ADBI Working Paper Series

ECONOMIC IMPACT OF OBESITY IN THE REPUBLIC OF KOREA

Wankyo Chung

No. 755
July 2017

Asian Development Bank Institute

Wankyo Chung is an associate professor at the Graduate School of Public Health, Seoul National University.

Suggested citation:

Chung, W. 2017. Economic Impact of Obesity in the Republic of Korea. ADBI Working Paper 755. Tokyo: Asian Development Bank Institute. Available: https://www.adb.org/publications/economic-impact-obesity-republic-korea

Please contact the authors for information about this paper.

Email: wankyo@snu.ac.kr

Asian Development Bank Institute
Kasumigaseki Building, 8th Floor
3-2-5 Kasumigaseki, Chiyoda-ku
Tokyo 100-6008, Japan

Tel: +81-3-3593-5500
Fax: +81-3-3593-5571
URL: www.adbi.org
E-mail: info@adbi.org

Abstract

Obesity, defined as abnormal or excessive fat accumulation that may impair health, has a clearly measurable impact on health and health-related quality of life, and generates considerable economic burden. This study builds on previous research by examining the available evidence on obesity, estimating obesity-related medical costs using more representative and reliable data, and estimating obesity-related risk of disability in the Republic of Korea. The obesity rate is higher for males than for females and for the self-employed (including their dependents) than for employed adults (including their dependents) in the Republic of Korea. The obesity rate shows a weak U-shaped pattern in relation to income for employed adults. It has been growing over time, especially among younger adults and adolescents, indicating greater obesity in the future. Obesity (relative to having a BMI <25) is shown to be associated with about 5,000 won (in 2010 won) higher medical costs for male adults and about 77,000 won (in 2010 won) higher medical costs for female adults. Severe obesity (relative to having a BMI <30) increases medical costs far more than obesity for both males and females, indicating higher cost effects for the few who are severely obese. Moreover, obesity is shown to have increased medical costs far more for relatively unhealthy individuals at higher percentiles of medical costs. When these estimated effects of obesity in increasing medical costs were used to estimate obesity-related aggregate medical costs in the Republic of Korea, they were 35.8 billion won (in 2010 won) for males and 306.5 billion won (in 2010 won) for females. Furthermore, obesity is positively associated with disability, indicating another cost of obesity. Therefore, obesity is associated with a significant economic burden in terms of medical costs and disability in the Republic of Korea.

JEL Classification: I12, I18

Contents

1. INTRODUCTION

The Republic of Korea experienced a growth in real GDP from 27.3 trillion won in 1960 to 1,463.8 trillion won (at 2010 GDP price) in 2015. Although the population increased simultaneously from 25 million to 50.6 million, real per-capita GDP increased from about 1.1 million won to 28.9 million won (see Appendix Table 1). Due to this economic growth, the Republic of Korea's per-capita GDP was 34,510 US$ (using purchasing power parity) in 2015, and was ranked 22nd out of 35 OECD countries (OECD 2016).[1]

Demographically, the share of the elderly aged 65 and over increased from 2.9% in 1960 to 13.1% in 2015. This change reflects the decline in fertility from 6 in 1960 to 1.2 (children per women aged 15 to 49 years old) in 2014 and the increase in life expectancy at birth from 52.4 years in 1960 to 82.2 years in 2014 (OECD 2016).

Aside from economic and demographic changes, national health insurance was introduced in 1977 and expanded to universal coverage in 1989. Driven by these changes, real per-capita health expenditure increased significantly from 56,116 won (2010=100) in 1970 to 2,000,531 won in 2014 and thus the share of national health expenditure in GDP increased from 2.67% in 1970 to 7.07% in 2014 (OECD 2016).

As one of the essential factors contributing to the rising medical costs and challenging financial stability of the national health insurance scheme, overweight and obesity are defined as abnormal or excessive fat accumulation that may impair health. In 2014, more than 1.9 billion adults (39% of the world's adults) aged 18 years and older were overweight (BMI>=25) and over 600 million adults (13%) were obese (BMI>=30) (WHO 2016a). Compared with other countries, the Republic of Korea shows a lower level of overweight and obesity. In 2014, the Republic of Korea ranked 55th out of 192 countries with 33.5% of adults aged 18 years and older being overweight (BMI>=25, age-standardized estimate) (WHO 2016b). However, the Republic of Korea's prevalence of overweight and obesity rose from 25.8% in 1998 to 31.5% in 2014 for adults aged 19 and over.

Overweight and obesity are one of the leading global risks for mortality in the world, responsible for 4.8% of deaths globally (WHO 2009). The WHO estimated them to be the third-highest risk factor among high-income countries including the Republic of Korea (those with 2004 gross national income per capita in excess of US$10,066), responsible for 8.4% of deaths. Obesity also has a clearly measurable impact on physical and mental health, and health-related quality of life, and generates considerable direct and indirect costs (Dixon 2010).

Many studies have estimated the economic burden of obesity (Finkelstein et al. 2009; Thorpe et al. 2004; Cawley and Meyerhoefer 2012). The most recent such 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 that estimated previously (Cawley and Meyerhoefer 2012). For example, while Finkelstein et al. (2009) estimated that annual medical spending on the obese was $1,429 (in 2008 dollars or 41.5%) higher than that on healthy-weight individuals, Cawley and Meyerhoefer (2012) showed that obesity increased annual medical costs by $2,741 (in 2005 dollars).

---

[1] The 35 OECD countries in the order of per-capita GDP in 2015 were Luxembourg, Norway, Switzerland, the United States, Ireland, the Netherlands, Austria, Australia, Germany, Sweden, Denmark, Iceland, Canada, Belgium, Finland, the United Kingdom, France, New Zealand, Japan, Italy, Spain, the Republic of Korea, Israel, the Czech Republic, Slovenia, Portugal, the Slovak Republic, Estonia, Greece, Poland, Hungary, Latvia, Chile, Turkey, and Mexico.

Even though few studies have focused on the economic burden of obesity in the Republic of Korea, four appear to be important to mention. 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 a higher BMI increased the hazard ratio of death, especially vascular mortality. Lee et al. (2012) estimated that medical costs due to 16 obese-related diseases were 2,128 billion won in the Republic of Korea, 4.6% of the total cost of national health insurance in 2011. Lee et al. (2015) divided obesity into obesity (25<=BMI<30) 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<=BMI<23). The estimated obesity-related medical costs were 1,142 billion won (in 2013 won) for males and 1,952 billion won (in 2013 won) for females.

This study builds on previous research by examining the available evidence on obesity, estimating obesity-related medical costs using more representative and reliable data, and estimating obesity-related risk of disability. A better and more reliable estimation of the economic burden of obesity will help us to develop and prioritize appropriate health interventions to reduce obesity.

2. TRENDS OF OBESITY

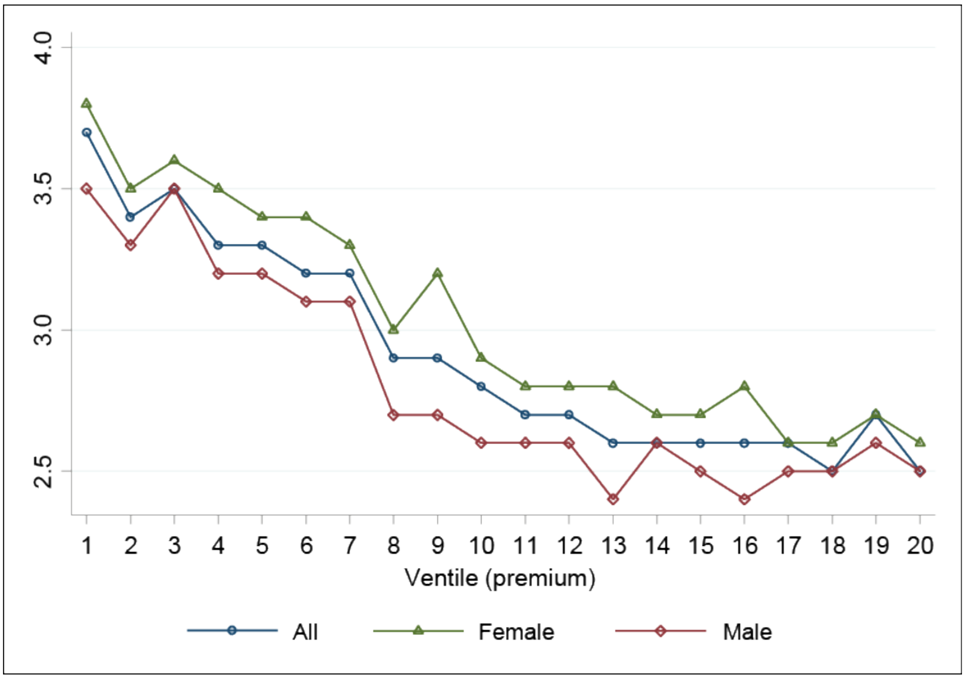
Obesity is a state of excessive body fat accumulation, which is difficult to measure. Body mass index [BMI, defined by weight (kg)/height (m)^2] has been used traditionally for its simplicity and data availability. Although shortcomings of BMI have been acknowledged, its correlation with the percentage of body fat and sensitivity in diagnosing obesity based on the percentage of body fat have been verified for citizens of the Republic of Korea (Chung, Park and Ryu 2016).

Obesity of infants aged 4–71 months is calculated based on those who took a health examination between 2012 and 2015. There were between 1.64 and 2.04 million infants approximately for each year from 2012 to 2015. For infants aged from 4 to 24 months (three groups of 4–6, 9–12, and 18–24 months), overweight alone was defined by being greater than or equal to the 95th percentile of weight-for-height. For infants aged from 30 to 71 months (four groups of 30–36, 42–48, 54–60, and 66–71 months), overweight was defined as 1.04<=BMI z-score <1.65 and obesity was defined as 1.65<=BMI z-score (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. When infants were divided by gender, overweight and obesity rates were higher for female than for 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, 8.9% and obesity rates were 2.9, 2.9, 3.1, and 2.9 % (NHIS 2016).

Interestingly, the obesity rate increased with months among 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 it declined with household income, proxied by ventiles of insurance premium (see Figure 1 and Appendix Table 2). The obesity rates were 3.7% at the first ventile but declined sharply to 2.6% at the 13th ventile and further down to 2.5% at the 20th ventile. When infants were divided by gender, the same declining pattern appeared, while the 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.

Figure 1: Distribution of Infant (30–71 Months) Obesity across Income in 2015



Source: National Health Insurance Service (2016).

Child obesity among children aged 6–18 years was defined by BMI (>=25 or >=95 percentiles for each age) and calculated based on data from students' health examinations at primary, junior high, and high schools (see Table 1).[2] The 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. The 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 those 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, the 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%. And male students showed higher obesity rates than female ones. In 2015, male versus female obesity rates were 9.5% and 8.5% for students at primary schools, 17.0% and 10.5% for those at junior high schools, and 23.3% and 15.3% for those at high schools.

Adult obesity is defined as a BMI of 25 or more based on the suggestion by the Korean Society for the Study of Obesity, and understanding that those from the Republic of Korea develop negative health consequences at a lower BMI. Data from the Korea National Health and Nutrition Examination Survey (KNHANES) are used to describe the trends of obesity, where measured weight is available to reduce bias due to measurement errors, for the total noninstitutionalized civilian population in the Republic of Korea (Kim 2014).

2 Sample size ranges from 82,581 (756 schools) to 194,065 students (749 schools).

Table 1: Child Obesity Rate (%) by Schools
(6–18 years old, 2009–2015)

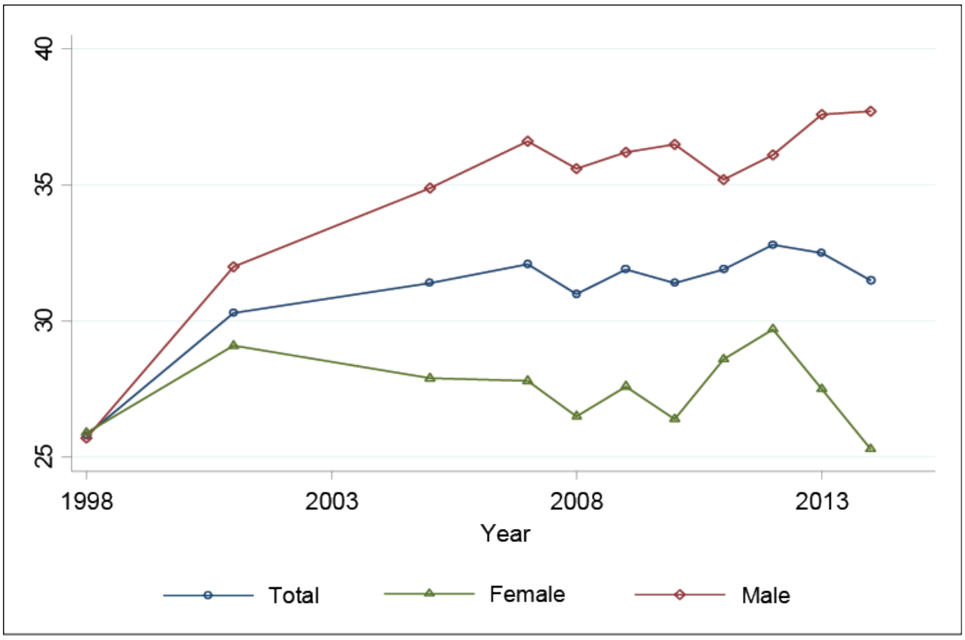
Year	Primary School	Junior High School	High School
2009	8.0	12.7	15.7
2010	8.3	12.6	16.3
2011	8.5	12.6	15.8
2012	9.0	13.2	16.5
2013	9.0	13.7	17.5
2014	8.9	13.5	18.2
2015	9.0	13.9	19.5

Source: Data from students' health examination at primary, junior high, and high schools.

In 2014, 31.5% of adults aged 19 and over were obese. Males showed a higher obesity rate of 37.7% than females at 25.3%. Obesity increased with age from 23.9% for those aged 19–29 to 31.8% for those aged 30–39, 31.1% for those aged 40–49, 35.4% for those aged 50–59, 36.8% for those aged 60–69, and 32.1% for those aged 70 and over.

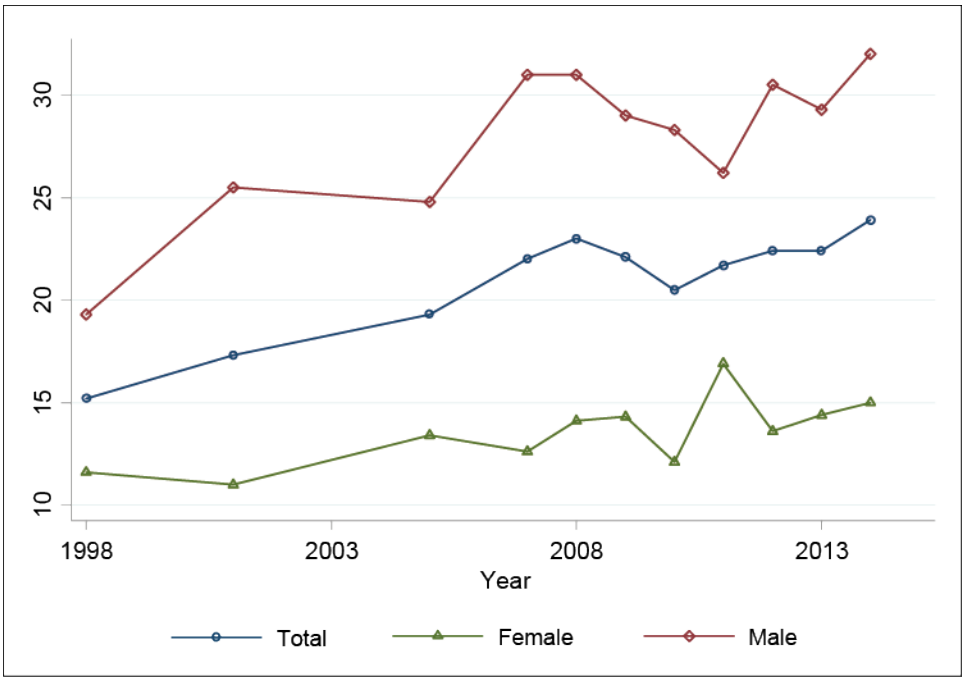
Figure 2 shows that adult obesity increased over time from 25.8% in 1998 to 31.5% in 2014 (see Appendix Table 3). This increase is driven by changes among males rather than females, because while male obesity increased from 25.7% to 37.7%, female obesity fluctuated between 25.9% and 25.3%. When the sample is limited to younger adults from 19 to 29 years old in Figure 3 (see Appendix Table 4), both males and females show an increasing trend during the period, pointing to greater obesity in the future. Obesity in younger adults increased from 15.2% in 1998 to 23.9% in 2014, with both male and female obesity increasing, from 19.3% to 32% and from 11.6% to 15%, respectively, during the period.

Figure 2: Trends of Adult Obesity from 1998 to 2014
(age>=19, BMI>=25)



Source: The Korea National Health and Nutrition Examination.

Figure 3: Trends of Young Adult Obesity from 1998 to 2014
(19<=age <=29, BMI>=25)



Source: The Korea National Health and Nutrition Examination.

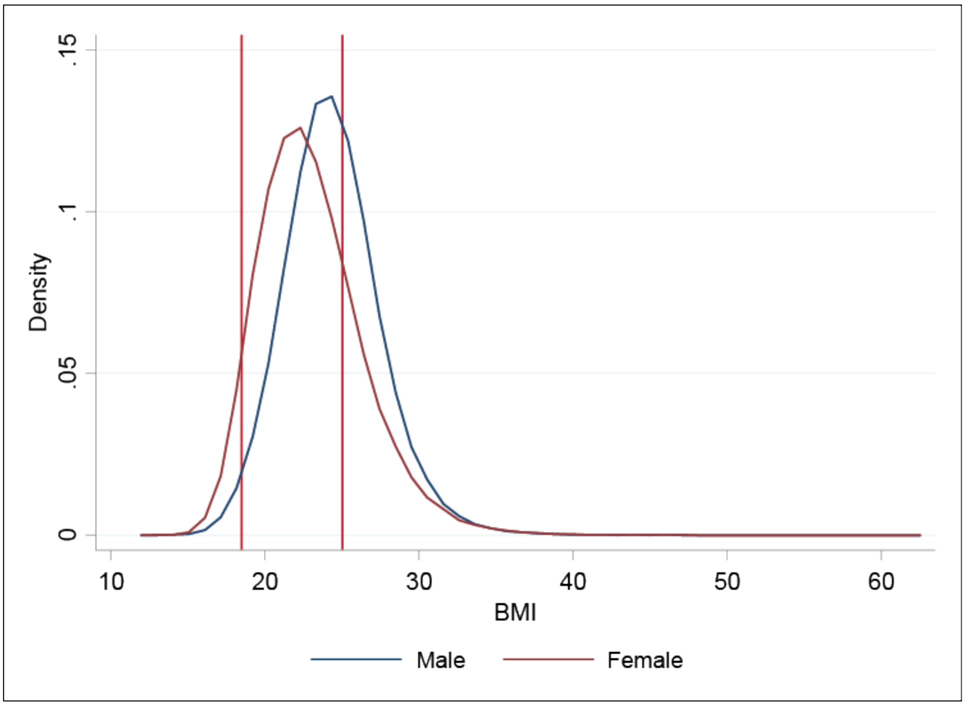
Although KNHANES is useful for describing the trends in obesity, it has a very small sample size—for example, 5,632 adults for 2014—for studying the distribution of obesity in detail. Instead, we use the National Health Insurance Service-National Sample Cohort (NHIS-NSC) database for studying the distribution of obesity, which has a representative sample of 1,025,340 individuals, 2.2% of the total eligible population from the Republic of Korea in 2002 (Lee et al. 2016). Although it currently comprises panel data following the same cohort over time from 2002 to 2013, we use data only from the years 2009 to 2013 because the sample that underwent a health examination changed considerably in 2008 and the health examination questionnaire changed in 2009.

The NHIS-NSC database contains variables to measure obesity from a nationwide health examination. The number of individuals who took the health examination totaled 211,541, 228,746, 235,336, 241,397, and 234,478, respectively, in the years from 2009 to 2013. They represent 21–24% of the total number of individuals in the sample cohort. Some individuals took the health examination more than once, and even up to five times, from 2009 to 2013. We limited the study sample to those who took the health examination once and randomly selected one of the health examinations for those who took the health examination more than once. The study sample comprises 416,330 individuals, distributed from 17.6 to 22.4 % between 2009 and 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, which is 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 4. The density shifts to the right for males with a greater peak at a higher value of BMI.

The average male BMI is 24.4 (ranging from 12.8 to 62.3) and the average female BMI is 23 (ranging from 12.2 to 50.8). Two vertical lines are drawn, one at 18.5 to divide underweight from normal weight and the other at 25 to divide obesity from normal weight.

Figure 4: Density of Adult Obesity
(age>=20, 2009–2013)

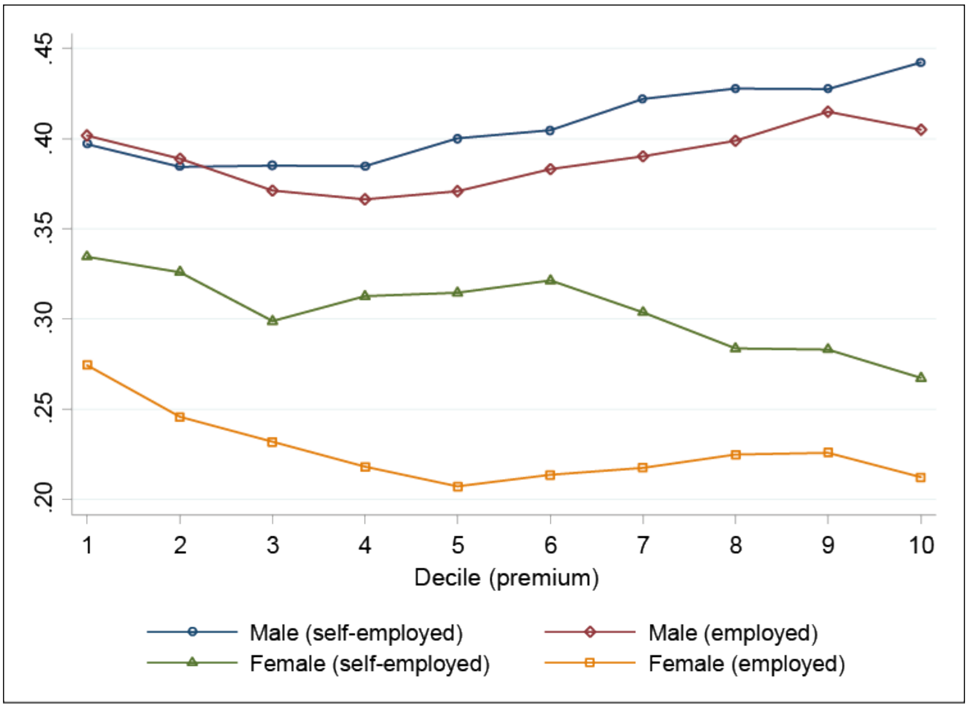


Source: National Health Insurance Service-National Sample Cohort (NHIS-NSC) database.

Interestingly, Figure 5 shows the distribution of obesity across income (see Appendix Table 5). We divided the sample between males and females because of their difference in obesity and regulation of energy homeostasis (Lovejoy, Sainsbury, and the Stock Conference 2008 Working Group 2009) and working status between self-employed workers and employed workers because health insurance premium, proxy for income (income is not directly available in the NHIS-NSC database), is calculated differently between the two. Health insurance premium is calculated based on the monthly income for 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 a higher income or wealth.

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

Figure 5: Distribution of Adult Obesity across Income
(age>=20, BMI>=25, 2009–2013)



Source: National Health Insurance Service-National Sample Cohort (NHIS-NSC) database.

For males, the self-employed (45,431 individuals) present a higher obesity rate than the employed (163,972 individuals) except for the first and second deciles. The obesity rate for 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% at 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 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 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 with both male and female employed workers.

Table 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 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 17 areas.

Table 2: Adult Obesity Rate (%) **by Areas**
(20 and over years old, 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

Source: Statistics Korea for population and National Health Insurance Service-National Sample Cohort (NHIS-NSC) database for obesity.

3. RISK FACTORS

The fundamental cause of obesity is an imbalance between calories consumed and calories expended. According to the National Institutes of Health of the US, other causes include an inactive lifestyle, an environment not supporting healthy lifestyle habits, genes and family history, health conditions, medicines, emotional factors, smoking, age, pregnancy, and a lack of sleep. We review some studies on the causes of obesity in the Republic of Korea.

Lee et al. (2014b) used dietary intake data of 33,745 subjects aged one year and over from KNHANES 2008–2011 to estimate total sugar intake and identify major food sources of sugar intake in the diet of the Republic of Korea's population. Their results showed that the mean total sugar intake was 61.4 g/person/day, corresponding to 12.8% of total daily energy intake and more than half of this amount (35.0 g/day) was from processed foods. The top 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 g/day) and second highest for young adults (19 to 29 years, 68.4 g/day) with a higher beverage intake but lowest for seniors aged 65 and over (39.1 g/day) and second lowest for children (1 to 2 years, 50.7 g/day).

Ma, Park and Kong (2015) studied the association between family meals and childhood obesity using 247 elementary students in one province of Gyeonggi-do in the Republic of Korea. The results showed that no breakfast or less frequent family breakfast meals, and more dining out, were positively associated with body mass index standard deviation score (BMI-SDS, 2007 Korean National Growth Charts).

Another study examined the association between dairy products and calcium intake and obesity for adults aged 19–64 from KNHANES 2007–209 (Lee et al. 2014a). It showed that a higher frequency of dairy product intake was associated with a reduced prevalence of obesity (OR=0.63; 95% CI=0.45–0.89 for ≥2 times/day vs. ≤1 time/month). Similarly, a 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 of the components contributing to the association. Meanwhile, Oh et al. (2017) showed that the prevalence of obesity increased with a diet deficient of protein intake for those aged 60 and over in the Republic of Korea.

With regard to physical inactivity, Kong et al. (2015) studied its association with 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 intakes. They used data on 63,111 adolescents from the 2013 Korea Youth Risk Behavior Web-based Survey. They defined overweight/obesity as a body mass index >=85th percentile and a high intake of fruits and vegetables 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 intake for socially disadvantaged girls should be prioritized as a means to prevent adolescent overweight/obesity.

4. OBESITY-RELATED MEDICAL COSTS

Obesity has a clearly measurable impact on health and generates considerable costs (Dixon 2010). Epidemiologists use the population attributable fraction to estimate the disease burden that could be eliminated together with obesity. The population attributable fraction can be defined as follows:

$$Population\ Attributable\ Fraction\ 1 = (Pe(RR-1)/[(Pe(RR-1)+1],$$

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 used is:

$$Population\ Attributable\ Fraction\ 2 = pd[((RR-1)/RR],$$

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, Panagiotou, and Graubard 2015; Rockhill 1988).

Lee et al. (2015) used PAF 1 for the estimation of obesity-related medical costs in the Republic of Korea. They divided obesity into obesity (25<=BMI<30) 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<=BMI<23). They estimated obesity-related medical costs of 1,142 billion won (in 2013) for males and 1,952 billion won for females in the Republic of Korea. However, they made a computational error in using adjusted RR in the PAF 1 equation. In addition, Rowe, Powell, and Flanders (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.

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 chose to use 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.

We use the NHIS-NSC database, which contains variables of obesity, medical costs, and other confounding factors. The study sample comprises 416,330 individuals, distributed from 17.6 to 22.4 % between the years 2009 and 2013. We estimate obesity-related medical costs for males and females, separately. They are different from each other in terms of obesity and regulation of energy homeostasis (Lovejoy, Sainsbury, and the Stock Conference Working Group 2009) and in labor force participation, leading to different medical uses. We limit the study sample to adults aged from 20 to 64, because of the dramatic changes in weight and/or medical costs expected for others.

Table 3 shows descriptive statistics for male adults (209,403 individuals). The average medical cost (including 0 medical cost) was about 514,000 won (in 2010) and 99.6% of it was spent on medical care.[4] The average BMI was 24.39 and 39.7% of adult males were obese as defined by BMI>=25 and 4.5% were severely obese as defined by BMI>=30. The average weight was 71.22 kg and the average height was 1.71 m, and they are correlated by 0.51 (p=0.00). Some 70.8% of adult males were current or former smokers, 43.8% drank alcohol more than twice a week, and 29.6% exercised more than 2 days per 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 males aged 20–64.

[4] Each year’s medical cost values were deflated to 2010 won using the medical component of the Consumer Price Index.

Table 3: Descriptive Statistics of Male Adults
(age>=20, 2009–2013)

	Mean	Std. Dev.	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
Being obese (=1 if BMI>=25)	0.397	0.489	0	1
Being severely obese (=1 if BMI>=30)	0.045	0.207	0	1
Weight (KG)	71.22	10.667	30	162
Height (M)	1.71	0.063	1.06	1.99
Smoking (current or former)	0.708	0.455	0	1
Drinking (>=2 days per week)	0.438	0.496	0	1
Exercise (>=2 days per week, >=20 min)	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)	0.13	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
No. of Obs.	209,403			

Source: National Health Insurance Service-National Sample Cohort (NHIS-NSC) database.

Similarly, Table 4 presents descriptive statistics for female adults (206,927 individuals). Their medical costs (including 0 medical cost) amounted to about 597,000 won (in 2010) and 99.8% of them were spent on medical care. Note that the medical costs were greater among females on average. The average BMI was 23.02, and 24.6% of adult females were obese as defined by BMI>=25, much lower than the male obesity rate of 39.7%, and 3.5% of adult females were severely obese as defined by BMI>=30, still lower than the male severe obesity rate of 4.5%.[5] The average female weight was 57.29 kg and the average height was 1.58 m, and these are correlated by 0.27 (p=0.00), weaker than their correlation for males. Some 6.4% of adult females were current or former smokers, 12% drank alcohol more than twice a week, and 20.9% exercised 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] For comparison, the prevalence of obesity (as defined by BMI>=30) was 32.2% among 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) was 72.3% among US adult men and 64.1% among US adult women (Flegal et al. 2010).

Table 4: Descriptive Statistics of Female Adults
(age>=20, 2009–2013)

	Mean	Std. Dev.	Min	Max
Cost (1,000 won, 2010 년=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
Being obese (=1 if BMI>=25)	0.246	0.431	0	1
Being severely obese (=1 if BMI>=30)	0.035	0.183	0	1
Weight (KG)	57.29	8.617	26	141
Height (M)	1.58	0.057	1.1	1.91
Smoking (current or former)	0.064	0.244	0	1
Drinking (>=2 days per week)	0.12	0.325	0	1
Exercise (>=2 days per week, >=20 min)	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
No. of Obs.	206,927			

Source: National Health Insurance Service-National Sample Cohort (NHIS-NSC) database.

Table 5 presents marginal effects of obesity on medical costs using OLS estimation. 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 costs by about 39,000 and is statistically significant at 5%. For females, obesity increases medical costs by about 100,000 won and severe obesity increases medical costs by 228,000 won. Both are statistically significant at 1%.

Note that the obesity effect is estimated while controlling for other related factors: smoking, drinking, exercise, nine age category dummies, 17 area dummies, five year dummies, 10 insurance premium dummies, and four categories of insurance-type dummies (the employee insured, the dependents of the employee insured, household head of the self-employed insured, other householders of the self-employed insured).[6] Among other factors, smoking increases medical costs for both males and females (statistically significant at 1% both for males and females), and exercise decreases medical costs for both males and females (statistically significant at 10% for males and 1% for females). However, drinking decreases medical costs 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.

[6] The categories of the 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: Marginal Effects of Obesity on Medical Costs
(age>=20, 2009–2013, in 2010 won)

	OLS				TPM (Logit, GLM [Gamma, log])			
	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)
No. of Obs.	209,403	209,403	206,927	206,927	209,202	209,202	204,663	204,663

Adjusted for smoking, drinking, exercise, nine dummies for age, 17 dummies for area, five dummies for year, 10 dummies for insurance premium, and four 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 (NHIS-NSC) database.

While the OLS results suggest higher medical costs for obesity, we use a two-part model to confirm the results (Jones 2000). The first part of the two-part model estimates the probability of positive medical costs and the second part estimates the level of medical costs conditional on positive costs. We use a logit mode for the first part and a Gamma Generalized Linear Model (GLM) with log link for the second part, following Cawley and Meyerhoefer (2012). The GLM can provide consistent estimation of obesity effects while the OLS-based model for logged medical costs provides inconsistent estimation unless the degree and form of heteroscedasticity are known to retransform the estimates (Manning and Mullahy 2001).

The second panel of Table 5 presents marginal effects of obesity, reflecting both parts of the two-part model.[7] For males, obesity (relative to having a BMI<25) increases medical costs by about 5,000 won and severe obesity (relative to having a BMI<30) increases medical costs by about 58,000 won. Again, only the latter is statistically significant at 1%. For females, obesity increases medical costs by about 77,000 won and severe obesity increases medical costs by about 169,000 won. Both are statistically significant at 1%. Severe obesity (relative to having a BMI<30) increases medical costs far more than obesity (relative to having a BMI<25) for both males and females, indicating higher marginal cost effects for the few that are 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 to be 35.8 billion won [in 2010 won, =0.397 (obesity rate in Table 1)*16,716,667 (average number of males aged 20 to 64 from 2009 to 2013)*5,400 won (marginal effect of obesity in Table 5)] and the aggregate medical cost of severe obesity was 43.6 billion won (=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 won (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 won (=0.035*16,117,986*169.1) on average from 2009 to 2013.

[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 the exclusion of observations with all positive values of medical costs in an area for the first part and exclusion of observations with zero cost for the second part.

When compared between males and females, the aggregate medical cost of female obesity is much higher than that of male obesity—8.55 times from 35.8 to 306.5 billion won—due to a higher marginal effect of obesity on female medical costs. Even for the aggregate medical cost of severe obesity, females show higher values than males—2.19 times from 43.6 to 95.4 billion won. These estimated aggregate costs are much lower than those estimated by Lee et al. (2015), who used an epidemiological approach.[8] 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 population size from 2009 to 2013 and inflated the estimated costs to 2013 won by the medical care component of the Consumer Price Index. The recalculated aggregate medical cost of obesity was 55 billion won for males and 486.3 billion won for females. These values were still lower than the 1,142 billion won for males and 1,952 billion won for females in Lee et al. (2015).

We next examine the differential marginal effect of obesity across the distribution of medical costs in Table 6. For males, obesity increases medical costs by 2.7, 7.8, 14.8, 23.0, and 33.7 thousand won (in 2010 won) at the 10th, 25th, 50th, 75th, and 90th percentiles of medical cost. For females, obesity increases medical costs by 4.1, 9.7, 23.9, 64.4, and 216.8 thousand won (in 2010) at the respective percentiles of medical cost. All are statistically significant at 1%. Therefore, obesity increases medical costs far more for relatively unhealthy individuals at higher percentiles of medical cost. Similarly to the results in Table 3, females show a higher marginal effect of obesity at each percentile of medical cost.[9]

Table 6: Marginal Effects of Obesity at Different Percentiles of Medical Cost
(age>=20, 2009–2013, in 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)

Adjusted for smoking, drinking, exercise, nine dummies for age, 17 dummies for area, five dummies for year, 10 dummies for insurance premium, and four 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 (NHIS-NSC) database.

[8] Aside from the methodology, Lee et al. (2015) used a different sample, year, and source of data.

[9] Although not shown in the table, severe obesity increases medical costs by 3.5, 8.1, 20.8, 40.7, and 126.3 thousand won in 2010 at the respective percentiles of medical cost for males, and it increases medical costs by 6.3, 17.2, 42.5, 112.8, and 445.9 thousand won at the respective percentiles of medical cost for females. All are statistically significant at 1%.

5. OBESITY-RELATED DISABILITY

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

The NHIS-NSC database provides data on moderate and severe disability (grade 1~6). Out of 209,403 male adults aged 20 to 64, 5.3% had a disability (0.67% having a severe disability + 4.64% having a moderate disability), while out of 206,927 female adults aged 20 to 64, 3% had a disability (0.41% having a severe disability + 2.57% having a moderate disability). The binary outcome of having a disability is used in a logistic estimation, controlling for the same risk factors used in the tables above, such as smoking, drinking, exercise, nine age categories, 17 area dummies, five year dummies, 10 insurance premium dummies, and four categories of insurance-type dummies.

Table 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. However, 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. Similarly to medical costs, disability shows a stronger association with obesity or severe obesity among females than males.

Table 7: Effects of Obesity on Disability
(Odds Ratio from logistic regression, age>=20, 2009–2013)

	Male		**Female**	
Obesity	1.032		1.434***	
	(0.021)		(0.039)	
Severe Obesity		1.173***		1.975***
		(0.057)		(0.099)
No. of Obs.	209,403	209,403	206,927	206,927

Adjusted for smoking, drinking, exercise, nine dummies for age, 17 dummies for area, five dummies for year, 10 dummies for insurance premium, and four 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 (NHIS-NSC) database.

6. CONCLUSION

The infant obesity rate was 2.8% in 2015 and it was higher for female infants. It increased with months among infants but declined with household income, proxied by ventiles of insurance premium. Child obesity increased with age and over time from 2009 to 2015, and male students presented a higher obesity rate than female ones.

The obesity rate is higher for male than for female adults and for the self-employed (including their dependents) than for employed adults (including their dependents). The obesity rate shows a weak U-shaped pattern in relation to income for employed adults. It has been growing over time, especially for males and younger adults, indicating greater obesity in the future.

After selecting a reliable data and estimation model, obesity (relative to having a BMI <25) is shown to be associated with about 5,000 won (in 2010 won) higher medical costs for male adults and about 77,000 won higher medical costs for female adults. Severe obesity (relative to having a BMI <30) increases medical costs far more than obesity for both males and females, indicating higher cost effects for the few that are severely obese. Moreover, obesity is shown to have increased medical costs far more for relatively unhealthy individuals at higher percentiles of medical costs.

When the estimated effects of obesity in increasing medical costs were used to estimate obesity-related aggregate medical costs in the Republic of Korea, they were 35.8 billion won (in 2010 won) for males and 306.5 billion won for females. Furthermore, obesity is positively associated with disability, indicating another cost of obesity. Therefore, obesity is associated with a significant economic burden in terms of medical costs 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 costs (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 and more reliable estimation of the economic burden of obesity will help us to develop and prioritize appropriate health interventions to reduce obesity. The OECD (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.

While the concerned ministries (especially the Ministry of Health and Welfare and the Ministry of Education) and laws (about 25 laws) have introduced many interventions to improve diets and increase physical activity in the Republic of Korea, they are assessed as being uncoordinated and focused on children (Kim et al. 2009; Lee et al. 2015). For example, the Ministry of Health and Welfare provides budget support for local governments' obesity programs, develops educational materials and publicizes them, and provides vouchers for management services related to the physical activity and diet of obese children. The National School Lunch Act, introduced in 1981, has provisions on school dietitians, nutritional requirements, and dietary consultation. However, it is noteworthy that combining interventions in a multiple-intervention strategy would provide an affordable and cost-effective solution, significantly enhancing health gains relative to isolated actions (OECD 2010).

REFERENCES

Burkhauser R.V. and J. Cawley (2004), Obesity, disability, and movement onto the Disability Insurance rolls, University of Michigan Retirement Research Center, WP 2004-089.

Cawley, J. and C. Meyerhoefer (2012), The medical care costs of obesity: an instrumental variables approach, Journal of Health Economics, 31.

Chung W., C.G. Park, and O. Ryu (2016), Association of a new measure of obesity with hypertension and health-related quality of life, PLoS One, 11(5): e0155399.

Dixon, J.B. (2010), The effect of obesity on health outcomes, Molecular and Cellular Endocrinology 316(2):104–8.

Finkelstein E.A., J.G. Trogdon, J.W. Cohen, and W. Dietz (2009), Annual medical spending attributable to obesity: payer- and service-specific estimates, Health Affairs, 28(5): w822–31.

Flegal K.M., M.D. Carroll, C.L. Ogden, L.R. Curtin (2010), Prevalence and trends in obesity among US adults, 1999–2008, Journal of the American Medical Association 303(3):235–41.

Flegal K.M., O.A. Panagiotou, and B.I. Graubard (2015), Estimating population attributable fractions to quantify the health burden of obesity, Annals of Epidemiology, 25: 201–7.

Hong S., S. Yi, J.W. Sull, J.S. Hong, S.H. Jee, and H. Ohrr (2015), Body mass index and mortality among Korean elderly in rural communities: Kangwha Cohort Study, PLoS One, 10(2): e0117731.

Howard J.T. and L.B. Potter (2014), An assessment of the relationships between overweight, obesity, related chronic health conditions and worker absenteeism, Obesity Research & Clinical Practice, 8(1):e1–e15.

Jee S.H., J.W. Sull, J. Park, S. Lee, H. Ohrr, E. Guallar, and J.M. Samet (2006), Body-mass index and mortality in Korean men and women, New England Journal of Medicine, 355:779–87.

Jones A. (2000), Health Econometrics, Chapter 6 in Anthony J. Culyer and Joseph P. Newhouse, editors, Handbook of Health Economics, Volume 1A, pp. 265–336.

Kim H., Y. Kang, N. Kwark, E. Kang, and E. Kim (2009), Trends in Obesity and Comprehensive Policy Strategy to Prevent Obesity in Korea, research paper 2009–07 (in Korean), Korea Institute for Health and Social Affairs.

Kim Yuna (2014), The Korea National Health and Nutrition Examination Survey (KNHANES): Current Status and Challenges, Epidemiology and Health, 36:e2014002.

Kong I.G., H.J. Lee, S.Y. Kim, S. Sim, and H.G. Choi (2015) Physical activity, study sitting time, leisure sitting time, and sleep time are differently associated with obesity in Korean adolescents: a population-based study. Medicine 94(44):e1965.

Lakdawalla D.N., J. Bhattacharya, and D.P. Goldman (2004), Are the young becoming more disabled? Health Affairs, 23(1): 168–176.

Lee H.J., J. Cho, H. Lee, C. Kim, and E. Cho (2014a) Intakes of Dairy Products and Calcium and Obesity in Korean Adults: Korean National Health and Nutrition Examination Surveys (KNHANES) 2007–2009, PLoS One 9(6): e99085.

Lee H.S., S.O. Kwon, M. Yon, D. Kim, J.Y. Lee, J. Nam, S.J. Park, J.Y. Yeon, S.K. Lee, H.Y. Lee, O.S. Kwon, and C.I. Kim (2014b), Dietary total sugar intake of Koreans: based on the Korea National Health and Nutrition Examination Survey (KNHANES), 2008–2011., Journal of Nutritional Health, 47(4):268–276.

Lee S., Y. Yoon, G. Hyun, and E. Lee, (2012), How to tax on health risk factors to obtain financial stability of National Health Insurance, research paper (in Korean), 2012-08, Health Insurance Policy Institute, National Health Insurance Service.

Lee S., Y. Yoon, J. Baek, G. Hyun, and H. Kang, (2015), Socioeconomic impact of major health risk factors and evaluation of their regulatory policy, Research paper (in Korean), 2015-1-0009, Health Insurance Policy Institute, National Health Insurance Service.

Lee, J., J.S. Lee, S.H. Park, S.A. Shin, , and K. Kim, (2016), Cohort Profile: The National Health Insurance Service-National Sample Cohort (NHIS-NSC), South Korea. International Journal of Epidemiology; doi:10.1093/ije/dyv319.

Lovejoy J.C., A. Sainsbury, and the Stock Conference Working Group (2009), Sex differences in obesity and the regulation of energy homeostasis, Obesity Reviews, 10(2): 154–67.

Ma S.Y., H.J. Park, and E.H. Kong (2015), The relation between the frequency of family gathered meals and the Body Mass Index-Standard Deviation Score in Elementary Students, The Korean Journal of Obesity, 24(1):51–8.

Manning W.G. and J. Mullahy (2011), Estimating log models: to transform or not to transform? Journal of Health Economics, 20(4): 461–94.

National Health Insurance Service (2016), 2016 A White Paper on Obesity, Wonju Korea.

OECD (2010), Obesity and the Economics of Prevention: Fit not Fat, OECD Publishing, Paris.

OECD (2016), OECD.Stat, (database) (accessed 11 January 2017).

Oh C., B.H. Jeon, S.N.R. Storm, S. Jho, and J. No (2017), The most effective factors to offset sarcopenia and obesity in the older Korean: physical activity, vitamin D, and protein intake, Nutrition 33:169–73.

Rockhill B., B. Newman, and C. Weinberg (1998), Use and misuse of population attributable fractions, American Journal of Public Health, 88:15–19.

Rowe A.K., K.E. Powell, W.D. Flanders (2004), Why population attributable fractions can sum to more than one, American Journal of Preventive Medicine, 26(3):243–249.

Thorpe K.E., C.S. Florence, D.H. Howard, and P. Joski (2004), The impact of obesity on rising medical spending, Health Affairs, 23(6):W4480–4486.

World Health Organization (2009), Global Health Risks: Mortality and Burden of Disease Attributable to Selected Major Risks (WHO Press, Geneva).

World Health Organization (2016a), Fact Sheet on Obesity and Overweight, updated June 2016. (WHO Press, Geneva).

World Health Organization (2016b), Global Health Observatory data repository, updated February 2015. (WHO Press, Geneva).

You J and J. Choo (2016), Adolescent overweight and obesity: links to socioeconomic status and fruit and vegetable intakes, International Journal of Environmental Research and Public Health, 13(3).

APPENDIX

Appendix Table 1: Economic, Demographic and Health Expenditure Trends of the Republic of Korea (1960–2015)

Year	Real GDP (2010=100), Million Won	Real per-capita GDP (2010=100), Won	Population, Thousands	Share of the Elderly, %	Real per-Capita Health Expenditure, Won (2010=100)	Health Expenditure Share of GDP
1960	27,305,008	1,091,660	25,012	2.9		
1961	29,184,235	1,132,679	25,766	2.9		
1962	30,304,612	1,143,008	26,513	3		
1963	33,089,704	1,213,778	27,262	3		
1964	36,219,772	1,294,296	27,984	3		
1965	38,821,707	1,352,453	28,705	3.1		
1966	43,473,916	1,476,918	29,436	3.1		
1967	47,437,372	1,574,372	30,131	3.1		
1968	53,693,715	1,741,137	30,838	3		
1969	61,501,442	1,949,687	31,544	3		
1970	67,649,998	2,098,271	32,241	3.1	56,116	2.67
1971	74,722,595	2,272,398	32,883	3.2	52,901	2.33
1972	80,065,800	2,389,638	33,505	3.1	50,690	2.12
1973	91,937,605	2,695,869	34,103	3.2	49,053	1.82
1974	100,635,699	2,900,811	34,692	3.2	45,758	1.58
1975	108,549,204	3,076,728	35,281	3.5	72,558	2.36
1976	122,785,601	3,425,123	35,849	3.5	81,349	2.38
1977	137,860,801	3,786,158	36,412	3.6	85,325	2.25
1978	152,714,602	4,130,862	36,969	3.7	100,909	2.44
1979	165,887,197	4,419,624	37,534	3.7	140,231	3.17
1980	163,064,999	4,277,252	38,124	3.8	148,918	3.48
1981	174,773,901	4,513,410	38,723	3.9	163,250	3.62
1982	189,218,997	4,811,507	39,326	4	171,992	3.57
1983	214,275,501	5,368,914	39,910	4	186,132	3.47
1984	236,652,102	5,856,862	40,406	4.1	193,026	3.30
1985	254,991,800	6,248,919	40,806	4.3	208,286	3.33
1986	283,612,301	6,881,510	41,214	4.4	220,792	3.21
1987	318,970,998	7,663,576	41,622	4.5	239,490	3.13
1988	356,943,603	8,492,339	42,031	4.7	276,874	3.26
1989	382,035,701	8,999,867	42,449	4.8	336,308	3.74
1990	419,518,104	9,785,984	42,869	5.1	360,583	3.68
1991	462,954,800	10,692,858	43,296	5.2	376,932	3.53
1992	491,544,604	11,235,829	43,748	5.4	409,982	3.65
1993	525,199,404	11,883,784	44,195	5.5	423,309	3.56
1994	573,549,998	12,847,899	44,642	5.7	435,799	3.39
1995	628,442,203	13,936,583	45,093	5.9	480,030	3.44
1996	676,169,298	14,852,807	45,525	6.1	538,996	3.63
1997	716,213,295	15,585,582	45,954	6.4	562,974	3.61
1998	677,027,701	14,626,892	46,287	6.6	548,545	3.75

continued on next page

Appendix Table 1 *continued*

Year	Real GDP (2010=100), Million Won	Real per-capita GDP (2010=100), Won	Population, Thousands	Share of the Elderly, %	Real per-Capita Health Expenditure, Won (2010=100)	Health Expenditure Share of GDP
1999	753,590,199	16,165,678	46,617	6.9	638,546	3.95
2000	820,843,797	17,461,748	47,008	7.2	699,207	4.00
2001	857,989,498	18,117,342	47,357	7.6	814,200	4.49
2002	921,758,996	19,355,666	47,622	7.9	842,044	4.35
2003	948,796,205	19,824,694	47,859	8.3	924,711	4.66
2004	995,285,705	20,718,106	48,039	8.7	975,525	4.71
2005	1,034,337,497	21,486,889	48,138	9.1	1,082,410	5.04
2006	1,087,876,403	22,489,821	48,372	9.5	1,223,152	5.44
2007	1,147,311,394	23,608,371	48,598	9.9	1,326,980	5.62
2008	1,179,771,395	24,102,202	48,949	10.3	1,395,680	5.79
2009	1,188,118,401	24,157,568	49,182	10.7	1,524,093	6.31
2010	1,265,308,000	25,608,149	49,410	11	1,640,225	6.41
2011	1,311,892,696	26,354,107	49,779	11.4	1,707,465	6.48
2012	1,341,966,504	26,836,946	50,004	11.8	1,775,604	6.62
2013	1,380,832,595	27,495,852	50,220	12.2	1,872,643	6.81
2014	1,426,540,304	28,290,925	50,424	12.7	2,000,531	7.07
2015	1,463,800,593	28,919,124	50,617	13.1		

Source: OECD.Sta. (2016, http://stats.oecd.org)

Appendix Table 2: Infant Obesity Rate by Premium Ventile in 2015
(%, 30–71 months old)

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

Source: National Health Insurance Service (2016).

Appendix Table 3: Adult Obesity Rate
(%, 19 years old and over, 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

Source: The Korea National Health and Nutrition Examination.

Appendix Table 4: Young Adult Obesity Rate
(%, 19–29 years old, 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

Source: The Korea National Health and Nutrition Examination.

Appendix Table 5: Adult Obesity Rate by Premium Decile
(%, 20 years old and over, 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

Source: National Health Insurance Service-National Sample Cohort (NHIS-NSC) database.