0	1
Age (40–44)	0.189	0.392	0	1
Age (45–49)	0.129	0.335	0	1
Age (50–54)	0.178	0.383	0	1
Age (55–59)	0.109	0.312	0	1
Age (60–64)	0.125	0.331	0	1
Number of Observations	206,927			

BMI = body mass index.
Note: Age = 20–64 years.
Source: National Health Insurance Service-National Sample Cohort database.

was more than that of males at ₩597,000 in 2010. Average BMI was 23.02 kg/m^2, and 24.6% of adult females were obese, much lower compared with males' obesity rate of 39.7%, and 3.5% of adult females were severely obese, still lower compared with males' severe obesity rate of 4.5%.[5] Average female weight was 57.29 kilograms and height was 1.58 meters, and they are correlated by 0.27 (p=0.00), weaker than the correlation of those factors for males. As for the adult females' health-related habits, 6.4% were current or former smokers, 12% were drinking alcohol more than 2 times per week, and 20.9% were exercising more than 2 days per week and more than 20 minutes per day. There were more females aged 40–54 (49.6%), but fewer females aged 20–29 (13.6%) and aged 30–39 (13.3%).

5.5 Model

Epidemiologists use the population attributable fraction (PAF) to estimate the disease burden that could be eliminated together with obesity. The population attributable fraction can be defined as follows:

$$Population\ Attributable\ Fraction\ 1 = \frac{Pe(RR-1)}{Pe(RR-1)+1}$$

where Pe is the proportion of obese and RR is the relative risk for an obesity-related disease category, unadjusted for other confounding risk factors (Rockhill 1998).

Another definition is:

$$Population\ Attributable\ Fraction\ 2 = pd\left(\frac{RR-1}{RR}\right)$$

where pd is the proportion of cases exposed to the risk factor (e.g., proportion of patients in an obesity-related disease category who were obese) and RR is the relative risk of an obesity-related disease category, adjusted for other confounding risk factors. Using either equation, the total obesity-related disease burden can be estimated by multiplying each disease-specific population attributable fraction by each disease-specific medical cost and summing them up over all the obesity-related diseases. However, there have been common computational errors using adjusted RR in the PAF 1 equation rather than correctly in the PAF 2 equation (Flegal et al. 2015; Rockhill 1998). In addition, Rowe et al. (2004) showed that PAFs of individual risk factors can add up to more than 1 for diseases with multiple risk factors, suggesting the impossible situation where more than 100% of cases are preventable.

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5 For comparison, the prevalence of obesity (as defined by BMI>=30 kg/m^2) was 32.2% among United States (US) adult men (aged 20 or over) and 35.5% among US adult women in 2007–2008, while the prevalence of overweight (as defined by BMI>=25 kg/m^2) was 72.3% among US adult men and 64.1% among US adult women (Flegal et al. 2010).

An alternative to the epidemiological approach is an econometrics-oriented one (Finkelstein et al. 2009; Thorpe et al. 2004; Cawley and Meyerhoefer 2012). Typically, this econometric approach estimates the relationship between medical costs and obesity directly, while controlling for other confounding factors. We choose this approach to avoid the limitations of the epidemiological approach and having to select obesity-related illnesses and apply the PAF to each illness to sum them up.

5.6 Results

Table 5.5 provides the marginal effects of obesity on medical cost using ordinary least squares (OLS) estimation. We control for other obesity-related factors: smoking, drinking, exercise, 9 age category dummies, 17 area dummies, 5 year dummies, 10 insurance premium dummies, and 4 categories of insurance type dummies (the employee insured, the dependents of the employee insured, household head of the self-employed insured, other cohabitants of the self-employed insured).[6]

For males, obesity (relative to having a BMI<25) does not lead to higher medical costs in a statistically significant way. However, severe obesity (relative to having a BMI<30) increases medical cost by ₩39,000 and is statistically significant at 5%. For females, obesity increases medical cost by ₩100,000 and severe obesity increases medical cost by ₩228,000. Both are statistically significant at 1%.

Among other factors, smoking increases medical cost for both males and females (statistically significant at 1% both for males and females), and exercise decreases medical cost for both males and females (statistically significant at 10% for males and 1% for females). However, drinking decreases medical cost for both males and females (statistically significant at 1% both for males and females), requiring further study of self selection bias and the types of alcoholic drink and alcohol concentration in addition to the drinking frequency.

While the OLS results suggest higher medical cost for obesity, we use a two-part model to confirm the results (Jones 2000). The first part of two-part model estimates the probability of positive medical cost and the second part estimates the level of medical cost conditional on positive cost. We use a logit model for the first part and a gamma generalized linear model (GLM) with log link for the second part,

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6 Categories of reference groups are youngest age group of 20 to 24, area of Seoul, year of 2009, the 1st decile of health insurance premium (proxy for income or wealth), and household head of the self-employed insured.

Table 5.5 Marginal Effects of Obesity on Medical Cost, 2009–2013 (2010 won)

	Ordinary Least Squares				Two-Part Model (Logit, Gamma Generalized Linear)			
	Male		Female		Male		Female	
Obesity	−10.631		99.657***		5.376		77.268***	
	(7.831)		(10.001)		(5.975)		(7.416)	
Severe Obesity		39.486**		227.845***		57.891***		169.117***
		(16.643)		(26.848)		(15.980)		(19.399)
Number of Observations	209,403	209,403	206,927	206,927	209,202	209,202	204,663	204,663

Notes: Age = 20–64 years. Adjusted for smoking, drinking, exercise, 9 dummies for age, 17 dummies for area, 5 dummies for year, 10 dummies for insurance premium, and 4 dummies for insurance type. Robust standard errors in parenthesis.
* significant at 10%, ** significant at 5%, *** significant at 1%.
Source: National Health Insurance Service-National Sample Cohort database.

following Cawley and Meyerhoefer (2012). GLM can provide consistent estimation of obesity effect while the OLS-based model for logged medical cost provides inconsistent estimation unless the degree and form of heteroscedasticity is known to retransform the estimates (Manning and Mullahy 2001).

The second panel of Table 5.5 provides the marginal effects of obesity, reflecting both parts of the two-part model.[7] For males, obesity (relative to having a BMI<25) increases medical cost by ₩5,000 and severe obesity (relative to having a BMI<30) increases medical cost by ₩58,000. Again, only the latter is statistically significant at 1%. For females, obesity increases medical cost by ₩77,000 and severe obesity increases medical cost by ₩169,000. Both are statistically significant at 1%. Severe obesity increases medical cost far more than obesity for both males and females, indicating higher marginal cost effects for the few severely obese.

These estimates can be used next to estimate the aggregate medical cost of obesity in the Republic of Korea. For male adults aged 20 to 64, the aggregate medical cost of obesity was estimated

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7 Note that there are few individuals with zero medical cost both for males and females because the medical cost data in the NHIS-NSC database is obtained from the insurance claims. Note also changes in the number of observations due to exclusion of observations with all positive values of medical cost in an area for the first part and exclusion of observations with zero cost for the second part.

to be ₩35.8 billion (in 2010 won),[8] and the aggregate medical cost of severe obesity was ₩43.6 billion (=0.045*16,716,667*57.9) on average from 2009 to 2013. For female adults aged 20 to 64, the aggregate medical cost of obesity was estimated to be ₩306.5 billion (in 2010 won, =0.246*16,117,986 [average number of females aged 20 to 64 from 2009 to 2013]*77.3) and the aggregate medical cost of severe obesity was ₩95.4 billion (=0.035*16,117,986*169.1) on average from 2009 to 2013.

When comparing males and females, aggregate medical cost for females is much higher than for males. Female costs are higher by a factor of 8.55 times, from ₩35.8 to ₩306.5 billion. Even for aggregate medical cost of severe obesity, females show higher values than males, 2.19 times from ₩43.6 to ₩95.4 billion. These estimated aggregate costs are much lower than those estimated by Lee et al. (2015), who used an epidemiological approach.[9] For the purpose of comparison, under the strict assumption that our estimated marginal effect of obesity based on adults aged 20 to 64 generalizes to the whole population, we used the average number of the whole population from 2009 to 2013 and inflated the estimated costs to 2013 won by the medical care component of Consumer Price Index. The recalculated aggregate medical cost of obesity was ₩55.0 billion for males and ₩486.3 billion for females. These values were still lower than ₩1,142 billion for males and ₩1,952 billion for females in Lee et al. (2015).

We next examine the differential marginal effect of obesity across the distribution of medical cost in Table 5.6. For males, obesity increases medical cost by ₩2,700; ₩7,800; ₩14,800; ₩23,000; and ₩33,700 (in 2010 won) at the 10th, 25th, 50th, 75th, and 90th percentiles of medical cost. For females, obesity increases medical cost by ₩4,100; ₩9,700; ₩23,900; ₩64,400; and ₩216,800 (in 2010 won) at the respective percentiles of medical cost. All are statistically significant at 1%. Therefore, obesity increases medical cost far more for the relatively unhealthy individuals at higher percentiles of medical costs. Similar

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8 It was estimated by (0.397 [obesity rate in Table 5.1]*16,716,667 [average number of males aged 20 to 64 from 2009 to 2013]*₩5,400 [marginal effect of obesity in Table 5.5]).

9 Apart from methodology, Lee et al. (2015) used a different sample, year, and source of data. Lee et al. (2015) used PAF 1 for the estimation of obesity-related medical costs in Korea. They divided obesity into obesity (25 kg/m^2<=BMI<30 kg/m^2) and severe obesity (30<=BMI) and estimated their respective relative risk of incurring diseases (27 diseases for males and 31 diseases for females) in relation to normal weight (18.5 kg/m^2<=BMI<23 kg/m^2). They estimated obesity-related medical costs of ₩1,142 billion (in 2013) for males and ₩1,952 billion for females in the Republic of Korea.

Table 5.6 Marginal Effects of Obesity at Different Percentiles of Medical Cost, 2009–2013 (2010 won)

	10th	25th	50th	75th	90th
Male (209,403)					
Obesity	2.728***	7.813***	14.770***	23.026***	33.700**
	(0.332)	(0.599)	(1.205)	(3.361)	(13.118)
Severe Obesity	3.481***	8.058***	20.824***	40.693***	126.338***
	(0.754)	(1.417)	(2.863)	(7.888)	(31.214)
Female (206,927)					
Obesity	4.134***	9.699***	23.877***	64.407***	216.844***
	(0.654)	(0.997)	(1.845)	(4.757)	(16.302)
Severe Obesity	6.279***	17.218***	42.518***	112.823***	445.886***
	(1.472)	(2.306)	(4.236)	(10.611)	(37.030)

Notes: Age = 20–64 years. Adjusted for smoking, drinking, exercise, 9 dummies for age, 17 dummies for area, 5 dummies for year, 10 dummies for insurance premium, and 4 dummies for insurance type. Standard errors in parenthesis.
* significant at 10%, ** significant at 5%, *** significant at 1%.
Source: National Health Insurance Service-National Sample Cohort database.

to the results in Table 5.5, females show a higher marginal effect of obesity at each percentile of medical cost.[10]

We further examine the association between obesity and disability to provide evidence on another cost of obesity. Lakdawalla et al. (2004) showed not only higher rates of disability among the obese but also higher rates of disability growth among the obese than among the non-obese. Burkhauser and Cawley (2004) found some evidence that obesity increases the probability of health-related work limitations and absenteeism, and Howard and Potter (2014) showed that obesity is related to higher rates of worker absence.

NHIS-NSC database provides data on moderate and severe disability (grades 1–6). Out of 209,403 male adults aged 20 to 64, 5.3% had disability (0.67% having severe disability and 4.64% having moderate

[10] Although not provided in the table, severe obesity increases medical cost by ₩3,500; ₩8,100; ₩20,800; ₩40,700; and ₩126,300. in 2010 won at the respective percentiles of medical cost for males, and it increases medical cost by ₩6,300; ₩17,200; ₩42,500; ₩112,800; and ₩445,900 at the respective percentiles of medical cost for females. All are statistically significant at 1%.

Table 5.7 Effects of Obesity on Disability (Odds Ratio from Logistic Regression), (2009–2013)

	Male		Female	
Obesity	1.032		1.434***	
	(0.021)		(0.039)	
Severe Obesity		1.173***		1.975***
		(0.057)		(0.099)
Number of Observations	209,403	209,403	206,927	206,927

Notes: Age = 20–64 years. Adjusted for smoking, drinking, exercise, 9 dummies for age, 17 dummies for area, 5 dummies for year, 10 dummies for insurance premium, and 4 dummies for insurance type. Robust standard errors in parenthesis.
* significant at 10%, ** significant at 5%, *** significant at 1%.
Source: National Health Insurance Service-National Sample Cohort database.

disability) while out of 206,927 female adults aged 20 to 64, 3% had disability (0.41% having severe disability and 2.57% having moderate disability). The binary outcome of having disability is used in a logistic estimation, controlling for the same risk factors used in the tables above: smoking, drinking, exercise, 9 age categories, 17 area dummies, 5 year dummies, 10 insurance premium dummies, and 4 categories of insurance type dummies.

Table 5.7 presents the odds ratio results obtained from logistic regression models. For males, the adjusted odds ratio between obesity and disability was 1.032 (95% confidence interval: 0.992–1.074), indicating a statistically insignificant positive association between the two. Meanwhile, the odds ratio between severe obesity and disability was 1.173 (95% confidence interval: 1.066–1.291), indicating a statistically significant positive association between the two. For females, the adjusted odds ratio was 1.434 (95% confidence interval: 1.359–1.513) between obesity and disability and it was 1.975 (95% confidence interval: 1.790–2.179) between severe obesity and disability, which were both statistically significant. Similar to medical cost, disability shows a stronger association with obesity or severe obesity among females rather than males.

5.7 Conclusion

Our study shows that obesity and overweight impose a heavy burden on the individual and the Korean economy. Infant obesity rates are higher in females, while differences between gender are seen through the life course: the obesity rate is higher for male than female adults and for the self-employed (including their dependents) than the employed adults (including their dependents). The obesity rate shows a weak U-pattern with income for the employed adults. Obesity has been growing over time especially for males and younger adults, indicating a greater burden in the future.

Our estimates show obesity is associated with higher medical costs of ₩5,000 for male adults and ₩77,000 for female adults. Severe obesity increases medical cost far more than obesity for both males and females, indicating higher cost effects for the few severely obese. Moreover, obesity is shown to have increased medical cost far more for the relatively unhealthy individuals at higher percentiles of medical costs.

When the estimated effects of obesity in increasing medical cost were used to estimate obesity-related aggregate medical cost in the Republic of Korea, it was ₩35.8 billion for males and ₩306.5 billion for females. Furthermore, obesity is positively associated with disability, indicating another cost of obesity. Therefore, obesity is associated with a significant economic burden of medical cost and disability in the Republic of Korea.

However, to the extent that the failure to treat obesity as endogenous leads to underestimation of the links between obesity and medical cost (Cawley and Meyerhoefer 2012) and between obesity and disability (Burkhauser and Cawley 2004), our estimated economic burden of obesity can be underestimated. Without question, a better estimation of obesity's economic burden will help us to develop and prioritize appropriate health interventions to reduce obesity. The Organisation for Economic Co-operation and Development (2010) found that interventions such as health education and promotion, regulation and fiscal measures, and counseling in primary care are all effective in tackling obesity and have favorable cost-effectiveness ratios relative to a scenario where chronic diseases are treated only as they emerge.

Concerned ministries (especially the Ministry of Health and Welfare and Ministry of Education) have introduced many interventions to improve diets and increase physical activity in the Republic of Korea. For example, the Ministry of Health and Welfare provides budget support to local governments' obesity programs, develops educational materials and publicizes them, and provides vouchers for management services of physical activity and diets of obese children. The National School Lunch Act, introduced in 1981, has provisions on school dietitians, nutritional requirements, and dietary consultation. However, such schemes are criticized for lack of inter-ministerial coordination and being focused only on children

(Kim et al. 2009; Lee et al. 2015). Instead, combining interventions under one strategy would provide a more affordable and cost-effective solution, significantly enhancing health gains relative to isolated actions (Organisation for Economic Co-operation and Development 2010).

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Appendixes

Table A5.1 Infant Obesity Rate by Premium Ventile in 2015 (%)

Ventiles	All (1,140,033)	Male (588,332)	Female (551,701)
1	3.7	3.5	3.8
2	3.4	3.3	3.5
3	3.5	3.5	3.6
4	3.3	3.2	3.5
5	3.3	3.2	3.4
6	3.2	3.1	3.4
7	3.2	3.1	3.3
8	2.9	2.7	3
9	2.9	2.7	3.2
10	2.8	2.6	2.9
11	2.7	2.6	2.8
12	2.7	2.6	2.8
13	2.6	2.4	2.8
14	2.6	2.6	2.7
15	2.6	2.5	2.7
16	2.6	2.4	2.8
17	2.6	2.5	2.6
18	2.5	2.5	2.6
19	2.7	2.6	2.7
20	2.5	2.5	2.6

Note: Age = 30–71 months.
Source: National Health Insurance Service (2016).

Table A5.2 Adult Obesity Rate, 1998–2014 (%)

Year	Total	Male	Female
1998	25.8	25.7	25.9
2001	30.3	32.0	29.1
2005	31.4	34.9	27.9
2007	32.1	36.6	27.8
2008	31.0	35.6	26.5
2009	31.9	36.2	27.6
2010	31.4	36.5	26.4
2011	31.9	35.2	28.6
2012	32.8	36.1	29.7
2013	32.5	37.6	27.5
2014	31.5	37.7	25.3

Note: Age >= 19.
Source: Korea National Health and Nutrition Examination Survey, Ministry of Health, Welfare and Family Affairs, the Republic of Korea.

Table A5.3 Young Adult Obesity Rate, 1998–2014 (%)

Year	Total	Male	Female
1998	15.2	19.3	11.6
2001	17.3	25.5	11.0
2005	19.3	24.8	13.4
2007	22.0	31.0	12.6
2008	23.0	31.0	14.1
2009	22.1	29.0	14.3
2010	20.5	28.3	12.1
2011	21.7	26.2	16.9
2012	22.4	30.5	13.6
2013	22.4	29.3	14.4
2014	23.9	32.0	15.0

Note: Age = 19–29 years.
Source: Korea National Health and Nutrition Examination Survey, Ministry of Health, Welfare and Family Affairs, the Republic of Korea.

Table A5.4 Adult Obesity Rate by Premium Decile, 2009–2013 (%)

	Male		Female	
Decile	Self-employed	Employed	Self-employed	Employed
1	39.7	40.2	33.5	27.4
2	38.5	38.9	32.6	24.6
3	38.5	37.1	29.9	23.2
4	38.5	36.6	31.3	21.8
5	40.0	37.1	31.5	20.7
6	40.5	38.3	32.1	21.4
7	42.2	39.0	30.4	21.8
8	42.8	39.9	28.4	22.5
9	42.8	41.5	28.3	22.6
10	44.2	40.5	26.7	21.2

Note: Age = 20–64 years.
Source: National Health Insurance Service-National Sample Cohort database.

6

Obesity in Thailand and its Economic Cost

Yot Teerawattananon and Alia Luz

6.1 Introduction

Thailand is regarded as one of the leading countries in global health (Thaiprayoon and Smith 2014). Overall resources devoted to health care have increased markedly, especially after the introduction of a tax-financed universal health coverage scheme in the 2000s (Limwattananon et al. 2007; Prakongsai et al. 2009). In 2013, the Thai government spent 17% of its annual budget on the health sector, equating to more than 6% of gross domestic product (GDP). Despite these successes, Thailand is now seeing increasing rates of obesity and overweight; its prevalence appears to have grown in line with per capita GDP. In 2014, 33% of males and 43% of females were obese.

Given the potential effect of obesity on the Thai health system, this chapter presents a case study on obesity, exploring its trends (Section 6.2), causes (Section 6.3) and impact including the health problems resulting from this condition, the cost to the health care system of obesity-related illnesses, and the social impact (Section 6.4). Finally, this chapter concludes with policy responses of the government in Section 6.5 and presents the various ways that the country has tackled this issue.

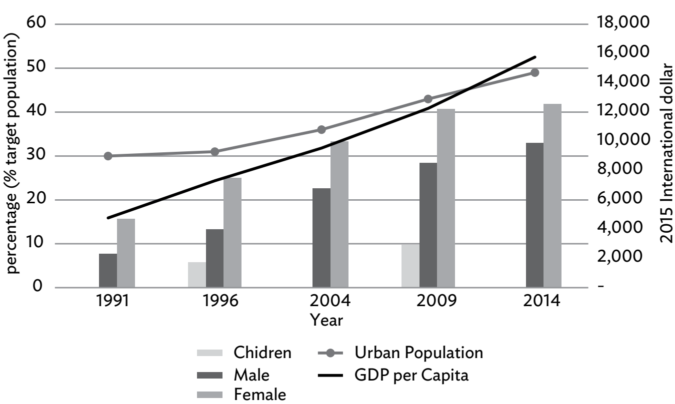
6.2 Data

We draw upon the National Health Examination Survey (NHES), a nationally representative cross-sectional survey using a multistage, stratified sampling of the Thai population that combines interviews and physical examinations. NHES surveys are frequently used in Thailand when assessing epidemiological information about under- or overnutrition as well as key health problems related to nutritional status. So far, it has been conducted five times—in 1991, 1996, 2004, 2009, and 2014—in order to assess the health and nutritional status of adults and children (though children were included only in 1996, 2009, and 2014) (Aekplakorn 2011; Aekplakorn et al. 2014). The fifth survey is under analysis and the results (for the adult part only) given here are preliminary findings.

6.2.1 Overall Trends

Over the 23-year period from the first to the fourth NHES, obesity prevalence in Thailand increased more than 2.5 times (Aekplakorn et al. 2014). Obesity prevalence appears to have grown in line with per capita GDP (see Figure 6.1). This trend is also comparable with the growing number of Thais living in urban areas. In 2009, 41% of female adults, 28% of male adults, and almost 10% of Thai children were obese. In 2014, the survey showed that the prevalence of obesity rose to 33% for males, while the prevalence in females increased to 43%. Thailand has now become one of the countries with the highest prevalence of obesity in Asia (second only to Malaysia), ahead of richer countries such as the Republic of Korea, Japan, and Singapore (Cheong 2014). However, the obesity epidemic in Thailand is still far behind the obesity problems of countries in Europe, the Americas, and Australia.

Figure 6.1 Obesity Prevalence, Gross Domestic Product per Capita, and Percentage of Urban Population in Thailand, 1991–2014



GDP = gross domestic product.

Sources: For obesity prevalence, the 1st, 2nd, 3rd, 4th, and 5th National Health Examination Surveys in Thailand. For % urban population and GDP, the World Bank Indicators and the Poverty and Equity Database (1990–2015).

Although the obesity prevalence is higher in females than males, the prevalence of obesity in males is rising at an alarming rate. In the 1991 and 1996 surveys, the obesity prevalence for females was approximately two times higher than males. After that, the ratio of obese females to males has fallen to 1.5, 1.4, and 1.3 in 2004, 2009, and 2014, respectively.

6.2.2 Age Variation

The fourth NHES illustrated that the prevalence of childhood obesity is highest for children at ages 12–14 years old (7.2%) followed by 1–5 years old (4.6%) and 6–11 years old (3.5%). For adults, the highest prevalence is observed in populations aged 45–59 years (42.4%), followed by 30–44 years (38.4%), 60–69 years (35.6%), 70–79 years (25.5%), 15–29 years (19.5%), and 80+ years (12.8%). This trend is similar for both genders (Aekplakorn et al. 2014).

6.2.3 Rural vs. Urban Areas and Regional Variations

For childhood obesity, Mohsuwan et al. (2011) report that during 1991–2009, for Thai children aged 6–14 years, the prevalence of stunting decreased from 6.6% to 3.7% and the prevalence of being underweight decreased from 8.7% to 4.1%. For urban and rural children, the gap in prevalence for these conditions has decreased over time. Meanwhile, the increase in childhood obesity prevalence has been observed at a higher rate in rural areas as compared to urban areas, although the total prevalence remains higher in urban (13%) compared to rural (8%) areas.

For adults, the prevalence of obesity is higher in urban than in rural areas for both genders. The difference in prevalence between urban and rural is greater in males (36.1% vs. 25.1%) than females (44.9% vs. 38.8%) (Aekplakorn et al. 2014). Bangkok has the highest prevalence of obesity for both males (38.8%) and females (49.4%), followed by the central region (33.3% for males and 44.5% for females), the southern region (27.4% and 44.7%), the northern region (27.5% and 36.3%), and the north-eastern region (22.5% and 39.1%). This obesity trend likely reflects the differences in average income per capita across regions.

6.3 Risk Factors

6.3.1 Child Obesity

Similar to other countries, childhood obesity was given a higher priority in health research in Thailand, with more research addressing etiology and impacts of childhood obesity than other population groups. This may be justifiable given that childhood and adolescent obesity both have immediate and long-term effects on health and well-being. Those who are overweight or obese as children are likely to be obese as adults and/or have more serious adverse consequences later in life.

Skelton et al. (2011) argue that although both nature and nurture can contribute to childhood obesity, the rapid rise in obesity around the globe almost certainly points to behavioral and environmental changes as having a greater impact than genetics or biological reasons. In the paper, they document a number of genetically linked causes, endocrinological disorders, infectious etiologies (e.g., adenovirus or AD36), gut microbiota, and even stress that can increase a child's risk of obesity. However, almost all literature on the subject in relation to Thailand focuses on external factors.

Sakamoto et al. (2001) illustrate a positive relationship between parents' education and household incomes with childhood obesity in Thailand, especially in rural areas. This evidence confirms the stronger influence of systemic mechanisms (or environmental effects) on childhood obesity compared to individual genetic make-up. Nevertheless, the positive relationship contrasts with the results found in developed nations (Sobal and Stunkard 1989). Many studies in high-income countries suggest that lower-income households often have unhealthier food environments than those in wealthy communities (French et al. 2001). With fewer grocery stores and more convenience stores, neighborhood residents in poor communities in high-income countries find it difficult to purchase affordable, healthy foods. However, this situation is likely to be different in developing countries, where sources of energy-dense foods, such as fast foods, are more likely to be located in wealthier communities. Children from households of higher socioeconomic status in Thailand are more likely to consume more total calories as well as a greater proportion of calories from fats and proteins.

The urban-rural obesity prevalence has been an area of focus in many countries, including Thailand. Using data from a demographic surveillance system, Firestone et al. (2011) assess whether urban environments contribute to children's risk of obesity in Thailand. They find that urban residence persists as a risk factor for obesity after adjusting for child characteristics. They also indicate that community wealth concentration and television coverage were strongly associated with risk for obesity. This may be explained by the fact that fast foods are heavily marketed in Thai television. Children living in communities with greater media exposure and easily accessible fast food stores could have a greater consumption of food products with low nutritional value.

With urbanization, children worldwide have increasing access to electronic media, such as computer and video games, mobile phones, and the internet in everyday life. In Thailand, the number of internet cafés that provide online gaming services increased 1.8 times over two years from 2008 to 2010 (Ministry of Culture, Thailand 2012). In addition, more and more Thai children and adolescents own mobile phones. A study by Mo-suwan et al. (2014) analyzing nationally representative health examination survey data among 6–14-year-old children and adolescents found that computer game use for more than an hour a day and television viewing for more than two hours a day is significantly associated with being overweight among girls who spent ≤ 3 days per week in 60 minutes of moderately intense physical activity. However, these sedentary behaviors did not seem to be risk factors for being overweight among Thai boys. Though there are differences in the effects on gender, Mo-suwan et al. state that these behaviors are detrimental to living an active lifestyle in general; time spent on electronic media use not only reduces time allocated to physical activity but also increases the likelihood of consuming fast foods and sweetened beverages.

With the potential for Thai children to have access to unhealthy food at home, they also may be inundated with it in other spheres of life, namely at school. It is very common in Thailand that preschoolers and school students have lunch provided to them at their kindergarten or elementary schools (Yothasamut 2016). All schools receive 10 baht (30 cents) per day per student from the central government, though schools can secure extra budget from the local government and/or voluntary contribution from parents. Because few schools prepare food for students in the school kitchen, most schools procure their meals from external vendors. Nevertheless, the current food procurement system prevents schools from buying food products and meals with the best quality. Rather, schools buy food through consideration of the lowest price in the bidding process. A study by Kai et al. (2008) indicates that dishes offered to children contain a high amount of fat, which are the preferred choice of food by preschoolers and students, and insufficient quantity of vegetables and fruits that are relatively expensive. School teachers hesitate to procure meals and dishes rich with vegetables and fruits for fear of complaints. In addition, many students can buy snacks, sweets, and carbonated drinks from food stalls at the entrance of the schools and sometimes on school grounds (Yothasamut 2016).

In brief, two key factors relevant to childhood and adolescent obesity are the biological factors and social environment surrounding children. Although there is a dearth of literature addressing the former in Thailand, a number of national and international studies reveal the importance of the social environment on childhood and adolescent obesity. These include parents' socioeconomic status, geographical location (rural vs. urban), children's exposure to media promoting unhealthy food and behaviors, marketing and availability of unhealthy foods and beverages, as well as sedentary behaviors.

6.3.2 Adult Obesity

It has long been recognized that childhood or adolescent obesity can lead to adult obesity. Similar to childhood obesity, this may be explained by biological or genetic reasons as well as individual behaviors and environmental factors. Unlike childhood obesity, however, there are a number of social variables that affect adult obesity. Education, income, and occupation cause variations in behavior, thereby changing energy consumption, energy expenditure, and metabolism. These social variables are directly related to adults, not children. Jitnarin et al. (2010) report from a nationally representative household survey that Thai male adults who are older, live in urban areas, have higher annual household income, and who are a non- or former smoker are identified to be at increased risk of overweight and obesity. In addition, Thai female adults who are older, have higher education, are not in a marriage-like relationship, and are in semi-professional occupations are at greater risk of overweight and obesity. The study also shows that Thais aged 46–55 years have the highest risk of being overweight or obese. These findings may be explained by many reasons. First, urbanization can have adverse effects on diets since urban populations tend to consume more energy-dense yet low nutritional value foodstuffs. Urban populations are likely to have less physical activity due to better transportation systems and limited public spaces for exercise. Secondly, Thais aged 46–55 years are at the peak of their career and tend to place a lower priority on the quality of their products and curbing spending habits, including on food and beverages. At the same time, they have less leisure time and lead sedentary lifestyles. Lastly, social norms in Thailand and other Asian communities believe that having heavier weights represents access to more resources, thus equating to health and wealth. There is less social stigma in being fat than in other regions, at least for men.

6.3.3 Elderly Obesity

A nationally representative community survey conducted by the Ministry of Public Health in 2013 found that elderly Thai females are more likely to be obese than their male counterparts (Ministry of Public Health, Thailand 2013). Higher household incomes, higher education levels achieved, and living in urban areas are also risk factors for elderly obesity in Thailand. Although there is strong association between chronic diseases (i.e., hypertension and diabetes) and obesity, the precise mechanisms linking the two conditions remain unclear. Further, there is no clear explanation of inter-individual differences, i.e., the reasons why not all obese elderly individuals develop type 2 diabetes (Eckel et al. 2011). This survey also demonstrates that elderly people with less than 20 natural teeth or less than 4 posterior occluding pairs are unlikely to eat enough vegetables and fruits and therefore are more prone to being obese. In addition, results from the National Health Examination Survey reveal that Thai elderly people are less active as they age.

6.4 Impact

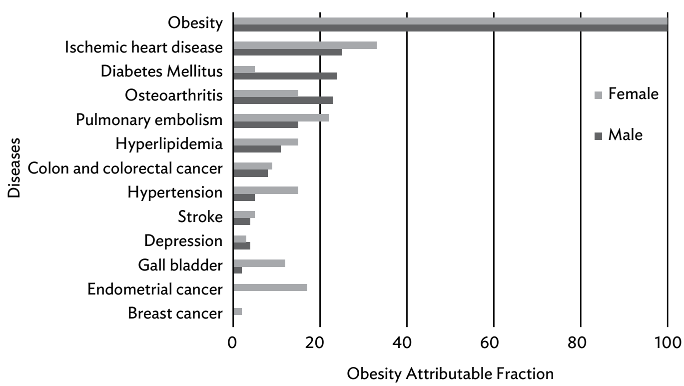
It is not easy to measure the health impact of obesity due to its long-term effects by nature and the involvement of multiple factors in the impact evaluation. Ideally, it requires a well-defined cohort study with a very large sample size that is monitored over a significant number of years, even decades. Using cross-sectional data always poses challenges in interpretation and control of bias. For example, Vapattanawong et al. (2010) assess the relationship between body mass index and mortality among Thai elderly using two large databases: the Vital Registry and the NHES. They find that there are higher mortality rates in people who are underweight, compared to persons with normal weight, and observe a higher magnitude in males compared to females. Being overweight or obese appears to have different effects by gender as a lower risk of mortality was observed in females but not in males. The findings are consistent with several studies in other countries, explaining a lower mortality rate among those with higher body mass index (BMI) measures in very old population groups as opposed to an intuitively expected higher mortality. This is called the “survival effect,” which posits that obese persons may have already died from complications and conditions resulting from obesity, leaving only those who are genetically disposed to or able to tolerate the higher body fat accumulation. In addition, some members of the elderly population with low BMI may have unrecognized illnesses or health problems unrelated to obesity that lead to their higher mortality rates. Some degree of difference in the magnitude of association by gender was found. This may reflect the paradox that obesity is more pronounced in the older Thai females than in males. This example highlights the importance of establishing a longitudinal cohort study with a significant sample size in Thailand. This is not only to have better understanding of the biological, behavioral, and environmental factors contributing to obesity among the Thai population but also to ensure that intervention effectiveness related to obesity is well measured and the results can be used to inform future policy development in tackling the increased epidemic of obesity in the country.

Despite the challenges above, based on case-control studies and epidemiological modeling, this section describes why obesity is so important and what are the health, economic, as well as social implications and impact of the epidemic in Thailand.

6.4.1 Health Impact

Obesity is strongly associated with noncommunicable diseases (NCDs) because it increases the risks of type 2 diabetes and cardiovascular diseases as well as some cancers. These risks have been shown to be reversed with weight loss (Zomer et al. 2016). In Thailand, Pitayatienanan et al. (2014) estimated the health impact of obesity among the Thai population in terms of the obesity attributable fraction, which reflects the proportion of the incidence of comorbidity in the Thai population due to obesity. The results are shown in Figure 6.2. Obesity contributes to 25% of diabetes cases in males and 52% in females. Ischemic heart disease is the second to diabetes in terms of the obesity-attributable fraction, indicating that of ischemic heart disease cases, 25% of cases for males and 33% of cases for females are attributable to obesity. Osteoarthritis and pulmonary embolism are the third and fourth. Obesity contributes

Figure 6.2 Estimated Obesity Attributable Fraction in Selected Diseases in Thailand



Source: Modified from Pitayatienanan et al. (2014).

to a higher proportion of osteoarthritis cases in males (23%) than in females (15%) while it contributes to a higher proportion of pulmonary embolism cases in females (22%) than in males (15%).

Hyperlipidemia is the fifth with 11% of cases in males and 15% of cases in females attributed to obesity. The sixth is hypertension with 5% of cases in males and 15% of cases in females attributed to obesity. There were three cancers included in this study. Two of them are cancers related to the female reproductive organs, namely breast cancer (2%) and endometrial cancer (17%). Colon and colorectal cancer affects both males (with obesity attributable fraction of 8%) and females (with obesity attributable fraction of 9%). There is only one mental health problem included in the analysis. It is estimated that 4% of depression in males and 3% of cases in females are attributable to obesity. While obesity is not a disease, some experts may consider it as such for cases of extreme obesity that significantly hampers daily living and reduces quality of life, prompting the need for surgery.

The data above clearly shows that obesity has a significant impact on quality of life and life expectancy amongst the Thai population, especially given its association to NCDs. The Burden of Disease team of the International Health Policy Program in Thailand reports that NCDs are the most relevant and attributable factor for disability-adjusted life years lost in Thailand. They contribute to 75% or 7.95 million disability-adjusted life years lost in 2013 (Bundhamcharoen 2016). They are by far more significant than infectious diseases, maternal and child health problems, and injuries combined.

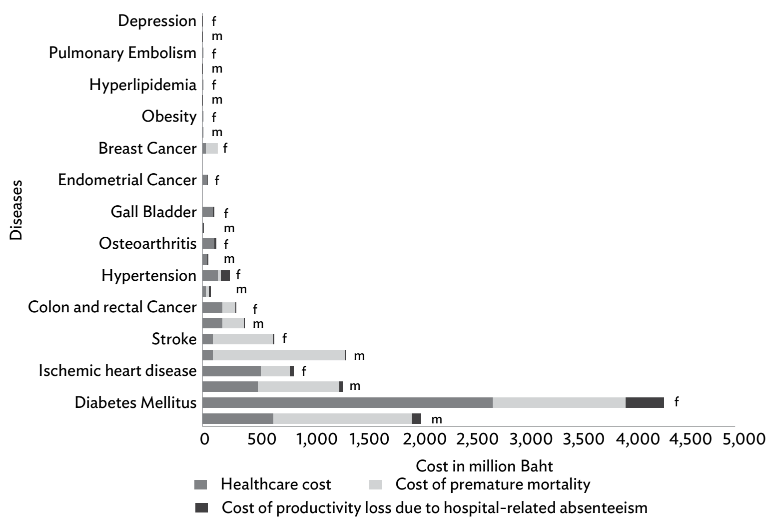
6.4.2 Economic Impact

Obesity requires significant resources in the health sector for treating and caring for patients with obesity-induced health problems. For each comorbidity, the inpatient and outpatient health care costs attributable to obesity can be calculated by multiplying the number of patients in a single year with the given comorbidity with the corresponding obesity-attributable fraction, and the average cost of each comorbidity per person per year. The total health care cost for obesity can be estimated from the sum of all the co-morbidities' total cost. The costs associated with productivity loss due to premature death can be calculated for each comorbidity using, for example, the human capital approach. This approach suggests that the number of deaths attributed to obesity in a given year, disaggregated by age and gender, are multiplied by the average lifetime earnings each person would receive if he or she lived through his or her lifespan (see Box 6.1 for more information on the approach used for cost estimation).

Collaborative research led by the Health Intervention and Technology Assessment Program of the Ministry of Public Health and Mahidol University revealed that obesity generates a considerable cost to Thai society, estimated to be about $404 million or ฿12 billion annually (Pitayatienanan et al. 2014). Among these, 46% or $186 million is due to direct health care cost for both out-patient and in-patient care. The remaining (54% or $218 million) comes from indirect costs including opportunity cost related to premat ure mortality ($195 million or ฿5,864 million) and hospital-related absenteeism ($23 million or ฿694 million).

Figure 6.3 illustrates the economic costs of obesity in Thailand by the type of costs, gender, and comorbidity. Diabetes, ischemic heart disease, stroke, colon and colorectal cancer, and hypertension as a result of obesity are the top five diseases consuming resources from the health care system as well as households in Thailand. Although obese Thai females have higher health care costs than obese males ($134 million vs. $52 million), the cost of premature mortality is higher for obese males than females. This may be explained by the fact that obese Thai males

Figure 6.3 Economic Cost of Obesity in Thailand by Gender, Disease Category, and Cost Component



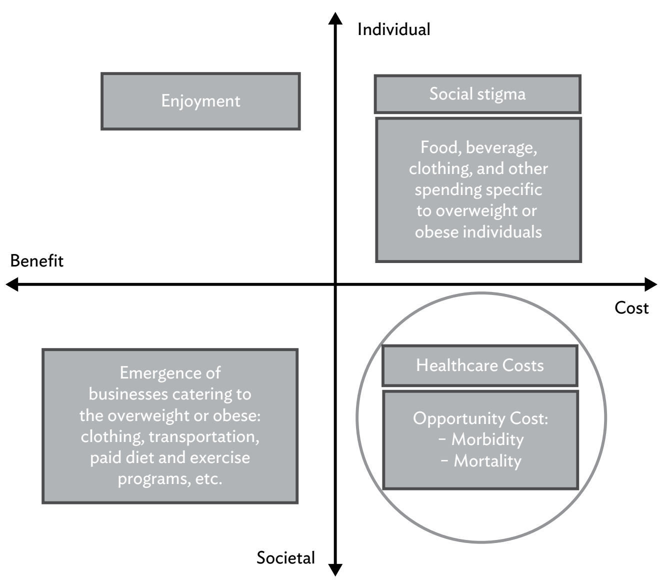
m = male, f = female.
Source: Modified from Pitayatienanan et al. (2014).

usually die at a younger age than obese females and the income earned by Thai males is higher than females.

The economic costs of obesity for Thailand are in line with other studies. Withrow and Alter (2011) conducted an economic study based on a systematic review of the direct costs of obesity in 32 studies from Australia, Brazil, Canada, the People's Republic of China, France, Ireland, Italy, Japan, New Zealand, Sweden, Switzerland, and the United States. They conclude that obese individuals spend approximately 30% more on health care than those with normal weight. They also indicate that obesity accounts for 0.7% to 2.8% of a country's total health expenditure, which is comparable to the Thai study. The Thai study results show that obesity accounts for 1.5% of the national health spending.

Box 6.1 Economic vs. Societal Cost of Obesity: Are They the Same?

Estimating the economic cost of obesity is illustrated in the plane below depicting benefits and costs of both societal and individual perspectives.



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Box 6.1 *continued*

If choice of lifestyle is assumed as the primary cause of obesity—i.e., eating unhealthy food and beverages, inadequate physical activity—then its enjoyment can be taken as a personal benefit. However, this comes at a cost, especially given spending on food, drinks, and products and/or services that may be specific to obese individuals. There is also an opportunity cost to physical inactivity because the time spent on sedentary activities could take away from income generating activities. In addition, obese and overweight individuals may need to account for their size in terms of housing, transportation, clothing, and logistical concerns that in general may cater to the normal sized population.

In terms of societal impact, obesity could generate businesses to cater to this segment of the population. Examples include fast-food chains, sugar-dense beverages, and high calorie foodstuffs; clothing stores catering to oversized individuals; and, paid programs for diet, fitness, and care. However, the societal cost of obesity includes health care costs of treating obesity and obesity-related complications. There is also the opportunity cost of morbidity and premature mortality, including employee presenteeism (reduced worker productivity), and absenteeism (short or long-term absence from work).

The review of literature illustrates that only the last component, namely societal cost, is counted in the economic cost of obesity including the Thai study. This may be due to the individual's costs offsetting the individual gain. On the other hand, the social gains are negligible due to the fact that businesses cater to demands in different markets, such that if there is no demand for obesity-specific products, businesses will turn to other areas. Thus, there is no opportunity lost from the shift from obesity-related business to other markets.

This framework relies on the assumption of a perfect market and free choice for consumers. However, if consumers have limited choices in terms of their consumption of unhealthy food (i.e., unable to afford appropriate food) or their living or work conditions force them to have sedentary lifestyles, then the individual cost may not be offset by the individual gain. Theoretically, in this case, the individual cost should also be included in the economic cost. However, this can be very challenging in practice to justify whose individual cost should be included and how to proportionally include them.

Another criticism on estimating social cost of obesity, especially on opportunity cost from premature mortality, is that if the study applies the human capital approach, the impact can be overestimated. This is because the human capital approach assumes that the economic loss from a person who dies prematurely is equivalent to the loss of their lifetime productivity, which is usually calculated through the estimated income loss from age of death until retirement. Realistically, there is unemployment of some degree, in which case there is potential for that person's productivity loss to be filled in by an unemployed individual. In this case, the opportunity cost is much shorter than the lifetime loss of income, and translates to the training and learning/transition phase of the new employee. This approach is also known as the "friction cost approach."

Source: Prepared by authors.

6.4.3 Social Impact

The social determinants of health, including gender, education, occupation, geographical household location, and income, have been described above as part of the etiology of obesity. This section describes the other direction—how obesity affects or compounds these social factors. The previous section showed how obese individuals are more likely to have obesity-related diseases and poor health, therefore more likely to have higher spending on health care and health-related issues, such as travel costs for seeking care. They also take more leave days from work and have shorter active lives or less productive working years. Nevertheless, from the authors' review of literature, there are no studies aiming to quantify the impact of obesity on these social and economic outcomes. One potential study would be comparing between education spending in households with obese older family members and those without obese family members. Another would be to explore the differences in income, controlling for other factors, of obese and non-obese individuals, especially for those who are self-employed. This type of research should be areas for future exploration to understand further the full impacts of obesity.

Another social impact from obesity is psychosocial consequences. Although, in general, the Thai population has a relatively positive attitude towards obesity, especially for children and adult men (Laung-Ubon 2010), many studies show that the attitudes towards obesity are negative (e.g., several survey participants view it as disgusting; see Box 6.2) for certain groups, particularly women and teenagers, often due to the influence of international celebrities and beauty standards (Tangpaibulsapth 2010). According to many surveys, the majority of high school and university female students view obesity as tremendously undesirable (Chiraponseth 2008; Kitchanapaibul 2012; Tinkajec and Pumwiset 2012). Those who are obese may believe that they are inferior to others and feel (often correctly) that they are the subject of other people's judgmental or damaging discussions. More than half of the respondents in a survey have tried to lose weight (Penprom et al. 2010). Though exercise and fasting are the most prevalent means to lose weight, many believe that the most effective way is medication and treatment in private health facilities, which is now popular and has become a booming industry. In this survey, 12% have used medical interventions. The survey also found that medicines are often dangerous, including amphetamines, diuretics, laxatives, sedatives, etc. Marketing of products such as coffee, tea, and nutritional supplements geared towards weight loss is widespread; many of these products have not been approved by the Thai Food and Drug Administration. As a result, there are often

Box 6.2 The Social Stigma of Obesity in Thailand

Generally, weight is considered to be a natural part of social conversations or interactions in many Asian cultures, including Thailand. While children are considered cute when chubby, there is an opposite and negative reaction to older individuals who are overweight or obese, though there is now pushback on these perceptions. One such example is when a Thai government official posted a photo of an overweight/obese woman working in a gas station on social media with the tagline "News Highlight: I came across a strange and rare creature because it works in shifts. #What an ugly human being? #How dare it be born?" Internet responders condemned his post, prompting the governor of his region to open an investigation and the woman to file charges against him. The official eventually apologized to the woman and the charges were dropped. This anecdote highlights opposing views on what is socially acceptable in terms of body size.

Source: Coconuts Bangkok (2016).

reports of adverse events of these types of products that are being sold through word-of-mouth or online (Kitchanapaibul 2012).

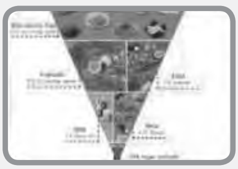
Other studies look at the relationship of obesity with religious beliefs, such as a study on Muslim women in the south of Thailand, where most military personnel are Muslims (Nima et al. 2015). They found that women have a strong conviction that being a good Muslim is reflected in daily living. In their belief, good Muslim practitioners control their diet and desire to eat as well as their physical activity; in this case, obese individuals are considered bad practitioners and face social stigma. This is another area that warrants further exploration.

6.5 Policy Responses

At present, all developed countries have implemented a number of policies for prevention and control of obesity (Popkin et al. 2013). Although there are more obese people living in developing countries than in developed countries, few developing countries have seriously responded to the obesity epidemic with concrete policies. Thailand is one of the developing countries that gradually improved policy support for obesity control. Chavasit et al. (2013) review the historical development of obesity control policies in Thailand in the past two decades. This review focuses only on activities and policies at the national level and excluded pilot studies and community as well as industry initiatives. Further, the authors provide policy updates from 2011, shown in

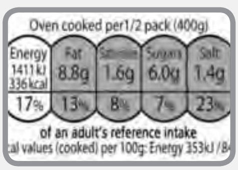
Figure 6.4. Most policies developed in the first decades were initiated by the Thai Ministry of Public Health. Other government authorities, professional communities, and members of civil society have also been active in recent years as the obesity problem has become more evident and the impact of the work of the Thai Health Promotion Foundation (primarily focusing on non-state actors) has become more prominent. There are few national policies and activities related to physical activity, save the recent national campaign in 2015 led by the Crown Prince to promote bicycle use, called "Ride for Mom and Dad," which achieved the world record for the largest number of people riding a bicycle in a public event (Nanuam 2015; Bangkok Post 2015).

Figure 6.4 Historical Development of National Policies or Activities Addressing Obesity in Thailand



1996

- The MOPH endorsed the food-based dietary guidelines and nutrition flag to inform the proper portions of cereals and other complex carbohydrates, fruits, vegetables, animal foods, legumes and pulses, sugar, salt, and fat that should be consumed by Thais daily.



1998

- The MOPH issued "nutrition labeling" recommendations on a voluntary basis except for milk and related products as well as food products that have nutrient claims.

2005

- The MOPH launched a public campaign on meals with "half fruits and vegetables and half others" for daily consumption.

2007

- The Thai FDA and Public Relations Department regulated commercialization of "Foods for Children" by limiting food advertising to children on prime-time television.

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Figure 6.4 *continued*

2009

- Thai public health authorities and local government conducted various national campaigns that promote regular exercise or physical activity, incuding making the world record on 2012 and 2013.
- The Thai National Health Assembly issued a resolution on overweight and obesity resulting in the development of the national action plan to fight against being overweight and obese, which was completed in 2011.

2010

- The modified food-based dietary guidelines were issued.
- "Sweet Enough Network" was established by a group of dentists, pediatricians, and public health workers to endorse regulations to reduce added sugar in food products and campaign against the sale of sugary beverages at schools. One success was the issuance of a national law prohibiting added sugar in follow-up infant formulas.

2011

- The Thai FDA implemented the guidelines for daily amounts for saturated fatty acids, sugar, and sodium on a voluntary basis except for snacks. The interpretation is based on package, not one serving, regardless of package size.

2015

- A public campaign led by the Crown Prince to encourage bicycle use called "Bike for Mom and Dad" on national mother and father's days (12 August and 5 December 2015) was initiated.
- An educational reform: "Moderate Class, More Knowledge" was implemented in state schools to cut class hours and increase extracurricular activities including sports.

FDA = Food and Drug Administration, MOPH = Ministry of Public Health.

Source: Modified from Chavasit et al. (2013).

Zhang et al. (2014) classified five types of food policy to prevent obesity at the national level: i) school focused policy; ii) labeling, packaging, and restaurant focused policy; iii) marketing policy; iv) pricing policy; and v) nutrition education and national dietary guidelines. Each of these five policies is essential in preventing obesity, with advantages and disadvantages depending on the context and country. Countries must find an appropriate and synergic combination of these policies to ensure overall effectiveness. While programs are now in place in Thailand for policy types i, ii, iii, and v (for which, in particular, many policies are already in place), pricing policies have not been touched upon, even though they may have immediate impact.

Food prices are a contentious issue, especially in the context of Thailand, which is a major food exporter. Aside from the obvious need for daily living, food affects all levels of Thai society. Given that 50% of the labor force is concentrated on the agricultural sector, food prices are subject to changes not only from the market but from laborers and consumers as well. The impact of changing food prices on a national policy level is pervasive—from small street sellers to large-scale producers of Thai products to customers. Food industries have long influenced and maintained close ties with policy makers. Given its profit-making drive, industry has a strong incentive to prevent any policies from controlling prices for certain products, e.g., higher prices for unhealthy food or subsidized cost of healthy ones such as fruits and vegetables.

As described above, obesity is not only related to biological factors but is highly affected by social determinants, e.g., gender, occupation, education, urbanization, and socio-economic class. The current policies rarely address these determinants; for example, there is no particular policy focusing on ensuring the access of poor and/or urban areas to healthy food, communication strategies for healthy living targeted towards vulnerable groups, nor workplace policies on food and physical activity. Marketing and pricing policies that have been shown to be effective in other countries to address problems in these social groups are challenging or cannot be implemented properly due to the reasons stated above.

Although noncommunicable diseases incur substantial health care costs that are presently subsidized by the government's health insurance schemes, obesity treatments, including surgical treatments, are not part of the benefits package. These interventions are cost-effective and now included in benefits packages of many countries (Picot et al. 2009). On the contrary, costly treatment interventions for obesity-related health consequences, such as acute coronary syndrome, diabetes, hypertension, osteoarthritis, obesity-related malignancy, or sleep apnea, are included in the health benefits package. This phenomenon reflects Thai attitudes about obesity. One is that obesity is the result of lifestyle choices and eating habits, e.g., preference for unhealthy foods or excessive eating. Another is that obese individuals without diseases are still healthy and therefore do not need treatment. The perspective of wealth equating to more access to resources and food propagates the "fat is rich" ideal. In the private health sector, medical and surgical treatments are often offered at relatively high costs, targeting higher socio-economic classes, many of whom desire to look fit and adhere to prevailing standards of beauty. As a result, the Thai public and government officials may not readily accept the use of public resources and taxpayer monies for obesity treatments, unless the aforementioned attitudes change.

Lastly, there is a lack of policy or program evaluation on obesity prevention and control interventions in Thailand. Decision makers may find it difficult to assess and modify existing policies in order to have greater health gains and allocate more investment for obesity policies due to insufficient data on impact. Many question the effectiveness and value of investment in policies, especially those with opposing views or incentives such as industry. Furthermore, the most useful nationally representative data sources—the National Health Examination Survey and the National Survey on Food and Nutrition—are conducted only every five years and may not provide timely information for policy impact measures. Investment in surveillance, research, and program evaluation is urgently needed in Thailand.

6.6 Conclusion

Obesity contributes to significant health problems, as well as negative economic impact, in Thailand; noncommunicable diseases are by far the major cause of death and disabilities. The economic burden of obesity is $404 million annually, equivalent to 0.13% of Thailand's gross domestic product.

The etiology of obesity is complex, involves multiple factors, and is context-specific. Genetics and biology are uncontrollable factors. Although individual behaviors, socio-economic factors, and environmental factors are modifiable, there is no evidence on highly effective measures to control them. As a result, all developed and developing countries are dealing with similar challenges.

Developing countries are lagging behind developed countries in terms of their policy responses to obesity, despite the sharp increase of obesity prevalence observed in recent years. Like other countries, Thailand's obesity policies focus on nutrition and physical activity education and setting national standards, while food marketing or pricing policies are rarely introduced. This may reflect the strong influence of food industries that act against such interventions. In addition, it highlights the need for more investment in obesity research as well as monitoring and evaluation of obesity policy.

With a robust civil society, strong public health authorities (including the Thai Health Promotion Foundation, which has both financial power and leadership in health promotion), and good health care infrastructure, Thailand has the potential to eradicate the obesity epidemic. It is highly encouraging that in 2016, the health minister himself took leadership and focused efforts on the issue by initiating a project called "Ministry of Public Health's Executives without a Big Belly," encouraging all top leaders of the Thai Ministry of Public Health and other public health authorities to maintain BMIs below 25 kg/m (Ministry of Public Health, Thailand 2016). However, obesity is not only controlled by the health sector. It remains to be seen how leadership in the health sector can influence overall government policy and support the public to tackle obesity and overweight.

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7

Health and Economic Burden of Overweight and Obesity in Indonesia

Soewarta Kosen

7.1 Background

High body mass index (BMI) contributed to 4 million deaths globally in 2015, more than two-thirds of which were due to cardiovascular disease (Global Burden of Disease 2015 Obesity Collaborators). Although economic growth and urbanization have reduced food insecurity and improved quality of life, they have also provided access to low cost and low nutrient foods that are high in energy, and people have increased the consumption of refined grains, red and processed meats, unhealthful fats, and sugar-sweetened beverages, which are all associated with weight gain (Malik and Hu 2016). Modernization, urbanization, economic development, and increased wealth have led to predictable shifts in diet, referred to as the nutrition transition.

In Indonesia, the trend of rising overweight and obesity is reflected in the results of the Basic Health Survey, a national community-based survey that measured BMI in 2007, 2010, and 2013. Prevalence of a BMI higher than 25 kilograms per meters squared among males aged more than 18 years was 13.9% in 2007, 14.8% in 2010, and 19.7% in 2013; and for females aged 18 years and above the prevalence of the same BMI was 13.9% in 2007, 15.5% in 2010, and 32.9% in 2013. The increased prevalence was more prominent among females compared with males (National Institute of Health Research and Development 2013).

High BMI is a major risk factor for noncommunicable diseases such as cardiovascular diseases (mainly ischemic heart disease and stroke), diabetes (type 2), musculoskeletal disorders (especially osteoarthritis, a highly disabling degenerative disease of the joints), gout, gall-bladder disease, asthma, low back and neck pain, and chronic kidney disease as well as some cancers (breast, liver, and esophagus). The risk for these noncommunicable diseases increases as BMI increases. Childhood obesity is also associated with a higher chance of obesity, premature death, and disability in adulthood. Obese children may experience breathing difficulties, increased risk of fractures, hypertension, cardiovascular disease, insulin resistance, and psychological effects (World Health Organization 2016).

This chapter adds to recent literature on obesity in Indonesia. Roeming and Qaim (2012) find that changing food consumption patterns coupled with decreasing levels of physical activity are important determinants of BMI and directly contribute to the rising trend of obesity in Indonesia. Hanandita and Tampubolon (2015) find that the income inequality accompanying Indonesia's economic growth may aggravate the dual burden of under- and overnutrition. Finally, Aizawa and Helble (2017) analyze the transition of socioeconomic-related excess weight disparity, including overweight and obesity from 1993 to 2014, using the Indonesian Family Life Survey. Their results show that the proportion of overweight and obese people increased rapidly in the entire population, but poorer groups showed stronger trends. In this chapter, I estimate the health and economic burden of overweight and obesity by calculating costs (direct and indirect) attributed to overweight and obesity in Indonesia in 2016. This is the first effort to estimate the costs of overweight and obesity-attributable diseases in Indonesia by applying the global burden of disease method.

7.2 Data and Methodology

The data for this study is provided by the National Institute of Health Research and Development. Indonesia collects anthropometric data at national, provincial, and city/district levels periodically through the Basic Health Research (Ministry of Health 2014). Additionally, health offices at various levels conduct routine nutrition surveillance and collect anthropometric measurements (weight and height).

7.2.1 Cost of Illness Approach

The majority of studies costing overweight and obesity and most economic literature costing disease and injuries adopt the cost of illness approach (Drummond 1992; Hodgson 1983, 1994; Rice 2000). This approach analyzes the impact of illness from a macroeconomic perspective by aggregating several dimensions. The economic consequences of illness consist of (i) the expenses incurred because of the illness plus other related indirect costs and (ii) the value of loss of productivity due to reduced or lost working time.

The cost of illness approach does not include the impact on welfare and leisure time. It does not capture the long-term dynamic impact of disease on changes in demographic composition, or reduced resources for investing in financial and human capital formation. Thus, it provides a static and only partial estimate of the total macroeconomic impact of disease. A more complete measure of the economic impact of overweight and obesity would include factors such as the loss of life and productive years as well as the financial burden on overweight and obese people and their families, providers of their health care and insurance, and their employers.

7.2.2 Direct Costs of Overweight and Obesity

Direct costs represent the monetary value of goods and services consumed because of overweight and obesity-related illness, and for which a payment is made. Some direct costs result from the use of health care services (medical expenditures including hospitalizations, physician services, home health care, medications, and services of other health care providers due to the treatment of overweight and obesity related diseases), medical supplies, and equipment. Other costs are related to non-health care costs (including transportation to reach health care providers and care-giving by non-health providers such as family members); in this analysis we exclude the non-health care costs as they are not available for Indonesia. Two main approaches can be used to estimate the direct costs of overweight and obesity: disease episode (annual cost approach) and lifetime cost approach.

7.2.3 Indirect Costs of Overweight and Obesity

Morbidity Costs

Morbidity costs are an indirect cost representing the value of lost productivity by persons who are ill or disabled from overweight and obesity related diseases. An ill person may be unable to work their usual job or perform usual housekeeping and childcare activities. Morbidity costs are estimated by determining what a person would have been able to earn (performing paid labor), and by estimating a value for lost productivity.

Mortality Costs

A person has an increased probability of dying from diseases linked to overweight and obesity. The value of lives lost is known as the mortality cost and can be measured using the human capital approach, which values life according to what an individual produces, or the willingness to-pay approach, which values life according to what someone would pay to avoid illness or death.

Another measure of the value of lives lost prematurely is the potential years of life lost (PYLL). PYLL denotes the number of years an individual would have lived had they not died of overweight and obesity-attributable diseases. The PYLL is determined by the number of years of life expectancy remaining at the age of death.

Global Burden of Disease Method: Disability-Adjusted Life Years

The disability-adjusted life year (DALY) (Murray and Lopez 1997) incorporates both the impact of overweight and obesity-related illness and disability and premature death, i.e., the qualitative and quantitative aspects of illness, by combining them into one measure. The DALY is defined as years of healthy life lost. Years of healthy life lost due to living with a disability are the product of the number of cases of disease, duration of each case, and a disability weight that reflects the degree of disability. Disability weights have been developed to be used with years lived with a specific illness, incorporating data from several countries, including Indonesia.

Potential years of life lost from premature death are determined by comparing age at death with the expected life expectancy of Indonesians. The mortality component of the DALY is similar to the PYLL.

The DALY is based on the premise that the best approach for measuring the burden of disease is to use units of time. Having chosen time as the unit of measure, the burden of disease can be calculated using incidence or prevalence measures. Time lost due to premature mortality is a function of the death rate and the duration of life lost due to a death at each age. Because death rates are incidence rates, there is no obvious alternative for mortality than to use an incidence perspective.

In contrast, for non-fatal health outcomes, both incidence and prevalence measures have been routinely used. Thus, it is possible to calculate the number of healthy years of life lost because of people living with disease, in terms of prevalent cases of disease in the population in the year of interest, or in terms of the incident stream of healthy years of life lost into the future for cases of the disease in the year of interest.

The DALY measures the gap between the actual health status of a population and some "ideal" or reference status, using time as the measure. In developing the DALY indicator, two key value choices were identified: (i) how long "should" people in good health expect to live? (ii) How should we compare years of life lost through death, with years lived with poor health or disability of various levels of severity?

There are at least two ways of measuring the aggregate time lived with a disability. One method is to take point prevalence measures of disability, adjusting for seasonal variation if present, and express them as an annual prevalence. The alternative is to measure the incidence of disabilities and the average duration of each disability. The product of the incidence and the duration will then provide an estimate of the total time lived with disability. This is the approach used for the DALY.

To estimate years of life lost due to disability for a population, the number of disability cases is multiplied by the average duration of the disease and a weight factor that reflects the severity of the disease on a scale from 0 (perfect health) to 1 (dead) (Murray and Lopez 1996).

DALY = YLL + YLD

YLL = years of life lost due to premature mortality

Years of life lost (YLL): Years lost due to premature mortality. YLL are calculated by subtracting the age at which a person dies from the longest possible life expectancy for a person at that age, then adding up the instances of premature death across a population.

YLD = years of life lost due to disability

Years lived with disability (YLD): Years lost to less-than-ideal health. YLD incorporates both the length of time people experience a disability—defined as any cause of non-fatal health loss—and the severity of that disability. That means YLD measures both long-term, chronic causes of ill health, such as low back pain, and short-term, acute instances of illness, such as a case of appendicitis.

Disability-adjusted life year (DALY): Total health loss due to both premature death (YLL) and nonfatal causes of ill health (YLD). DALYs are the sum of YLL and YLD. Therefore, they capture the combined effect, in terms of mortality (death) and morbidity (non-fatal illness), of any given cause of health loss within a population.

The calculation is as follows (World Health Organization 2001).

$$\text{YLLi} = \frac{KCe^{ra}}{(r+\beta r)^2} \times \left[e^{-(\beta+r)(L+a)} \times (r+\beta r) \times \left((L+a)-1\right) - e^{-(r+\beta r)a} \times \left((-(r+\beta r)(a-1)\right)\right] + \left[\left(\frac{1-K}{r}\right)(1-e^{-rL})\right]$$

where

i = condition or type of disease
e = base of the system of natural logarithms, approximately 2.71828
r = discount rate (r = 0.03)
C = age-weighting correction constant (C = 1)
β = parameter from the age-weighting function
K = age-weighting modulation factor
a = age of death
L = standard expectation of life at age a

$$\text{YLDi} = D\left\{\frac{KCe^{ra}}{(r+\beta)^2}\left[e^{-(r+\beta)(L+a)}[-(r+\beta)(L+a)-1]e^{-(r+\beta)a}\right.\right.$$
$$\left.\left.[-(r+\beta)a-1]\right]+\frac{1-K}{r}(1-e^{-rL})\right\}$$

where

i = the condition or type of disease
e = base of the system of natural logarithms, approximately 2.71828
a = age of onset of the disability
L = duration of disability
r = discount rate (r = 0.03)
β = parameter from the age-weighting function
K = age-weighting modulation factor
C = adjustment constant necessary because of unequal age weights
D = disability weights: number on a scale from 0 to 1 that represents the severity of health loss associated with a health state (Institute for Health Metrics and Evaluation 2013)

7.3 Results

Table 7.1 shows the total number of cases with 12 diseases attributed to overweight and obesity in 2015 (approximately 1,997,385), with names of diseases, population-attributable risk due to overweight and obesity, and cost of hospitalization per episode per case.

Table 7.2 shows the number of deaths attributed to diseases related to overweight and obesity in 2016 (102,792 deaths).

Table 7.1 Overweight and Obesity-Related Diseases, Population-Attributable Risk, Unit Cost Per Episode, 2015

Disease	Population-Attributable Risk Due to Overweight-Obesity	Cost of Hospitalization Per Episode Per Case (Rupiah)	Total Number of Cases
Ischemic heart disease	**18.11**	5,552,200	36,000
Hypertensive heart disease	**34.59**	2,586,100	24,000
Stroke	**25.55**	8,049,900	51,270
Diabetes	**46.74**	5,702,300	76,450
Chronic kidney disease	**20.38**	5,178,100	2,050
Esophageal cancer	**14.6**	8,124,300	950
Liver cancer	**9.43**	7,378,900	260
Gall bladder and biliary tract disease	**24.36**	5,732,800	110
Breast cancer	**13.68**	8,124,300	4700
Osteoarthritis	**14.57**	4,894,100	5,300
Low back and neck pain	**3.17**	6,009,100	3,900
Asthma	**13.97**	3,459,800	82,030
Total cases			**1,997,385**

Source: Author's calculation using Global Burden of Disease population-attributable risk, Indonesian epidemiological data and disease costs (Murray and Lopez 1996; World Health Organization 2001; Ministry of Health 2016).

Table 7.3 shows the total productive years lost in Indonesia due to morbidity, disability, and premature mortality from high BMI-related diseases in 2016 was just over 7 million DALYs. With gross domestic product per capita of Indonesia in 2016 of $5,660 (International Monetary Fund 2017), the total indirect cost due to overweight and obesity in 2016 was $28.3 billion, equal to Rp368.3 trillion.[1]

Medical expenditures include hospital costs (in-patient services) based on the standard tariff of the National Health Insurance in a Class B Hospital (Region 1, that is, provinces in Jawa Island) and out-patient services in primary care and secondary care facilities.

1 $1 = Rp13,000. Due to rounding, conversion may not be exact.

Table 7.2 Number and Proportion of Deaths Attributable to Overweight and Obesity, 2016

	Total Deaths	Attributed to High BMI (%)	Attributed to High BMI (Number)
Ischemic heart disease	305,490	13.62	41,608
Hypertensive heart disease	33,320	27.3	9,096
Stroke	235,450	17.75	41,792
Diabetes	2,328	37.97	884
Chronic kidney disease	4,298	20.49	881
Esophageal cancer	2,704	13.01	352
Liver cancer	1,344	8.46	114
Gall bladder and biliary tract disease	4,590	20.92	960
Breast cancer	18,190	13.9	2,528
Osteoarthritis	0	NA	NA
Low back and neck pain	0	NA	NA
Asthma	36,380	12.58	4,577
Total cases			**102,792**

BMI = body mass index.
Source: Author's calculation using Global Burden of Disease parameters for attributable death (Murray and Lopez 1996).

Table 7.3 Productive Years Lost Due to Diseases Attributed to Overweight and Obesity, 2016

Disease	Percent from Total DALYs Lost	Percent Attributed to Overweight and Obesity	DALYs Lost
Ischemic heart disease	8.98	18.11	1,170,920
Hypertensive heart disease	0.96	34.59	239,086
Stroke	7.13	25.55	1,311,635
Diabetes	4.61	46.74	1,551,394
Chronic kidney disease	1.72	20.38	252,386
Esophageal cancer	0.06	14.60	6,728
Liver cancer	0.38	9.43	25,800
Gall bladder and biliary tract disease	0.13	24.36	22,801
Breast cancer	0.78	13.68	76,827

continued on next page

Table 7.3 *continued*

Disease	Percent from Total DALYs Lost	Percent Attributed to Overweight and Obesity	DALYs Lost
Osteoarthritis	0.59	14.57	61,893
Low back and neck pain	3.91	3.17	89,242
Asthma	1.95	13.97	196,139
Total DALYs lost:			**5,004,851**

DALY = disability-adjusted life year.
Note: Total DALYs (productive years) lost in Indonesia from all causes in 2016 is estimated at 72,000,000.
Source: Author's calculation using Global Burden of Disease attributable risk, Indonesian epidemiological data and disease costs (Murray and Lopez 1997).

Table 7.4 shows that total medical expenditures of in-patients due to overweight and obesity-related diseases in Indonesia in 2016 was about 1.5 trillion rupiah ($115.6 million).

Table 7.4 Total Medical Expenditures (In-Patients) of Overweight and Obesity-Attributable Diseases, 2015 (rupiah)

Disease	Total Cases	Cost Per Episode	Total Cost
Ischemic heart disease	36,000	5,552,200	199.87 billion
Hypertensive heart disease	24,000	2,586,100	62.06 billion
Stroke	51,270	8,049,900	412 billion
Diabetes	76,450	5,702,300	435 billion
Chronic kidney disease	2,050	5,178,100	10.61 billion
Esophageal cancer	950	8,124,300	7.71billion
Liver cancer	260	7,378,900	1.91 billion
Gall bladder and biliary tract disease	110	5,732,800	630.60 million
Breast cancer	4700	8,124,300	38.18 billion
Osteoarthritis	5,300	4,894,100	25.93 billion
Low back and neck pain	3,900	6,009,100	23.43 billion
Asthma	82,030	3,459,800	283.80 billion
Total expenditures			**1.502 trillion**

Source: Author's calculation using Indonesian epidemiological data and disease costs (Ministry of Health 2016).

Table 7.5 shows the total medical expenditures of out-patient services for diseases attributable to overweight and obesity: about Rp14.4 billion ($1.1 million). I estimate that in 2016, the total macroeconomic loss due to overweight and obesity was in the amount of Rp369.7 trillion ($28.4 billion), which includes total medical expenditures for in-patient services (Rp1.5 trillion or $115.6 million), total medical expenditures for out-patient services (Rp14.4 billion or $1.1 million), and the total indirect costs (loss of productivity/DALYs lost, Rp368.3 trillion or $28.3 million).

Table 7.5 Total Medical Expenditures (Out-Patient Services) of Overweight and Obesity-Attributable Diseases, 2016 (Rp)

Disease	Total Cases	Cost Per Episode	Total Cost
Ischemic heart disease	36,000	50,000	1.80 billion
Hypertensive heart disease	24,000	50,000	1.20 billion
Stroke	51,270	50,000	2.56 billion
Diabetes	76,450	50,000	3.82 billion
Chronic kidney disease	2,050	50,000	102.50 million
Esophageal cancer	950	50,000	47.50 million
Liver cancer	260	50,000	13.00 million
Gall bladder and biliary tract disease	110	50,000	5.50 million
Breast cancer	4700	50,000	235.00 million
Osteoarthritis	5,300	50,000	265.00 million
Low back and neck pain	3,900	50,000	195.00 million
Asthma	82,030	50,000	4.10 billion
Total expenditures			**14,350 billion**

Source: Author's calculation using Indonesian epidemiological data and disease costs (Ministry of Health 2016).

The total health sector budget in 2016 was about Rp60 trillion, so the proportion of total direct medical expenditures due to overweight and obesity from the total health sector budget was about 2.52%. If compared with the Indonesian gross domestic product in 2016 ($932.3 billion), the proportion of total macroeconomic loss due to overweight and obesity in 2016 was 3.04%.

7.4 Discussion and Conclusion

The analysis shows that the prevalence rate and the attributable disease burden of high BMI is quite significant in Indonesia. Obesity-related diseases may drain health care resources, and this is reflected in the increasing financial deficits of the Indonesian social health insurance system (Badan Penyelenggara Jaminan Sosial Kesehatan).

Public policy and supportive environments should be created to promote consumption of a variety of low-fat, high-fiber food, and opportunities for regular physical activity in work places and residences. Programs to promote healthy behavior enable individuals to lose weight by eating more fruits and vegetables as well as nuts and whole grains; engaging in daily moderate physical activity for at least 30 minutes; cutting the amount of fatty, sugary foods in the diet; moving from saturated animal-based fats to unsaturated vegetable oil-based fats. Other efforts include provision of a clinical response to the existing burden of obesity and associated disease conditions. Similar advice is given in McKinsey Global Institute (2014). Malik and Hu (2016) suggest taxes on unhealthy foods and beverages, front-of-package nutritional labeling, reduction of advertising of junk food and beverages to children, school-based education programs to reduce television viewing, reduced consumption of sugar-sweetened beverages, and school-based programs of physical activity. However, the Institute of Health Metrics and Evaluation argues that targeting sugar and fat components of diets may have a comparative smaller effect than promotion of increased uptake of vegetables, fruit, whole grains, nuts and seeds, and seafood omega-3 fatty acids (Global Burden of Disease 2015 Risk Factors Collaborators 2016).

Strong leadership is needed to more effectively intervene against major determinants of overweight and obesity, including limiting excessive caloric intake, encouraging physical activity, and curtailing ready-made and unhealthy food industries. Extensive and effective nutrition education should be developed and targeted to the general public, food industry, academics, and government officials. National regulations must heed advice and reduce extensive marketing of food high in fats, trans-fatty acids, free sugars, or salt, in accordance with the World Health Assembly resolution WHA63.14.

In 2018, the Indonesian Ministry of Industry plans to introduce regulations for reducing the contents of sugar, salt, and fat in food in response to the growing concern about rising overweight and obesity. The form of the sugar taxes is still being discussed and there are suggestions to include an excise tax. This will include introducing a sugar levy on soft drinks. The government of Indonesia also needs to promote standard surveillance methods as well as periodically monitor the results of nutrition-related surveys. The government needs to fully implement the current policies on the promotion of healthy eating, support of public transport, and provision of public green space and sidewalks. Additionally, urban planning should include bike lanes, wide pavements, and pedestrian precincts. As the global health community works to develop treatment and prevention policies to address overweight and obesity, timely information about levels of high BMI and their trends as well as the health impacts at the population level are needed for policy input. Interventions should be prioritized according to impact, cost-effectiveness, and feasibility.

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8

The Imminent Obesity Crisis in Asia and the Pacific: First Cost Estimates

Matthias Helble and Kris Francisco

8.1 Introduction

Whereas the prevalence, determinants, and consequences of overweight and obesity are well understood, the economic costs of overweight and obesity remain unknown for many developing countries in Asia and the Pacific.[1] Substantive research efforts have been undertaken to estimate the costs of overweight and obesity in developed countries like the United States (US) or Europe (e.g., Lehnert et al. 2013; Konnopka et al. 2011; Yach et al. 2006; Allison et al. 1999; Wolf and Colditz 1998; Seidell 1995). In the US the most recent studies estimate that every obese person spends approximately $2,741 per year in additional health care costs (Cawley and Meyerhoefer 2012). For Japan, the most recent estimates show a similar amount with $1,537 (Nakamura et al. 2007). Furthermore, due to higher rates of absenteeism and lower productivity at work, overweight and obesity are estimated to cost US business up to $66 billion annually (Hammond and Levine 2010). Similar numbers are known for European

1 The economies included in our analyses are the 42 member countries of the Asian Development Bank (ADB). We used Japan as our reference country in our direct cost estimation. We follow ADB's classification of subregions in our discussions: Armenia, Azerbaijan, Georgia, Kazakhstan, Kyrgyz Republic, Tajikistan, Turkmenistan, and Uzbekistan are classified under the Central Asia subregion. The People's Republic of China; Republic of Korea; Japan; Mongolia; and Taipei,China are classified under the East Asia subregion. Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan, and Sri Lanka are classified under the South Asia subregion. Brunei Darussalam, Cambodia, Indonesia, Lao People's Democratic Republic, Malaysia, Myanmar, Philippines, Singapore, Thailand, and Viet Nam are classified under the Southeast Asia subregion. Fiji, Papua New Guinea, Solomon Islands, Timor-Leste, Vanuatu, Palau, Marshall Islands, Micronesia, Samoa, Tonga, and Kiribati are classified under the Pacific subregion.

countries. In Germany, the additional medical costs are estimated to be 3.27% of health care expenditures (Lehnert et al. 2014).

Even though Asia and the Pacific has the largest number of overweight and obese patients, the cost of the condition is largely unknown. To our knowledge the number of countries for which cost estimates are available is very limited. We were able to find estimates for five Asian economies—Japan; Republic of Korea; the People's Republic of China (PRC); Taipei,China; and Thailand. We review these in Section 8.2 of this chapter. Section 8.3 will discuss the main findings of these studies. Given this gap in the literature, the main objective of this chapter is to develop a first cost estimate of overweight and obesity for the entire Asia and the Pacific region.

8.2 Existing Cost-of-Illness Studies for Asia

While the rapidly increasing prevalence of overweight and obesity in Asia and the Pacific is alarming, the literature on estimating the equivalent economic cost remains fairly limited. We retrieved four previous cost estimation studies on Japan that utilized a population-based prospective cohort study. In the studies of Kuriyama et al. (2002), Kuriyama et al. (2004), Ohmori-Matsuda et al. (2007), and Nakamura et al. (2007), information about the health and lifestyles of the participants were gathered as the baseline. The medical utilization and cost for each participant are then monitored over several years, based on their claim history files of the Japanese National Health Insurance. Kuriyama et al. (2002), Kuriyama et al. (2004), and Ohmori-Matsuda et al. (2007) used the data from the survey of beneficiaries of the National Health Insurance aged 40–79 years in Miyagi Prefecture, Japan, while Nakamura et al. (2007) used data from the survey of beneficiaries of the National Health Insurance aged 40–69 years in Shiga Prefecture, Japan. From these surveys, the monthly per person health care charges of different body mass index (BMI) categories were examined through analysis of covariance. Consistently, the four studies found that participants with BMI greater than 25 kilograms per meters squared incur higher per person medical cost as compared to participants with lower BMI. We will discuss their precise estimates in Section 8.4.

In addition, several other studies have estimated the economic burden of overweight and obesity in other parts of Asia. For instance, Zhao et al. (2008) estimated that the total direct annual cost of chronic diseases caused by overweight and obesity in the PRC amounted to $2.74 billion in 2003. This is equivalent to 3.7% of the total national medical cost for that year. Likewise, Ko (2008) estimated both direct and indirect cost related to overweight and obesity in a representative district hospital in Hong Kong, China. He noted that the annual cost amounted to $0.29 billion in 1998 and $0.43 billion in 2002, equivalent to around 8.2% to 9.8% of the total public expenditure on health in those years, respectively, in Hong Kong, China. Both the studies by Zhao et al. (2008) and Ko (2008) utilized the population-attributable fraction approach wherein the estimates reflect the extent to which a certain disease as well as the management cost related to that disease is attributable to a single factor.

Other studies estimated the economic burden of obesity in Korean adults. For example, Kang et al. (2011) estimated both the direct and indirect costs and gauge the economic burden reaching $1,787 million, which is about 3.7% of total health care expenditure. Similar to the studies of Zhao et al. (2008) and Ko (2008), Kang et al. (2011) also employed the population-attributable fraction approach with the aid of nationally representative surveys such as the National Health Insurance Corporation cohort survey and the 2005 Korea National Health and Nutrition Examination Survey.

In a similar vein, Fu et al. (2008) estimated the direct cost of obesity in Taipei,China using individual data sourced from the Cardiovascular Disease Risk Factors Two-Township Study survey and utilization data from the Bureau of National Health Insurance. This study likewise adopted the prevalence-based and population-attributable risk approach for six kinds of obesity-related metabolic syndrome diseases. The estimated cost of obesity amounted to about 2.9% of the national health care expenditure in Taipei,China. Correspondingly, Pitayatienanan et al. (2014) used the Obesity-Attributable Fraction in estimating the economic burden in Thailand. Aside from estimating the health care cost incurred by individuals, this study also estimated the cost of productivity loss due to premature mortality and the cost of productivity loss due to hospital-related absenteeism by adopting a human capital approach. The total cost of obesity in Thailand was estimated at $725.3 million or about 1.5% of Thailand's national health expenditure and about 0.13% of its gross domestic product (GDP). Moreover, it was noted that 54% of this cost can be attributed to the loss in productivity due to obesity.

8.3 Data on Overweight and Obesity in Asia and the Pacific

8.3.1 Overweight and Obesity Data

The main data used in this chapter comes from the Institute for Health Metrics and Evaluation at the University of Washington. Due to the lack of trend data for the prevalence of overweight and obesity in many lower- and middle-income countries, the Institute for Health Metrics and Evaluation developed a model-based approach to produce country-level estimates that are based on nationally-representative surveys, reports, and published studies that included data for height and weight. To estimate the prevalence data on obesity and overweight by age, sex, country, and year, the Institute for Health Metrics and Evaluation employs a spatiotemporal Gaussian process regression model with a 95% confidence interval. The estimation bias for the self-reported height and weight were corrected using mixed-effect linear regression. In our study, we utilized data on country-specific prevalence of BMI greater than or equal to 25 kilograms per meters squared for both males and females.

8.3.2 Other Data

To match the data we collected from the Institute for Health Metrics and Evaluation, we gathered other information from several data sources. The data for male, female, and total population were downloaded from the United Nations Population Division "World Population Prospects: The 2015 Revision" (United Nations 2015) while the data on total health care expenditure, consumer price index, and official exchange rate were downloaded from the World Development Indicators database of the World Bank (World Bank 2016). Based on the metadata of the World Bank, the total health care expenditure is defined as the sum of public and private health expenditure. This includes activities related to health care, family planning, nutrition, and emergency aid. On the other hand, the consumer price index reflects the period average of the changes in the cost of acquiring a basket of goods and services for an average consumer. The Laspeyres formula was used to calculate this indicator. Meanwhile, the official exchange rate is calculated as the annual average of monthly exchange rate data for the local currency unit relative to the US dollar.

Additionally, we included data on the GDP and GDP per capita of each economy. These data were downloaded from the World Economic Outlook database (October 2016) of the International Monetary Fund (International Monetary Fund 2016).[2] Lastly, we collected information on the comparative prices of medical procedures in Asia. Although data

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2 As explained on the World Economic Outlook website, the expenditure-based GDP that was used in our estimation was computed by subtracting the free on board value of imports of goods and services from the total final expenditures at purchasers' prices (including the free on board value of exports of goods and services). The computed GDP in local currency was then translated to US dollars using the yearly average of the market exchange rate. Meanwhile, GDP per capita was derived by dividing the converted GDP by the total population for that year.

on medical prices are relatively scarce, we obtained several comparative tables on prices of medical procedures in different Asian countries from several websites that promote medical tourism.[3] We used the comparative prices of heart bypass and angioplasty, as these procedures are commonly performed on overweight and obese individuals with high risk of heart disease.

8.4 Estimating the Direct Costs of Overweight and Obesity

Aside from increasing the risk of several noncommunicable diseases and other negative health consequences, overweight and obesity are also associated with high economic costs. In health economics, the economic costs are divided into two groups: direct and indirect costs. First, direct costs are all costs that are incurred for treating obesity-related illnesses. The direct costs can be further divided into medical costs (e.g., doctor's fees, medicines, and medical operations) as well as nonmedical direct costs (e.g., costs of transporting the patient to the hospital). Indirect costs, on the other hand, capture the loss due to lower productivity or lesser quality of life of individuals as an effect of overweight and obesity. This cost can be related to disability or absenteeism in work. This section explains the methodology used and the results obtained for the direct costs, while Section 8.5 covers the indirect costs.

8.4.1 Estimating Direct Costs Across Economies

Standard Approaches to Estimate Direct Costs

The direct costs of overweight and obesity can be calculated in two ways. The first is called the epidemiological approach and is based on the idea that overweight and obesity contribute to certain diseases and their treatment generates medical costs. If we know the relative risk of an obesity-related disease (adjusted for other confounding factors) as well as the medical costs for the treatment of each disease, we can calculate the direct costs for the entire population. We simply multiply

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[3] Some examples of these websites are: http://medicaltourism.com/Forms/price-comparison.aspx, http://www.health-tourism.com/philippines-medical-tourism/, http://formosamedicaltravel.com/medical-tourism-blog/tag/hip-replacement-cost-comparison/. Likewise, online magazines such as: Medical Travel Singapore, 2007 edition, Parkway Group Healthcare and Medical Tourism Association Survey – August 2007 similarly present some information on the comparative prices of medical procedures.

the overweight and obesity-related disease burden with the disease-specific costs and sum up over all related diseases and the respective population. The data requirement for this approach, called population-attributable fraction, is rather intensive. We need to know the relative risks related to obesity and the medical costs for all overweight and obesity-related diseases. In almost all countries in Asia and the Pacific, data on disease-specific medical costs are unavailable. This lack of data severely hampers the cost calculation not only for overweight and obesity, but for all noncommunicable disease risk factors and for all diseases in general.

The second approach, which has become more popular in recent years, is an econometric approach (e.g., Finkelstein et al. 2009 or Cawley and Meyerhoefer 2012). The basic idea is that in a representative sample we try to measure the additional medical costs that overweight and obese people need to bear (controlling for possible confounding factors). We introduce a dummy variable for overweight and obese persons in the sample and then estimate their additional medical expenditures. In a final step we can extrapolate the costs for the entire population. The data requirements for this approach are less intensive compared to the first approach. Most importantly, a representative survey that contains data on medical expenditures is required. Again, for developing Asia and the Pacific no comparable surveys across countries exist that would allow us to systematically estimate the cost across countries.

New Methodology to Estimate Direct Costs Across Countries

Due to lack of data we had to develop a methodology to estimate the direct costs across countries. The underlying idea of our approach is to use the case of Japan as a baseline scenario for which we have solid estimates on the direct costs of overweight and obesity. In a first step, we assume that overweight and obesity in other economies in Asia and the Pacific have similar costs. However, these costs need to be adjusted to the varying costs of drugs and medical services. We argue that GDP per capita is an appropriate way to adjust to different price levels across the region. Second, even when adjusted by the price level, economies in the region cannot afford to have the same total health care expenditures compared to Japan. We therefore also adjust for the total amount of health care expenditures.

Step 1: Use Direct Cost Estimates for Japan as Baseline

In Japan a number of detailed econometric studies have been undertaken to estimate the costs of overweight and obesity. We chose the four most recent studies as listed in Table 8.1. All papers used nationally representative samples, analysis of adults of all ages, and the standard

Table 8.1 Estimated Per Person Annual Cost of Overweight and Obesity in Japan

Reference	Year	Annual Cost (¥)	Reference Year	CPI Adjustment to 2013	¥ Equivalent in 2013	¥ to $ Exchange Rate	$ Equivalent in 2013
Kuriyama et al. 2002	1995–1998	300,744	1998	0.96	288,714	97.6	2,958
Kuriyama et al. 2004	1995–2001	264,672	2003	0.99	262,025	97.6	2,685
Nakamura et al. 2007	1991–2000	151,574	2006	0.99	150,059	97.6	1,538
Ohmori-Matsuda et al. 2007	1996–2001	342,240	2001	0.98	335,395	97.6	3,436
Mean							2,654

CPI = consumer price index.
Source: Authors.

BMI cutoffs. All authors estimated the additional expenditures either per month or per year. We therefore first annualized all costs and listed the costs in column three. As we can see, the cost estimates vary between ¥151,574 (Nakamura et al. 2007) and ¥342,240 (Ohmori-Matsuda et al. 2007). Such differences are not uncommon in this literature. For example, in the case of the US, the annual direct costs estimated by Finkelstein et al. (2009) are $1,429, whereas Cawley and Meyerhoefer (2012) estimated them to be $2,741.

Second, we adjusted the prices for each study (from reference year) to the 2013 price level using the consumer price index. Finally, we converted the price from Japanese yen into US dollars and calculated the average across all studies. The cost was $2,654, which is very close to the amount for the US in the seminal paper by Cawley and Meyerhoefer (2012).

Step 2: Gross Domestic Product Per Capita Adjustment of Health Care Costs

Medical costs vary considerably across countries for a variety of reasons. For many developing countries we only have anecdotal evidence of medical costs by diseases or medical procedures. However, since medical travel (patients traveling abroad to seek medical treatment) has become more widespread in recent years (Helble 2011), more data on prices for medical procedures have been published online. Table 8.2 lists the prices for two medical procedures—heart bypass and angioplasty, in seven Asian economies retrieved from various websites.

Table 8.2 Comparative Prices of Medical Procedures in Asia ($)

Medical Procedure	India	Rep. of Korea	Malaysia	Philippines	Singapore	Taipei,China	Thailand
Heart bypass[a]	7,900	26,000	12,100	11,500[b]	17,200	25,000[c]	15,000
Angioplasty[a]	5,700	17,700	8,000	–	13,400	6,000[c]	13,000

Notes:
a From Medical Tourism.com (http://medicaltourism.com/Forms/price-comparison.aspx).
b From Health Tourism.com (http://www.health-tourism.com/philippines-medical-tourism/).
c From Formosa Medical Travel.com (http://formosamedicaltravel.com/medical-tourism-blog/tag/hip-replacement-cost-comparison/).
Source: Authors.

It should be noted that these prices typically do not reflect the costs incurred by domestic patients. Foreign patients are typically treated in private health care facilities where the price tends to be higher compared with public hospitals. Furthermore, the medical services included as well as the quality might vary across countries. But there clearly appears to be a correlation between the GDP per capita of a given country and the price offered for medical procedures. To test this hypothesis, we ran simple correlations between the GDP per capita and the price of the two medical procedures above (Table 8.3). We chose heart bypass and angioplasty as both interventions can be caused by overweight and obesity. The correlation between GDP per capita and the cost is 0.51 for heart bypass surgery and 0.46 for angioplasty. We thus observe a clear relationship between GDP per capita and the cost of medical treatments.

To obtain the additional health care expenditure due to overweight and obesity, we adjust the $2,654 to the level of GDP of all Asia and the Pacific economies. For example, our estimations predict that a person suffering from overweight or obesity in India will face additional health care costs of $101.86 per year. Using this simple approach, we are able to calculate an estimate of additional health care expenditures for all countries.

Table 8.3 Correlations between Gross Domestic Product Per Capita and Price of Medical Procedures

	GDP Per Capita	Heart Bypass	Angioplasty
GDP Per Capita	1.000		
Heart Bypass	0.512	1.000	
Angioplasty	0.455	0.466	1.000

GDP = gross domestic product.
Source: Authors.

Step 3: Adjustment to Total Health Care Expenditures

We argue that one additional adjustment is needed to obtain a more realistic cost estimate. One strong underlying assumption of the GDP per capita adjustment is that all patients across the region could have the same level of care as a patient in Japan. But in many developing countries access to health care is limited due to various factors, most importantly problems of affordability and access. For example, an obese Indian person typically does not have the same means or access to health care services compared to an obese Japanese person.

To account for the difference in affordability and access, we propose to adjust for total health care expenditures of the country, as a proxy of a country's ability to cope with its citizens' ill health. In other words, the expenditures reflect the level of care that a country can afford.

In the second adjustment we calculate how much the total health care expenditures differ from Japan. We use the per capita health care expenditures of Japan as the benchmark and adjust for the other countries. For example, in India the per capita health care expenditure is $68.53 whereas in Japan it amounts to $3,960.20 In terms of the relative capacity to seek medical treatment, India can only offer around 1.73% of the Japanese level. This again is a strong assumption. Some countries might offer a similar level of affordability and access compared to Japan at relatively lower costs. However, as long as we do not have empirical evidence to demonstrate the case, we need to rely on this strong assumption.

Overall, we thus adjust twice: first for the price differences for medical treatments and second for the difference in terms of affordability and access of health services. After the two adjustments we obtain a direct cost estimate for each overweight and obese person in all countries in our sample. In a last step, we simply multiply the number of overweight and obese people in each country with the estimated annual direct medical costs.

8.4.2 Results of Direct Cost Estimates

The results from our direct cost estimation are shown in Table 8.4. In the first column we list the direct cost values while in the next two columns we compute how our estimates compare with each country's total health care expenditure and GDP, respectively.

In Central Asia, we observe that the direct cost of obesity is highest in Kazakhstan, followed by Azerbaijan and Turkmenistan. These three countries also exhibited the highest prevalence of obesity in 2013 for this subregion. In addition, we find that the percentage of our direct cost estimates relative to each of these countries' total health care expenditure exceeded 7%. The percentages of direct cost relative to their GDP are likewise high for these countries. Conversely, Tajikistan appears to spend the least on obesity.

Looking at the East Asia subregion, Japan appears to incur the highest direct cost due to obesity despite the relatively low prevalence rate of 23.3%, while the estimate for Mongolia appears to be lower despite the high prevalence of obesity at 49.4% (see Table 8.4). In our estimation, we use Japanese prices as our reference and practically assume that health care is more accessible in this country than in any other country in our sample (based on total health care expenditure). Hence, we expect that our direct cost estimate will also be high for countries such as the Republic of Korea, which has a similar level of total health care expenditure as Japan.

India incurs the highest absolute direct cost for obesity in the South Asia subregion. But when we equate the estimated direct costs relative to the total health care cost of each country, Maldives overtakes India clearly with over 6%. The values are also high for Bhutan (1.51%) and Sri Lanka (1.45%). The rate of overweight and obesity for Maldives was at 40.3% in 2013, while for Sri Lanka it was 26.2% and for Bhutan it was 35.3% (see Table 8.4).

Table 8.4 Direct Cost Estimates of Overweight and Obesity

Economy	Prevalence of Overweight and Obesity, 2013 (% of population)	Direct Cost		
		Value ($)	% of Total Health Care	% of GDP
Central Asia				
Armenia	53.0	17,400,000	3.45	0.16
Azerbaijan	63.4	364,000,000	8.95	0.50
Georgia	29.7	55,600,000	4.75	0.34
Kazakhstan	54.8	1,410,000,000	13.40	0.58
Kyrgyz Republic	50.8	5,434,683	1.11	0.07
Tajikistan	40.8	4,248,632	0.74	0.05
Turkmenistan	53.6	65,100,000	7.39	0.16
Uzbekistan	47.9	54,700,000	1.51	0.10

continued on next page

Table 8.4 *continued*

Economy	Prevalence of Overweight and Obesity, 2013 (% of population)	Direct Cost		
		Value ($)	% of Total Health Care	% of GDP
East Asia				
PRC	27.9	17,900,000,000	3.44	0.19
Korea, Rep. of	32.3	13,600,000,000	14.40	1.04
Japan	23.3	77,900,000,000	15.47	1.59
Mongolia	49.4	19,600,000	3.70	0.16
Taipei,China	32.4	–	–	–
South Asia				
Afghanistan	45.9	8,719,833	0.53	0.04
Bangladesh	16.9	14,200,000	0.30	0.01
Bhutan	35.3	1,070,865	1.51	0.06
India	20.1	443,000,000	0.53	0.02
Maldives	40.3	19,000,000	6.09	0.68
Nepal	13.0	1,724,662	0.16	0.01
Pakistan	33.1	44,700,000	0.71	0.02
Sri Lanka	26.2	35,800,000	1.45	0.05
Southeast Asia				
Brunei Darussalam	20.6	76,900,000	16.27	0.43
Cambodia	15.5	2,415,455	0.27	0.02
Indonesia	26.0	450,000,000	1.68	0.05
Lao PDR	24.6	1,429,996	0.66	0.01
Malaysia	46.3	1,090,000,000	8.40	0.34
Myanmar	18.2	5,002,899	0.39	0.01
Philippines	24.5	145,000,000	1.17	0.05
Singapore	38.2	5,050,000,000	37.18	1.68
Thailand	36.0	640,000,000	3.80	0.15
Viet Nam	13.1	53,500,000	0.44	0.03
The Pacific				
Fiji	51.2	7,575,501	4.24	0.18
Papua New Guinea	42.9	21,500,000	2.13	0.10
Solomon Islands	64.8	1,339,303	2.22	0.12

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Table 8.4 *continued*

Economy	Prevalence of Overweight and Obesity, 2013 (% of population)	Direct Cost		
		Value ($)	% of Total Health Care	% of GDP
Timor-Leste	4.9	310,128	0.43	0.01
Vanuatu	50.6	852,050	2.71	0.11
Palau	51.2	2,375,833	11.20	1.04
Marshall Islands	76.9	1,529,137	4.67	0.80
Micronesia	74.9	1,672,560	3.95	0.53
Samoa	84.0	3,396,783	6.15	0.43
Tonga	86.1	1,449,878	6.52	0.33
Kiribati	79.1	450,269	2.36	0.24

GDP = gross domestic product, PRC = People's Republic of China.
Source: Authors.

The Southeast Asia region is home to several countries that have experienced rapid increases in obesity rates from 1990 to 2013, such as Cambodia, Indonesia, the Philippines, and Thailand. Based on our estimates, Singapore, followed by Malaysia, incurs the highest absolute direct costs for overweight and obesity. Equating our estimates relative to the total health care expenditure and GDP, we find that the highest percentages are observed in Singapore, Brunei Darussalam, and Malaysia. The prevalence of obesity in Malaysia in 2013 was the highest in the region at 46.3%, followed by Singapore at 38.2% (see Table 8.4).

The results for the Pacific are particularly interesting. While obesity rates in this subregion are some of the highest in the world, our estimated direct costs appear to be smaller than other countries in different subregions. We attribute this to the fact that we used Japan as a benchmark, where we utilized the total health care expenditure of each country relative to Japan as an indicator of access to health care. We therefore expect that the direct cost of obesity would increase tremendously if the people of the countries in this region had the same level of access to health care as in Japan. Within the Pacific subregion, Papua New Guinea yields the highest direct cost. However, relative to each country's total health care expenditure and GDP, Palau appears to incur the highest cost on overweight and obesity. Shares of direct costs in total health care expenditure are also high in Tonga and Samoa while shares of direct cost in GDP are high in the Marshall Islands and Micronesia.

8.5 Estimating the Indirect Cost of Overweight and Obesity

8.5.1 Estimation Strategy

Our strategy for estimating the indirect cost of overweight and obesity in Asia and the Pacific is largely based on the disability-adjusted life year (DALY) metric developed by Murray et al. (2012). The DALY is a measure that incorporates the years of life lost due to premature death (mortality) as well as the years of life lost due to disability (morbidity) (see also World Health Organization 2017). The DALY is an extension of the concept of potential years of life lost due to premature death as it includes the years of "healthy" life lost due to disability or sickness. A unit of DALY represents a year's loss of healthy life. On the other hand, the measured disease burden shows the disparity between a population's health status and a healthy population standard.

The DALY for a disease or health condition is calculated as the sum of the years of life lost due to premature mortality (YLL) in the population and the equivalent "healthy" years lost due to disability (YLD) for incident cases of the health condition:

$$DALY=YLL+YLD$$

The YLL component is determined by comparing age at death with the expected life expectancy of the respective country (i), including several adjustment factors. The discount rate (r) used in the DALY is 3% to reflect how health is valued in the future. Additionally, the age-weighting adjustment factors are incorporated to account for the years of healthy life lived at different ages.

$$YLL_i = \frac{KC_e^{ra}}{(r+\beta r)^2}\ x\ [e^{-(\beta+r)(L+a)}\ x\ (r+\beta r)\ x\ \big((L+a)-1\big)$$

$$-\ e^{-(r+\beta r)a}\ x\ \Big(\big(-(r+\beta r)(a-1)\big)\Big] + \left[\left(\frac{1-K}{r}\right)(1-e^{-rL})\right]$$

where:
r = discount rate (r = 0.03)
C = age-weighting correction constant (C = 1)
β = parameter from the age-weighting function
K = age-weighting modulation factor
a = age of death
L = standard expectation of life at age a

The YLD component is the product of number of incident cases of disease, duration of each case, several adjustment factors, and a disability weight that reflects the degree of disability. The disability weights quantify societal preferences for different health states. These weights do not represent the lived experience of any disability or health state, or imply any societal value of the person in a disability or health state. Rather, they quantify societal preferences for health states in relation to the societal "ideal" of optimal health.

$$YLD_i = D\left\{\frac{KCe^{ra}}{(r+\beta)^2} x \left[e^{-(r+\beta)(L+a)}[-(r+\beta)(L+a)-1] - e^{-(r+\beta)a}[-(r+\beta)a-1]\right] + \frac{1-K}{r}(1-e^{-rL})\right\}$$

where:
a = age at the onset of disability
L = duration of disability
r = discount rate (r = 0.03)
β = age-weighting parameter
K = age-weighting modulation factor
C = age-weighting correction constant

Our DALY estimation includes eight types of disease attributable to high BMI: (1) ischemic heart disease, (2) stroke, (3) diabetes, (4) liver cancer, (5) breast cancer, (6) esophagus cancer, (7) gall bladder and biliary tract cancer, and (8) hypertensive heart disease. The contribution of each of these diseases to the DALY is presented in Table 8.5. None of these diseases is fully attributable to high BMI, however. For instance, ischemic heart disease is also caused by other factors such as age, stress, family history, smoking, or diabetes. Hence, the DALY estimation adjusts for the real contribution of overweight and obesity to each of these diseases, which is specified in the last column.

The DALY estimates for Asia and the Pacific economies are shown in Table 8.6. We observe that countries with high prevalence of overweight and obesity also lose more productive years as a consequence. This is also expected to result in a high economic burden.

To generate a monetary equivalent of the productive years lost from the DALY estimation, we multiply the figures in Table 8.6 with the per capita income in each of our samples. As previously mentioned, a unit of DALY is equivalent to a loss of one year of healthy life. Thus, we equate this loss to the potential average annual earnings in each individual economy and consider this to be the indirect cost of overweight and obesity.

Table 8.5 Disease Attributable to Overweight and Obesity

Disease		Risk Factor Attribution (%)	Proportion from Total DALY (%)	Real Contribution of BMI>=25 kg/m² to DALY (%)
1	Ischemic heart disease	15.63	6.76	1.06
2	Stroke	19.56	8.73	1.71
3	Diabetes	40.99	3.19	1.31
4	Liver cancer	9.99	2.26	0.23
5	Breast cancer	11.86	0.54	0.06
6	Esophagus cancer	14.59	0.86	0.13
7	Gall bladder and biliary tract cancer	11.28	0.15	0.02
8	Hypertensive heart disease	29.83	0.96	0.29
Total				**4.79**

BMI = body mass index, DALY = disability-adjusted life year, kg/m² = kilograms per meters squared.
Source: Institute for Health Metrics and Evaluation.

Table 8.6 Disability-Adjusted Life Year Estimates for Asia and the Pacific

		DALY for All Diseases	Real Contribution of Overweight and Obesity (%)	Total Productive Years Lost Due to Overweight and Obesity
1	Afghanistan	18,539,562	1.33	247,063
2	Armenia	895,647	0.95	8,553
3	Azerbaijan	2,759,950	1.14	31,363
4	Bangladesh	50,765,824	0.36	184,439
5	Bhutan	240,620	0.54	1,296
6	Brunei Darussalam	72,185	0.81	585
7	Cambodia	5,736,940	0.31	17,795
8	PRC	337,486,044	1.37	4,625,049
9	Fiji	328,420	1.88	6,188
10	Georgia	1,563,220	0.74	11,583
11	India	494,698,971	0.36	1,771,258
12	Indonesia	72,340,657	1.05	756,612
13	Japan	32,107,323	0.16	51,332

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Table 8.6 *continued*

		DALY for All Diseases	Real Contribution of Overweight and Obesity (%)	Total Productive Years Lost Due to Overweight and Obesity
14	Kazakhstan	6,106,554	0.99	60,653
15	Kiribati	45,852	2.00	916
16	Korea, Rep. of	11,293,720	0.29	33,247
17	Kyrgyz Rep.	1,768,906	0.93	16,477
18	Lao PDR	2,635,899	0.42	11,002
19	Malaysia	63,836,217	0.09	59,586
20	Maldives	60,800	0.57	347
21	Marshall Islands	24,810	2.09	518
22	Micronesia	31,031	1.52	472
23	Mongolia	1,101,810	1.15	12,695
24	Myanmar	19,078,657	0.52	99,270
25	Nepal	8,319,695	0.42	35,005
26	Pakistan	77,324,260	0.75	579,995
27	Palau	78,298	1.43	1,117
28	Papua New Guinea	3,494,152	1.02	35,542
29	Philippines	28,205,496	0.73	204,948
30	Samoa	45,827	2.55	1,167
31	Singapore	763,405	0.50	3,852
32	Solomon Islands	193,819	2.64	5,118
33	Sri Lanka	5,223,416	0.49	25,453
34	Taipei,China	5,618,176	0.50	28,264
35	Tajikistan	2,569,464	0.60	15,362
36	Thailand	19,075,344	0.47	89,665
37	Timor-Leste	326,080	0.22	718
38	Tonga	29,768	1.81	537
39	Turkmenistan	1,837,222	1.21	22,206
40	Uzbekistan	8,763,864	1.32	115,573
41	Vanuatu	91,298	1.97	1,801
42	Viet Nam	21,840,038	0.27	58,439

DALY = disability-adjusted life year, Lao PDR = Lao People's Democratic Republic, PRC = People's Republic of China.
Source: Institute for Health Metrics and Evaluation.

8.5.2 Results of Indirect Cost Estimates

Table 8.7 shows a detailed table on the indirect costs of overweight and obesity in Asia and the Pacific. Based on our estimates, countries such as Turkmenistan, Mongolia, Nepal, Afghanistan, and Indonesia with high rates of overweight and obesity (see Table 8.7), suffer from high economic losses because of lower productivity.

Table 8.7 Indirect Costs of Overweight and Obesity in Asia and the Pacific

	Indirect		
Economy	Value ($)	% of Total Health Care	% of GDP
Central Asia			
Armenia	31,900,000	6.31	0.29
Azerbaijan	249,000,000	6.11	0.34
Georgia	49,400,000	4.22	0.31
Kazakhstan	861,000,000	8.21	0.35
Kyrgyz Republic	20,900,000	4.27	0.29
Tajikistan	16,100,000	2.80	0.19
Turkmenistan	176,000,000	19.98	0.42
Uzbekistan	218,000,000	6.05	0.38
East Asia			
PRC	32,700,000,000	6.31	0.34
Korea, Rep. of	864,000,000	0.92	0.07
Japan	1,980,000,000	0.39	0.04
Mongolia	55,400,000	10.46	0.44
Taipei,China	619,000,000	–	0.12
South Asia			
Afghanistan	163,000,000	9.94	0.81
Bangladesh	190,000,000	4.09	0.12
Bhutan	3,177,009	4.49	0.17
India	2,620,000,000	3.11	0.14
Maldives	2,875,898	0.92	0.10
Nepal	24,200,000	2.21	0.13
Pakistan	731,000,000	11.70	0.32
Sri Lanka	82,300,000	3.32	0.12

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Table 8.7 *continued*

Economy	Indirect		
	Value ($)	% of Total Health Care	% of GDP
Southeast Asia			
Brunei Darussalam	26,100,000	5.51	0.14
Cambodia	18,000,000	1.99	0.12
Indonesia	2,780,000,000	10.39	0.30
Lao PDR	17,500,000	8.13	0.16
Malaysia	638,000,000	4.91	0.20
Myanmar	117,000,000	9.02	0.19
Philippines	567,000,000	4.58	0.21
Singapore	214,000,000	1.58	0.07
Thailand	551,000,000	3.28	0.13
Viet Nam	111,000,000	0.91	0.06
The Pacific			
Fiji	29,500,000	16.49	0.70
Papua New Guinea	102,000,000	10.12	0.48
Solomon Islands	10,100,000	16.79	0.91
Timor-Leste	3,598,982	4.96	0.06
Vanuatu	5,627,507	17.90	0.70
Palau	14,600,000	68.66	6.36
Marshall Islands	1,839,202	5.62	0.97
Micronesia	1,438,419	3.40	0.46
Samoa	4,897,133	8.87	0.61
Tonga	2,312,910	10.40	0.52
Kiribati	1,571,820	8.23	0.84

GDP = gross domestic product, Lao PDR = Lao People's Democratic Republic, PRC = People's Republic of China.
Source: Authors.

The summary of our results from the direct and indirect cost estimation is presented in Table 8.8. We used different strategies to estimate the direct cost and indirect cost related to overweight and obesity, and accordingly the resulting figures are very different. Our direct cost estimation is based on the estimates from three studies that utilized a model-based approach in computing the annual per capita health care spending of normal-weight and overweight or obese adults, with the aid of nationally representative surveys. Our indirect cost estimation is based on the DALY estimates that incorporate the risk factor attribution of overweight and obesity on the eight diseases we identified.

Based on our estimates, the direct cost of overweight and obesity in Asia and the Pacific equates to about 0.56% of the combined GDP in this region while the indirect cost is about 0.22%. A closer evaluation of our estimates reveals that the direct cost of overweight and obesity is heavily affecting the East Asia, Central Asia, and Southeast Asia regions. On the other hand, the indirect cost of overweight and obesity is a heavy burden particularly for the Pacific and Central Asia regions.

Table 8.8 Estimated Cost of Overweight and Obesity by Asian Development Bank Region

	Direct Costs			Indirect Costs		
	Value ($ million)	% of Total Health Care Expenditure	% of GDP	Value ($ million)	% of Total Health Care Expenditure	% of GDP
Central Asia	1,976	9.08	0.43	1,622	7.46	0.35
East Asia	109,419	9.78	0.69	35,599	3.19	0.22
South Asia	568	0.56	0.02	568	3.79	0.16
Southeast Asia	7,514	7.69	0.30	3,817	5.16	0.20
The Pacific	42	2.74	0.12	177	11.49	0.51
Total	**228,372**	**8.90**	**0.56**	**78,038**	**3.46**	**0.22**

GDP = gross domestic product.
Source: Authors.

8.6 Summary and Conclusion

This chapter estimated the costs of overweight and obesity across the Asia and the Pacific region. Due to a severe shortage of necessary data, our estimations rely of several assumptions. However, overall, we estimate a burden of 12.36% of health care expenditure, or 0.78% of GDP. In terms of direct costs, we estimate that overweight and obesity contribute to about 8.9% of health care expenditure. The subregion with the lowest costs is South Asia with 0.56%, while East Asia faces the highest costs with 9.78% of health expenditure. The low direct costs of South Asia are not an indication that overweight and obesity are a minor issue; rather, it is due to the fact that the health systems in these countries only provide a fraction of the health care that would actually be needed. Millions of overweight and obese people who suffer from related diseases are thus either not treated or undertreated. As the health care systems in the region should improve with economic growth, we expect that the share of non- or undertreated patients will decline. If the prevalence of overweight and obesity remains high or even increases, it will increasingly absorb the health expenditure.

As for the indirect costs, we estimate that two regions—Central Asia and the Pacific—will suffer most. The model for indirect costs yields the lowest estimates for East Asia, the main reason being that life expectancy is still relatively high in almost all countries of this subregion. Diseases that can be caused by overweight and obesity take away life prematurely, though to a lesser extent than in regions with lower life expectancies. Since we know that childhood obesity has sharply increased in several countries in East Asia, there is a risk that life expectancy will also be affected in the long run. Interventions to curb the rising trend in obesity are urgently needed. Unless swift action is taken, overweight and obesity threaten to undermine the economic development of the entire region.

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9

Effectiveness of Obesity Prevention and Control

Montarat Thavorncharoensap

9.1 Introduction

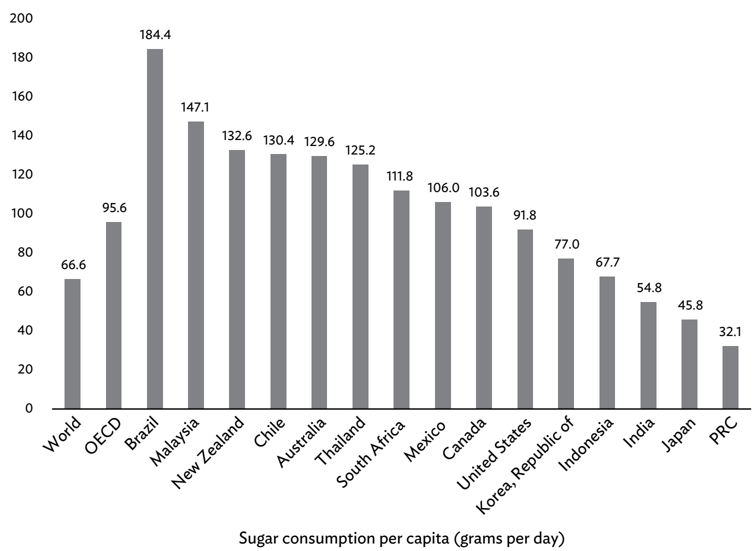
Given the obesity epidemic and negative consequences of obesity on health and the economy, its prevention and control have become a high priority for public health. Since the etiology of obesity is complex, a variety of interventions aimed to prevent and control obesity have been developed. These interventions mainly target increasing physical activity levels, decreasing energy-dense food consumption, and increasing fruit and vegetable consumption. Examples include those that aim to improve diet and/or physical activity through schools, primary care clinics, child care settings, communities, or workplaces; focus on food policy and regulation (e.g., taxation of unhealthy foods, marketing restrictions on unhealthy foods, labeling regulations, and fruit and vegetable subsidies); and promote walking, cycling, and using public transport.

This chapter reviews the current state of knowledge on the effectiveness of selected interventions that focus on obesity prevention and control, especially taxing sugar-sweetened beverages (SSBs), nutrition labeling and advertising bans on unhealthy food, and school-based interventions. These policies are increasingly gaining attention in the media and have been adopted by a few countries, providing case studies. The chapter uses evidence reported in systematic reviews, meta-analyses, and reviews of systematic reviews and meta-analyses. Since cost-effective analysis is an important tool in prioritizing interventions for obesity prevention, where available, evidence on cost-effectiveness is also summarized. Knowledge gaps regarding the effectiveness of such interventions are also discussed.

9.2 Sugar-Sweetened Beverages

According to the World Health Organization (WHO 2015a), "free sugar" is all monosaccharides and disaccharides added to foods and beverages by the manufacturer, cook, or consumer, as well as sugars naturally present in honey, syrups, fruit juices, and fruit juice concentrates. Since 2002, WHO has recommended free sugar intake to be reduced to less than 10% of total energy intake, and a further reduction to below 5% was recommended for additional benefits (WHO 2015a). Based on this recommendation, the amount of sugar consumed by typical adults should not exceed 6 teaspoons or 25 grams per day. According to the Organisation for Economic Co-operation and Development and Food and Agriculture Organization of the United Nations (OECD/FAO 2015), per capita sugar consumption was estimated at 66.6 grams with the highest found in Brazil (see Figure 9.1).

Figure 9.1 Sugar Consumption Per Capita in the World and Selected Countries



PRC = People's Republic of China.

Note: Average from 2012–14 (data for 2014 are estimated), per capita (grams per day) was estimated as per capita (grams per year)/365.

Source: Organisation for Economic Co-operation and Development/Food and Agriculture Organization of the United Nations 2015.

Although sugars are found naturally in many foods, a leading source of added sugar intake is the consumption of SSBs. In the United States, about 50% of the added sugar consumed is from SSBs (Welsh et al. 2011). SSBs include soft drinks, fruit drinks, sport drinks, and energy drinks that contain added sugar. Generally, a single 330-milliliter can of a sugar-sweetened carbonated soft drink contains 35 grams of added sugar, which alone exceeds the recommended limit of sugar intake.

Globally, consumption of SSBs is high. A recent study examining SSB sales indicated that the four regions with the highest reported consumption are North America, Latin America, Australia, and Western Europe, while the lowest reported consumption is the Asia and Pacific region (Popkin and Hawkes 2016). However, SSB sales (in calories per person) are increasing in many low- and middle-income countries and decreasing in high-income countries (Popkin and Hawkes 2016).

The Global School-Based Student Health Survey reveals the percentage of students aged 13–15 years who drank carbonated soft drinks at least once a day during the past 30 days (Table 9.1). Figures range between 29% in Indonesia to 54% in Samoa. Another study on obesity among adolescents in Pacific Island countries and territories found that 37% of students aged 13–15 years reported consuming at least one carbonated soft drink a day over the past 30 days (Kessaram et al. 2015).

Table 9.1 Students Aged 13–15 Years Who Drink Carbonated Soft Drinks One or More Times Per Day in Selected Developing Countries

Country	Year of Survey	% of Students
Brunei Darussalam	2014	46.30
Cambodia	2013	45.60
Indonesia	2015	28.80
Malaysia	2012	31.30
Philippines	2011	42.20
Samoa	2011	53.50
Solomon Islands	2011	45.10
Thailand	2015	57.70
Viet Nam	2013	34.60

Note: Time frame is during the past 30 days at the time the student took the survey.
Source: World Health Organization. Global School-Based Student Health Survey. http://www.who.int/chp/gshs/en/ (accessed 10 August 2016).

9.2.1 Sugar-Sweetened Beverages and Obesity Risk

Several studies have been conducted on the association between SSBs and obesity, but the findings have been inconclusive. Previously, a WHO-commissioned meta-analysis of randomized, controlled trial studies found that reducing added sugar intake lowers body weight by 0.8 kilograms (95% confidence interval [CI]: 0.39–1.21) (Te Morenga et al. 2012).

In 2015, Keller and Bucher Della Torre (2015) examined 13 systematic reviews on the relationship between SSBs and obesity in children. The quality of the included studies was low to moderate, and 9 indicated a positive association between SSBs and obesity. The two studies with the highest-quality methodology (i.e., Kaiser et al. 2013; Malik et al. 2013) reported conflicting findings; Kaiser et al. (2013) found inconclusive results, while Malik et al. (2013) found positive results regarding the relationship between SSBs and obesity. Later, the authors stated that the discrepancies may be explained by the fact that Malik et al. (2013) included both experimental (n = 5) and observational studies (n = 14), while Kaiser et al. (2013) included only experimental studies (n = 3). In addition, one out of three experimental studies in Kaiser et al. (2013) was not intended to examine the association between SSBs and obesity. All three experimental studies included had shorter durations than the studies found in Malik et al. (2013); a short-duration study may not be appropriate to assess the effect of interventions designed to detect weight loss.

Bes-Rastrollo et al. (2016) identified 23 systematic reviews (including 6 meta-analyses) through August 2015 that examined the relationship between SSBs and obesity. It found that the majority of studies, especially recent ones with robust methodologies, were more likely to identify a positive relationship between SSB consumption and obesity. Similarly, Bucher Della Torre et al. 2016 revealed that high-quality studies are more likely to suggest a positive relationship between SSB consumption and obesity.

It should also be noted that conflicts of interest impacted the findings of studies examining the relationship between SSBs and obesity. Bes-Rastrollo et al. (2016) indicated that industry-funded reviews are about five times more likely to demonstrate an insignificant relationship between SSB consumption and obesity than those without industry funding (Relative Risk = 5.3; 95% CI: 1.3–21.7). Similarly, a recent study examining the characteristics of 20 reviews (i.e., 5 meta-analyses, 3 qualitative systematic reviews, and 12 qualitative nonsystematic reviews) on the relationship between SSBs and obesity found that industry-funded reviews are more likely to indicate a weaker association between SSBs and obesity, whereas a stronger association was identified in reviews funded by other sources (Massougbodji et al. 2014).

9.2.2 Sugar-Sweetened Beverage Taxes

WHO has expressed concern that the increasing intake of free sugars, particularly in the form of SSBs, may increase the prevalence of obesity. In 2013, the WHO Global Action Plan (2013) encouraged member states to consider implementing taxes that discourage the consumption of less healthy foods, including SSBs. Governments in Australia, Fiji, Finland, France, Ireland, Mexico, Nauru, Samoa, and Sweden have already implemented such taxes.

Cabrera Escobar et al. (2013) conducted a meta-analysis of the impact of SSB taxes on SSB consumption and obesity. They identified nine articles published between 2008 and 2013, which contained studies conducted in the United States (6 studies), Brazil (1 study), France (1 study), and Mexico (1 study). In all, the price elasticity of demand (i.e., the change in consumer consumption with respect to changes in prices) was estimated.1 All studies indicated negative own-price elasticity, as higher SSB prices led to lower SSB consumption. The pool own-price elasticity was −1.299 (95% CI: −1.089 to −1.509), denoting that a 10% increase in a tax would reduce SSB consumption by 12.99%. With respect to the impact of taxes on obesity, studies conducted in the United States found that a 1% increase in SSB prices can reduce obesity prevalence in adults and children by 0.01% (Fletcher et al. 2010a) and 0.9% (Fletcher et al. 2010b), respectively. Another study in the United States indicated that a 10% increase in SSB prices can reduce obesity prevalence in men by 0.05% and in women by 0.34% (Han and Powell 2011), while a third study indicated that a 20% increase in SSB prices can reduce obesity prevalence by 0.03% (Smith et al. 2010).

More studies in Australia, India, Ireland, South Africa, and the United States have been conducted to examine the impact of SSB taxes on SSB consumption and obesity (Table 9.2). All, except Falbe et al. (2016) included modeling techniques that used price elasticity in demand to estimate the reduction of SSB consumption leading to reduced energy intake. Based on changes in energy intake, the changes in body weight and obesity prevalence were estimated.

A systematic review of SSB taxes intended to reduce overweight and obesity in middle-income countries was also recently conducted

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[1] Highly negative elasticity of demand means that an increase in product price will lead to a high reduction in consumption.

Table 9.2 Impact of Sugar-Sweetened Beverage Taxation on Sugar-Sweetened Beverage Consumption and Obesity

Study	Setting	Study Design and Assumptions	Effects of Taxes
Basu et al. (2014)	India	Method: Modeling Own-Price Elasticity: −0.94 (95% CI: −0.90 to −0.98)	A 20% SSB tax leads to • 3% reduction in overweight and obesity prevalence (95% CI: 1.6%–5.9%) and • 1.6% reduction in type-2 diabetes incidence (95% CI: 1.2%–1.9%). The largest effect was found in rural young men.
Briggs et al. (2013b)	Ireland	Pass-on Rate: 90% Method: Modeling Own-Price Elasticity: −0.90	A 10% SSB tax leads to • 1.3% reduction in obesity prevalence in adults and • 0.7% reduction in overweight prevalence in adults. No significant differences across gender or income were identified. However, the impact on young adults was greater than on older adults.
Briggs et al. (2013a)	United Kingdom	Method: Modeling Own-Price Elasticity: −0.92	A 20% SSB tax leads to reduced consumption of concentrated SSBs by 15% and nonconcentrated SSBs by 16%, • 1.3% reduction in obesity prevalence in adults (95% CI: 0.8%–1.7%), • 0.9% (95% CI: 0.6%–1.1%) reduction in overweight prevalence in adults, and • increase in tax revenue of £276 million annually. No significant differences across income were identified. However, the impact on children was more promising than on adults. A 10% SSB tax had approximately half of the effect of a 20% tax.
Manyema et al. (2014)	South Africa	Pass-on Rate: 100% Method: Modeling Own-Price Elasticity: −1.30 (assumed from systematic review)	A 20% SSB tax leads to • 3.8% reduction in obesity prevalence (95% CI: 0.6%–7.1%) in men and • 2.4% reduction in obesity prevalence (95% CI: 0.4%–4.4%) in women.

continued on next page

Table 9.2 *continued*

Study	Setting	Study Design and Assumptions	Effects of Taxes
Basu et al. (2014)	India	Method: Modeling Own-Price Elasticity: −0.94 (95% CI: −0.90 to −0.98)	A 20% SSB tax leads to • 3% reduction in overweight and obesity prevalence (95% CI: 1.6%–5.9%) and • 1.6% reduction in type-2 diabetes incidence (95% CI: 1.2%–1.9%). The largest effect was found in rural young men.
Briggs et al. (2013b)	Ireland	Pass-on Rate: 90% Method: Modeling Own-Price Elasticity: −0.90	A 10% SSB tax leads to • 1.3% reduction in obesity prevalence in adults and • 0.7% reduction in overweight prevalence in adults. No significant differences across gender or income were identified. However, the impact on young adults was greater than on older adults.
Veerman et al. (2016)	Australia	Pass-on Rate: 100% Method: Modeling Own-Price Elasticity: −0.63	A 20% SSB tax leads to • reduced consumption of SSBs from 141 g/day to 124 g/day in men and from 76 g/day to 68 g/day in women; • 2.7% and 1.2% reductions in obesity prevalence in men and women, respectively; • 16,000 fewer new cases of type 2 diabetes, 4,400 fewer new cases of ischemic heart disease, and 1,100 fewer new cases of stroke (after 25 years of tax implementation); and • increase in tax revenue of A$400 million annually.
Falbe et al. (2016)	United States	Method: Pre-Post Design	An SSB tax ($0.01 per ounce) decrease consumption of SSBs by 21%.

g = gram, SSB = sugar-sweetened beverage.

(Nakhimovsky et al. 2016) in Brazil, Ecuador, India, Mexico, Peru, and South Africa. Of the nine studies, four were observational studies, three were quasi-experimental studies, and two were modeling studies. All were published between 2008 and 2016. Based on the systemic review, SSB taxes led to increased SSB prices, which resulted in reduced SSB consumption. The review found that the own-price elasticity of SSBs ranged from −0.6 to −1.2, concluding that taxes can be an effective tool to control obesity in middle-income countries—even in India, where obesity prevalence and SSB consumption are lower than other middle-income or developed countries. However, the authors stated that tax rates must be set sufficiently high (i.e., at least 20%) to be effective and that SSB taxes alone may be insufficient to reduce energy intake enough to decrease population weight.

The most recent systematic review on the impact of SSB taxes was conducted by Bes-Rastrollo et al (2016). In this review, 24 articles published through August 2015 were identified. Of these articles, 17 were conducted in the United States; 3 were conducted in Australia; and 1 each was conducted in India, Ireland, South Africa, and the United Kingdom. SSB tax rates varied, but the majority of the studies (17 of 24) indicated that SSB taxes were negatively associated with body weight and obesity prevalence. The authors discussed that non-significant results were mostly found in studies with relatively low tax rates. The findings were consistent with the previous recommendation that at least a 20% tax rate should be implemented (Mytton et al. 2012).

9.2.3 Cost-Effectiveness of Sugar-Sweetened Beverage Taxes

A simulation model was conducted to estimate the cost and impact of a $0.01 per ounce SSB tax in the United States over a 10-year period (Gortmaker et al. 2015; Long et al. 2015). According to the study, the total cost of implementing the tax during the 10-year period was about $430 million, while the revenue generated from the tax was $12.5 billion. The model estimated that the cost per unit of body mass index (BMI, kilograms/meters squared) reduction was about $3.16 and that the tax would result in health care cost savings of $23.6 billion, a $55 health care cost-savings per every $1 spent. Thus, SSB taxes are considered a cost-effective intervention.

9.2.4 Summary and Recommendations

Based on existing evidence, SSB taxes may be an effective and cost-effective approach when used with other interventions, such as education and subsidies, to tackle the obesity epidemic. Nevertheless, it should be noted that almost all studies on the effectiveness of SSB taxes were limited to modeling techniques conducted in countries with high SSB consumption (except India). Studies on the effectiveness and cost-effectiveness of SSB taxes conducted in low-income countries and countries with low consumption of SSBs merit further study.

Further, the associations among childhood obesity, SSB consumption, and socioeconomic status varied by country. In developed countries, a negative correlation was found between socioeconomic status and obesity, while in less-developed countries, a positive correlation was identified (Wang and Lim 2012; Aizawa and Helble 2016). With respect to the relationship between SSB consumption and socioeconomic status in general, it was found that SSB consumption was negatively correlated with socioeconomic status (Wold 2009; Mazarello Paes et al. 2015). Nevertheless, in some countries, especially developing countries or countries in socioeconomic transition, a positive correlation was identified for SSB consumption and socioeconomic status (Han and Powell 2011; Ha et al. 2016; Wold 2009). Such different patterns of the relationships among obesity, SSB consumption, and socioeconomic status strongly support the need for further research on the effect of SSB tax in developing countries.

The price elasticity of demand and the substitution effect are important factors in the design of effective SSB tax policies. As the prices of SSBs rise due to taxation, the consumption of SSBs is expected to decrease. However, taxation rates need to be high enough to have a significant impact (Mytton et al. 2012). It should also be noted that the SSB tax is complicated because consumers have many food alternatives or substitutes if only one type of food is taxed. To reduce substitution with other unhealthy foods, the tax should be imposed on all kinds of SSB products, not only on carbonated drinks. In addition, taxes on a broad range of energy-dense products (i.e., those high in fat and sodium) as well as fruit and vegetable subsidies for specific population groups may be considered when used with SSB taxes (WHO 2015b).

Although SSB taxes are considered an attractive political option, common criticism for implementing SSB taxes is their regressive impact. Similar to other consumer taxes, the poor pay a greater proportion of their income in taxes than other segments of the population. Nevertheless, it should be noted that a SSB tax is also progressive and leads to a reduction in health inequality, given that the poorer segments consume more SSBs, have a higher prevalence of obesity, and are more sensitive to price changes; thus, they are more likely to have more benefits from such an intervention (Pomeranz 2013).

9.3 Food Labeling

Food labeling is a practical tool that can empower consumers to choose healthy diets. It is increasingly considered one of the more important components of multicomponent strategies to tackle obesity. Nutrition label formats can be classified into two categories: front-of-package labels and back-of-package labels. At present, back-of-package labels are the most widely adopted format (European Food Information

Council 2014). In addition, several symbols or logos, such as traffic lights, keyholes, hearts, and green checkmarks, have been developed to facilitate consumers' understanding of nutrition information. The traffic light and guideline daily amount (GDA) are among the most widely adopted formats (OECD 2014).

At present, many high-income countries, such as Australia, Canada, New Zealand, and the United States, mandate the display of nutrition information on pre-packed foods. According to a European Union regulation (OECD 2014), compulsory food labels had to be implemented by 2016. These labels, expressed as GDAs, indicate energy, fat, saturated fat, carbohydrates, sugars, proteins, and salt.

In light of the growing interest in nutrition labeling policy and regulation, numerous studies have been conducted to examine the effects of food labeling on consumers' understanding of food labeling schemes, food choices, eating habits, perceptions toward nutrition labeling, and calorie intake.

9.3.1 Effectiveness of Food Labeling

Several studies have been conducted on the impact of labeling on food selection and dietary intake. Numerous studies have focused on factors associated with the use of labeling and understanding of and attitudes toward food labeling. Systematic reviews and meta-analyses on the use, understanding, and impact of nutrition labeling on food selection and dietary intake are examined in this section.

Cowburn and Stockley (2005) conducted a systematic review on consumer understanding and use of nutrition labeling when making decisions about food selection. In their review, 103 studies from North America and Northern Europe were identified, and most were of moderate to poor quality. About one-third (28%) were conducted in real-world settings where the subjects actually made food purchase decisions. The review indicated that most consumers reported that they often or at least sometimes look at nutrition labels when purchasing food; women with higher income and education levels were more likely to look at nutrition labels. With respect to understanding nutrition labeling, the review found that consumers have difficulty understanding the information included on the label, especially when converting information from grams per 100 grams to grams per serving size and percent energy.

Campos et al. (2011) conducted a systematic review on the impact of labeling on consumer dietary habits. In addition, the prevalence of labeling use and consumer understanding of nutrition labeling were examined. The authors identified 120 studies from the United States

(87 studies), Europe (13 studies), Canada (9 studies), Australia or New Zealand (4 studies), Norway (2 studies), Germany (1 study), Thailand (1 study), Trinidad and Tobago (1 study), and multiple countries (2 studies). Of 65 studies that reported the prevalence of label use among consumers, self-reported label use was high, especially in New Zealand (82%), United States (75%), Canada (52%), and Europe (47%). People who were middle-aged, female, high-income, highly educated, and had healthier eating habits were more likely to report greater use of nutrition labeling.

While many studies found that consumers generally perceive nutrition labels to be useful, several others indicated that many consumers have difficulty understanding the information presented, especially for recommended daily amount, serving size, and percent daily values (Campos et al. 2011). With regard to label format and content, some indicated that the use of graphics, such as traffic lights, helped increase consumers' understanding and that providing nutrition information using front-of-package labeling is more effective than back-of-package labeling. Inconclusive evidence was found with regard to the level of detail or complexity of information favored by consumers. In terms of nutrition information sought by consumers, most studies found that most consumers look for information on fat and energy content. When looking at the impact of nutrition labels on dietary habits, the association between the use of nutrition labels and a healthier diet was consistently found.

Cecchini and Warin (2016) conducted a systematic review and meta-analysis to examine the impact of food labeling on food choice and calorie intake. Their study identified, nine peer-reviewed, randomized control studies published in English or French between 2008 and 2015. All studies were conducted in high-income countries: Australia, Canada, France, Germany, United Kingdom, and United States. For each study, the proportions of subjects that switched to healthier products and changed calorie intake following the implementation of food labeling were extracted. In addition, three formats of food labeling schemes—traffic lights, GDA, and others (e.g., front-of-package labels)—were compared and assessed for their effect on food choices and food consumption. The results showed that food labeling increased the proportion of people selecting healthier food choices by 17.95% (95% CI: 11.24%–24.66%). When comparing across labeling schemes, traffic light schemes were more effective than GDA and other schemes in increasing the selection of healthier food products. However, food labeling did not significantly reduce caloric intake. The authors explained that selecting healthier food choices by substituting unhealthy foods (e.g., trans fats) with healthier options (e.g., polyunsaturated fats) did not necessarily lead to a difference in caloric intake. Most of these studies were based on small sample sizes. A quality assessment of these studies was not conducted, but high heterogeneity was identified. Based on these limitations, the findings should be interpreted with caution. In addition, all were randomized and conducted in a laboratory setting in high-income countries, so further studies conducted in real-world settings and in low- and middle-income countries are needed.

Mandle et al. (2015) conducted a narrative review of studies examining consumer use of and attitudes toward nutrition labeling in countries outside of North America, Australia, New Zealand, and Europe; they identified 27 studies conducted in 20 countries in Asia, Africa, Latin America, and the Middle East. According to the review, education and socioeconomic status were positively associated with label use, and characteristics associated with label use are similar among the developing and developed countries. Most studies indicated that consumers prefer to have nutrition information labels on food packaging. Self-reported label use ranged from 40% to 70%. Common reasons for not using the nutrition labels were lack of interest, lack of time, and difficulties in interpreting the information on the label. In these studies, the percentage of consumers in selected countries who reported understanding the labels were 26.2% in Malawi (Kasapila and Shaarani 2013), 24.4% in Trinidad and Tobago (Peters-Texeira and Badrie 2005; Kasapila and Shaarani 2013), 44.0% in Botswana (Themba and Tanjo 2013; Kasapila and Shaarani 2013), and 55.9% in the Republic of Korea (Kim and Kim 2009). When comparing the preferences for label reference units, several studies indicated that "per serving size" is preferable to servings listed as "per 100 grams" (Mahgoub et al. 2007; Kim and Kim 2009; Singla 2010; Gregori et al. 2013). With respect to labeling format, simple, clear labels that are easy to see and interpret, using symbols or pictures, and avoiding complex technical information are preferable.

9.3.2 Cost-Effectiveness of Food Labeling

Using the chronic disease prevention model developed by the OECD and WHO, Cecchini et al. (2010) examined the cost-effectiveness of nutrition labeling in Brazil, People's Republic of China (PRC), Mexico, Russian Federation, South Africa, and United Kingdom. In the study, the cost per capita of implemented nutrition labeling ranged from $0.05 to $0.23. Based on the simulation, nutrition labeling was considered a cost-effective intervention in all studied countries after 20 years of implementation. In addition, after 50 years of implementation, it was found to be a cost-saving intervention in Brazil, PRC, Mexico, and Russian Federation.

Sacks et al. (2011) conducted a cost-effectiveness study of traffic-light nutrition labeling in Australia. The study estimated the change in BMI and prevalence of obesity using energy intake. It was assumed that a 10% reduction in energy intake was achieved from nutrition labeling. According to the study, traffic-light labeling would result in a 1.3 kilogram reduction in mean weight (95% CI: 1.2–1.4). The cost of implementing traffic-light labeling (including cost to the food industry; cost of social marketing campaigns; and cost of implementing, administering, and enforcing legislation) was estimated at A$81 million (95% CI: 44.7–108.0). Total cost offset (i.e., future health care costs saved due to the reduction of obesity-related conditions as the result of labeling) was estimated at A$455 million. Thus, the study concluded that traffic-light nutrition labeling is a cost-saving intervention.

9.3.3 Summary and Recommendations

Existing evidence consistently shows that consumers perceive nutrition labels to be useful and that labeling has a significant impact on food selection. In addition, nutrition labeling is considered a cost-effective or even cost-saving intervention in many countries. Although there is limited evidence regarding its impact on calorie intake and BMI, current evidence suggests that food labeling may be a cost-effective measure when used in a multicomponent strategy to tackle the obesity epidemic. However, most evidence is from studies that were conducted in high-income countries. Therefore, it is unclear as to what extent the findings can be applied to low- and middle-income countries, so further research is needed. The format and type of information that balances completeness and complexity of label information deserves further investigation as well. It should be noted that nutrition labeling alone may offer only limited benefits in tackling the obesity epidemic, so this should be implemented with other interventions, such as education, to increase consumer awareness and understanding of information placed on nutrition labels (Campos et al. 2011).

At present, food-labeling regulation varies across countries. The harmonization of food-labeling regulation would not only help protect consumers but would also decrease trade barriers and costs. Several regions have begun working toward the harmonization of food labeling in their regions (Tee et al. 2002; OECD 2014), and several related organizations, including WHO, Food and Agriculture Organization, and World Trade Organization are encouraging the harmonization of food-labeling regulation (FAO 2007; Kasapila and Shaarani 2011; Ettinger 2014). Harmonization is, however, complex, requiring governments, food industries, and academia to work closely together.

9.4 Marketing Restrictions on Unhealthy Food

Current evidence shows that children and adolescents may be at high risk of exposure to unhealthy food marketing (Kelly et al. 2010; Adams et al. 2012; Zhou, et al. 2015). Kelly et al. (2010) reviewed studies conducted in 13 countries in Asia, Western Europe, and North and South America from 2007 to 2008, indicating that food advertisements accounted for 11%–29% of all television advertisements. In addition, foods high in undesirable nutrients or energy accounted for 53%–87% of all food advertisements. On average, it was estimated that children are exposed to five food advertisements per hour.

Unhealthy food and beverage advertisements may affect children's eating habits and be associated with increased childhood obesity (Cairns et al. 2009). In 2010, WHO released recommendations urging member states to restrict the marketing of unhealthy foods and beverages to children (WHO 2010). Since 2011, many developed countries have tightened their regulations on the marketing of unhealthy foods and beverages to children (OECD 2014), but many still rely on industry self-regulation to reduce children's exposure to unhealthy food advertisements.

9.4.1 Food Advertisement and Obesity Risk

There is no systematic review or meta-analysis on the effects that advertisements have on BMI and obesity. However, many studies exist on the impact of exposure to unhealthy food and beverage advertisements on dietary intake and dietary behavior (Cairns et al. 2009; Mills et al. 2013; Boyland et al. 2016; Sadeghirad et al. 2016). This section identifies three recent meta-analyses examining the effects of food advertising on dietary intake, dietary preference, food-related behaviors, attitudes, and beliefs.

A recent meta-analysis by Sadeghirad et al. (2016) examined the effects of unhealthy food and beverage marketing on dietary intake and preferences among children aged 2–18 years. It identified 29 randomized, controlled trials published through January 2015: 17 were included in meta-analysis on dietary preference and 9 were included in meta-analysis of dietary intake. All were conducted in high-income countries—Australia, Canada, Netherlands, United Kingdom, and United States—and examined the impact of advertising delivered through television, movie commercials, advergames (i.e., electronic games to advertise a product), and branded logos. About half of these studies have a high risk of bias.

With regard to dietary intake, the meta-analysis identified a significant increase in dietary intake (mean difference = 30.4 kilocalories, 95% CI:

2.9–5.79) among children exposed to unhealthy food advertisements during or shortly after the exposure. When looking at dietary preference, children exposed to unhealthy food and beverage advertisements are 1.1 times more likely to choose the advertised product (relative risk = 1.1, 95% CI: 1.0–1.2). The meta-analysis also suggested that younger children may be more vulnerable to the influence of unhealthy food and beverage advertisements.

Mills et al. (2013) conducted a systematic review examining the impact of food and beverage advertisements on food- and beverage-related behavior, attitudes, and beliefs in the adult population. It included nine studies published between 1980 and 2012 and conducted in developed countries (i.e., France, Netherlands, and United States). Almost all of the identified studies were randomized, controlled trials that involved small sample sizes and were of moderate to poor quality. Further, all focused on television advertisements. Due to the heterogeneity, a meta-analysis was not conducted. This review indicated inconclusive effects of food advertising on food-related behaviors, attitudes, and beliefs, and revealed that the impacts of advertising vary across gender, weight, and existing food psychology.

Boyland et al. (2016) conducted a systematic review and meta-analysis examining the impact of acute exposure to unhealthy food and beverage advertising on dietary intake in children and adults. Only experimental studies, which focused on the impact of exposure from television and the internet, were included in this review. Seven studies were used to estimate the impact of advertisements on adults, while 13 studies were used to estimate the impact on children. The results revealed that exposure to advertisements results in a significant increase in dietary consumption (standard mean difference 0.37, 95% CI: 0.09–0.65). High heterogeneity (I^2 = 98%) was found, so the evidence should be interpreted with caution. When looking at adults, no significant effect of advertisements on dietary intake was found, but acute exposure to unhealthy food advertisements significantly increases the dietary intake among children (standard mean difference 0.56, 95% CI: 0.18–0.94). It is also worth noting that the evidence from children varied widely, resulting in high heterogeneity (I^2 = 98%).

9.4.2 Effectiveness of Marketing Restrictions on Unhealthy Food

A few studies examining the impact of unhealthy food advertising restrictions on BMI and obesity were based on mathematical simulation methods (Haby et al. 2006; Magnus et al. 2009; Veerman et al. 2009; Cecchini et al. 2010). A mathematical simulation for children aged 6–12 years was conducted in the United States, suggesting that by eliminating exposure to television advertising of foods high in fat, sugar, and/or salt among children, the average BMI can be reduced by 0.38 (Veerman et al. 2009). Similarly, a simulation model conducted in Brazil, PRC, India, Mexico, Russian Federation, South Africa, and United Kingdom estimated that the regulation of food advertisements can reduce BMI by 0.03 to 0.78 (Cecchini et al. 2010).

No systematic review or meta-analysis that examines the effects of unhealthy food advertising restrictions on BMI or obesity exists. Systematic reviews do exist examining how unhealthy food marketing restrictions affect the level of exposure of children. Chambers et al. (2015) conducted a systematic review to examine the effects on children of statutory regulations and self-regulation of unhealthy advertisements, and included 19 studies examining the effects of statutory regulation and 25 studies examining the effects of self-regulation. The review revealed that about 84% of the studies (16 of 19 studies) examining the effects of statutory regulation found that such regulation is effective. All of the studies examining the effects of self-regulation conducted by the food industry (7 studies) found that self-regulation is an effective method. On the other hand, about 60% of the studies (11 of 18 studies) conducted outside of the food industry found that self-regulation is not effective.

Similarly, a previous systematic review (Galbraith-Emami and Lobstein 2013) compared the changes in children's exposure to unhealthy advertisements after statutory regulation and self-regulation. The review found that high levels of exposure to unhealthy food advertisements still exist in several countries and revealed that studies sponsored by the food industry are more likely to indicate that self-regulation is effective in reducing the level of exposure to unhealthy food advertisements.

9.4.3 Cost-Effectiveness of Marketing Restrictions on Unhealthy Food

Using modeling techniques, the cost-effectiveness of banning unhealthy food and beverage television advertisements during children's peak viewing times was conducted in Australia (Magnus et al. 2009). An incremental cost-effectiveness ratio was estimated at A$3.70 per disability-adjusted life year (DALY). Using the threshold of A$50,000 per DALY, the interventions were considered very cost-effective.

Using the chronic disease prevention model, Cecchini et al. (2010) examined the cost-effectiveness of restrictions on marketing unhealthy foods to children in Brazil, PRC, India, Mexico, Russian Federation, South Africa, and United Kingdom. In the study, the cost per capita of implementing such an intervention ranged from less than $0.01 (in the PRC and India) to $0.30 (in the United Kingdom). Based on the simulation, after 20 years of implementation, restricting unhealthy food marketing to children is considered a cost-saving intervention in Brazil, and a cost-effective intervention in all the other countries except India. In addition, after 50 years of implementation, it was found to be a cost-saving intervention in Brazil and the PRC, and it was cost-effective in all other countries.

9.4.4 Summary and Recommendations

Although there is limited evidence on the long-term impact of advertisements on adult body weight and obesity, current evidence has consistently found that unhealthy food and beverage advertisements may increase dietary intake and preferences for unhealthy food in children during or shortly after exposure to such advertisements. In addition, restrictions on unhealthy food advertisements were found to be cost-effective in many settings. Thus, statutory regulations on unhealthy food advertisements may be regarded as a promising intervention in a multicomponent strategy that tackles obesity. Nevertheless, due to the limited evidence, the impact of government regulations on unhealthy food advertisements on BMI and obesity prevalence deserves further investigation. As most existing evidence focused on television advertising, the effects of food advertising delivered through other media, such as the internet, also warrant further investigation. High-quality evidence on the impact of food advertisements on adults and more studies in less-developed countries are also needed.

9.5 School-Based Interventions

Schools provide a promising setting for obesity prevention and control among children and adolescents due to their organizational structure, which facilitates the development of interventions using multi-professional and multicomponent approaches. In addition, children and adolescents spend a significant proportion of their time at school. Due to increased interest in school-based interventions, numerous studies have been conducted to examine the effectiveness of such interventions. According to a review by WHO, among interventions aimed at tackling the obesity epidemic, the effectiveness of school-based interventions was recognized (WHO 2009).

School-based interventions include several activities intended to create environments and cultures that support children eating healthier foods and being more active, such as nutrition education classes, physical education, activities that promote exercise, and improvements in the nutritional quality of school food. Several school-based programs also involve other settings, such as homes and communities. Many also involve parental support to encourage children to be more active, spend less time watching television and playing video games, and eat more healthy foods.

9.5.1 Effectiveness of School-Based Interventions

To date, many systematic reviews and meta-analyses have been conducted on the effectiveness of school-based interventions. Several meta-analyses showed inconclusive results due to the differences in study selection criteria, intervention delivered (i.e., characteristics, duration, intensity, and components), and outcomes (e.g., BMI, obesity prevalence, skinfold thickness, waist circumference, physical activity, and dietary behavior). A large variation across these studies was found in several systematic reviews and meta-analyses. For example, one meta-analysis (Guerra et al. 2013) examined the effectiveness of school-based interventions focusing on physical activity, but the types of physical activity included were diverse—dance, games, recreational athletics, endurance and resistance training, and sports. In addition, the weekly amount of time spent on intervention activities ranged from 75 to 270 minutes, while the duration of the interventions ranged from 2 to 48 months.

Due to the limited number of good-quality studies, and high heterogeneity identified in many reviews (Campbell et al. 2001; Doak et al. 2006; Flodmark et al. 2006; Kropski et al. 2008; Li et al. 2008), the effectiveness of school-based interventions cannot be clearly concluded. Mixed results were identified from several reviews (Doak et al. 2006; Flodmark et al. 2006; Lissau 2007; Brown and Summerbell 2009). Some concluded that school-based interventions were less likely to be effective (Kanekar and Sharma 2008; Harris et al. 2009), while others mentioned that school-based interventions were effective (Katz et al. 2008; Gonzalez-Suarez et al. 2009; Silveira et al. 2011).

To summarize the effectiveness of school-based interventions, three reviews of the existing systematic reviews and meta-analyses are identified here. In addition, evidence from recent related systematic reviews and meta-analyses, including one conducted in low- and middle-income countries, is also reported.

Amini et al. (2015) looked at existing English systematic reviews and meta-analyses published between 2001 and 2011 that aimed to evaluate the effectiveness of school-based interventions. Included in this study were 8 studies (4 systematic reviews and 4 meta-analyses) with a total of 106 primary studies. It should be noted that most of the primary studies were conducted in Western countries, especially the United States. According to this review, only two studies examined the effects of single-component interventions, which were physical activity (Harris et al. 2009) and nutrition education (Silveira et al. 2011). The other studies examined multicomponent interventions. All eight studies reported the effectiveness on anthropometric outcomes.

In terms of body weight or BMI reductions, the authors found that the effectiveness of school-based interventions was inconclusive in two studies. Four studies indicated that school-based interventions are effective, and two studies indicated that they are not effective. All studies reported high heterogeneity, most were at risk of publication bias, and many did not adequately assess or report the quality of primary studies. Therefore, conclusions should be made with caution. With regard to the components of interventions, it was unclear whether multicomponent interventions were more effective in terms of anthropometric outcomes than single-component interventions. However, the authors recommended multicomponent interventions targeting both dietary activity and physical activity because they also bring other health and social benefits. In terms of duration, the review found that duration was an important factor, but the optimal length for interventions remains unclear. The effectiveness of the intervention also differed across genders with inconclusive patterns. In addition, the authors suggested that the negative effects of interventions should be studied.

Khambalia et al. (2012) summarized the effectiveness of school-based interventions from 8 studies (5 systematic reviews and 3 meta-analyses) published from 1990 to 2010. Five of the eight reviews were of high quality, and all studies showed evidence of heterogeneity in terms of study design, intervention, and outcome. Although high heterogeneity was identified, the review suggested that some characteristics of school-based interventions may be effective. In fact, this review found that interventions combining diet and physical activity, delivered over the long term and with family involvement, are more likely to be effective in terms of reducing children's weight. However, several found that the effectiveness of interventions differed by gender. The authors stated the need for additional high-quality studies that focus on identified specific intervention characteristics that contributed to the effectiveness of the intervention.

Safron et al. (2011) reviewed 17 studies (12 systematic reviews and 5 meta-analyses), involving 196 primary studies that examined the effectiveness of school-based interventions. The quality of the included reviews was moderate to high. Among the reviews that reported BMI as an outcome, significant BMI reductions were found, on average, in 36% of the studies per review. Nevertheless, the effectiveness of the interventions was either small or insignificant, possibly due to the fact that the program was conducted with the general population instead of at-risk individuals. With respect to obesity or overweight prevalence, about 36% of the studies per review indicated that the interventions were effective. In terms of changes in physical activity and dietary behavior, about 57% and 96% (respectively) of the studies per review indicated that the interventions were effective. Effectiveness varied by gender and age; some interventions were more effective in girls and younger children. According to this review, interventions focusing on the reduction of sedentary behavior, moderate-to-vigorous physical activity, and parental involvement are promising.

Recent systematic reviews and meta-analyses published since 2015 that examine the effectiveness of school-based interventions are summarized. Wang et al. (2013) conducted a systematic review and meta-analysis to examine the effectiveness of childhood obesity prevention programs that followed participants for at least 1 year. Studies were conducted only in high-income countries. According to this review, at least moderately strong evidence indicated that school-based interventions are effective, including interventions that offer only physical activity and are delivered at school while incorporating home involvement. The evidence also indicated that a combination of physical activity and dietary intervention delivered at school settings and with the involvement of home and community settings is effective. Moderate-quality evidence indicated that school-based interventions focusing on only diet or physical activity delivered at school-only settings are also successful. When comparing single and multiple settings, it was found that multiple settings, especially the combination of school and home, are more likely than school-only settings to be effective. It should also be noted that high heterogeneity was found in the review, so findings should be interpreted with caution.

Hung et al. (2015) conducted a meta-analysis to examine the effects of school-based interventions, including studies that reported BMI or skinfold thickness as outcome measures. It also aimed to examine the effectiveness of each component of school-based interventions and identified 27 studies published between 1982 and 2010 that were conducted in the United States (15), United Kingdom (3), Greece (2), Italy (1), Finland (1), Russian Federation (1), Denmark (1), Chile (1), Switzerland (1), and Australia (1). The study indicated insignificant effects of school-based interventions on the reduction of BMI or skinfold thickness (standardized mean difference = 0.039, 95% CI: −0.013 to 0.092). High heterogeneity was also reported. When looking at subgroup analysis, a randomized, controlled trial design with only one program component (either physical activity or nutrition) can significantly reduce BMI (standardized mean difference = 0.168, 95% CI: 0.085 to 0.252) with no heterogeneity as compared to interventions with multiple components and a nonrandomized study. The study also revealed that the inclusion of a nutrition component with the existing component does not significantly increase the effectiveness of the school-based program. Furthermore, it was found that the duration of the intervention, age, and parental or specialist involvement does not have significant effects on BMI or skinfold outcomes.

With regard to the evidence in low- and middle-income countries, Verstraeten et al. (2012) conducted a systematic review to examine the impact of school-based activities in the primary prevention of obesity in children and adolescents. Twenty-two studies of low or moderate quality were included in the analysis. Due to the high variation across studies, meta-analysis was not conducted. This review found that 82% of the studies (18 of 22) reported significant positive effects of school-based interventions. Only 12 studies examined the effects of school-based interventions on anthropometric outcomes, while the other studies targeted dietary behavior and physical activity outcomes. Of those 12 studies, 8 found that school-based interventions are effective in terms of BMI reduction. Additionally, 7 studies focusing on the impact of school-based interventions in terms of the reduction of obesity prevalence were identified. Of those 7 studies, 3 found that the interventions (combinations of dietary and physical activity) are effective.

Finally, Kong et al. (2016) conducted a systematic review and meta-analysis of school-based nutrition education in the PRC. The meta-analysis identified 17 studies, many of which were of poor quality. It indicated significant effects of intervention on obesity (odds ratio: 0.73; 95% CI: 0.55 to 0.98). Due to the large variation across studies ($I^2 = 90\%$), the results should be interpreted with caution.

9.5.2 Cost-Effectiveness of School-Based Interventions

Cecchini et al. (2010) employed the chronic disease prevention model to examine the cost-effectiveness of several interventions, including school-based interventions, aimed at preventing obesity. The model was applied to seven countries (Brazil, PRC, India, Mexico, Russian Federation, South Africa, and United Kingdom). The cost of implementing school-based interventions ranged from $0.51 to $1.41 (in 2005 $) per student. The effectiveness of school-based interventions was found to be modest; after 50 years of implementation. As compared to food advertising and food labeling regulation they are less likely to be cost-effective.

The cost-effectiveness of school-based interventions was also recently examined in the PRC by Meng et al. (2013). In their study, an economic evaluation alongside a clinical trial was conducted. In Beijing, nine schools were involved in the study. The schools were randomly assigned as follows: three schools to nutrition intervention, three schools to physical activity, and three schools to a combination of nutrition and physical activity. In five other cities, six schools per city were randomly assigned (three schools to a combination of nutrition and physical activity and three schools to serve as controls). The costs per capita were $7.80 to implement nutrition interventions, $7.70 to implement physical activity interventions, and $26.80 to implement a combination of nutrition and physical activity interventions. The study found that school-based interventions are cost-effective, estimating that the cost per a one-point reduction in BMI from combined interventions is about $120. It costs about $1,310 to avoid one overweight and obesity case.

9.5.3 Summary and Recommendations

Despite the popularity of school-based interventions and the availability of numerous studies on the effectiveness of school-based interventions, there is inconclusive evidence on anthropometric outcomes and obesity. Nevertheless, school-based interventions have the potential to be a component in multicomponent strategies to tackle obesity, as they may provide other health benefits as well as help children develop healthy lifestyles regarding eating and physical activity, and these healthy lifestyles may remain throughout their lives.

Many reviews indicated that multicomponent interventions (i.e., a combination of diet and physical activity) involving multiple settings (i.e., school and home) are more effective than single-component interventions delivered in a single setting. However, conflicting findings also exist. A limited number of studies were designed to identify active components or to compare the effectiveness of components; therefore, it is difficult to determine the components that contribute to the effectiveness of the interventions. It should be noted, however, that the effectiveness of the components and characteristics that contribute to the effectiveness of interventions need to be proven before widespread promotion of school-based interventions can be justified. More studies are needed, especially to examine the effectiveness in lower- and middle-income countries, explore gender differences, and note the negative effects of interventions.

Although the number of studies on effectiveness is growing, the few studies on cost-effectiveness clearly show the need for further investigation.

9.6 Conclusion

Although only a small effect in terms of BMI reduction was identified, current evidence consistently shows that SSB taxes are an effective and cost-effective intervention to prevent obesity. In fact, it should be noted that, from a long-term public health perspective, this small effect may represent an important reduction of obesity at the population level.

With respect to nutrition labeling, the current evidence indicates that consumers perceive nutrition labels to be useful and it has significant impact on food selection. Although there is limited evidence on its impact on BMI and obesity prevalence, nutrition labeling is considered a cost-effective intervention in many settings.

Concerning market restrictions for unhealthy food advertisements, there is limited evidence on the impact of restricting unhealthy food advertising on BMI and obesity prevalence. Nevertheless, current evidence indicates that unhealthy food and beverage advertisements may increase dietary intake and the preference for unhealthy foods, especially in children. In addition, it was found that market restrictions on unhealthy food advertising are a cost-effective intervention in many settings.

Due to the limited number of good-quality studies and high variation across these studies, the effectiveness of school-based interventions in terms of BMI reduction and obesity prevalence was inconclusive. When looking at cost-effectiveness evidence, current evidence suggests that school-based interventions are less likely to be a cost-effective strategy. Despite this limitation, school-based interventions should still be recognized as an integral part of strategies to tackle the obesity epidemic. This is especially true for children, because such interventions may result in other health and social benefits. Nevertheless, high-quality studies examining the effectiveness of school-based interventions are needed.

Although numerous studies were conducted to examine the effectiveness of interventions aimed at obesity prevention and control, studies focused on the cost-effectiveness of such interventions are lacking. Nevertheless, the review of economic evaluations of obesity-related policies and interventions found that almost all of the interventions (25 of 27) are economically beneficial (McKinnon et al. 2016).

For both effectiveness and cost-effectiveness studies, most evidence comes from high-income countries, so evidence from low- and middle-income countries and areas are needed. High heterogeneity and the limited number of high-quality studies were commonly observed for several types of interventions. High-quality studies are needed to examine the effectiveness of nutrition labeling, market restrictions on unhealthy food advertisements, and school-based interventions on BMI or obesity. Such studies are vital to support evidence-based policies aimed at tackling the obesity epidemic. Further investigation is also needed to examine the adverse effects of interventions, such as social stigmatization and psychosocial problems.

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Wealthy but Unhealthy

Overweight and Obesity in Asia and the Pacific: Trends, Costs, and Policies for Better Health

Two of five adults in the Asia and Pacific region are overweight or obese. The costs associated with these conditions undermine economic growth as well as the achievement of the United Nations 2030 Sustainable Development Goals, particularly on health. Drawing on a wide array of experts from the region, this book compiles a series of studies examining the trends in and prevalence and economic costs of obesity and overweight, as well as policy recommendations. Giving rise to thought-provoking issues, the book is an invaluable read and sets the foundation for future research and policy making.

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The Asian Development Bank Institute, located in Tokyo, is the think tank of the Asian Development Bank. The institute aims to identify effective strategies to improve policy and development management in Asia and the Pacific. We work with an extensive network of partners in the region and globally to influence policies on poverty reduction, inclusive growth, the environment, regional cooperation, infrastructure development, middle-income countries, and private sector development.

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