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Medical costs attributable to overweight and obesity in Japanese individuals

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ABSTRACT

Objective: We aimed to reveal the association between body mass index (BMI) and medical costs in the current Japanese population, and to estimate the population attributable fraction (PAF) of medical costs due to overweight and obesity.
Methods: A generalized linear mixed model with log link function and gamma distribution was used to evaluate the association between BMI and medical costs in 34,537 beneficiaries of the National Health Insurance aged 40–69 years in Chiba City. Medical cost data were obtained from insurance claims submitted between April 2012 and March 2016. PAFs due to overweight (BMI $\geq$25.0 and <30.0 kg/m^2) and obesity (BMI $\geq$30.0 kg/m^2) were calculated.
Results: Overweight and obesity were significant predictors of excessive medical costs in all age and sex groups. PAF due to overweight and obesity was estimated to be 9.62% (95% confidence interval, 8.52–10.73%). Additionally, PAFs in 40–59-year-old individuals (12.76% in men and 11.63% in women) were greater than those in 60–69-year-old subjects (6.55% in men and 7.80% in women) for both sexes.
Conclusions: In the Japanese population, overweight and obesity are an excessive financial burden with an estimated PAF of 9.62% of total medical costs.

Introduction

Obesity is associated with increased mortality [1,2], as well as morbidities such as cardiovascular disease [3], cancer [3,4], and diabetes mellitus (DM) [3,5]. The prevalence of obesity has increased worldwide [6], including in Japan [7]. Significantly increased cost burdens related to overweight and obesity (Ow/Ob) have been revealed by studies performed in the United States (US) or European countries [8–13]. East Asian populations, including the Japanese, are thought to be more vulnerable to DM caused by Ow/Ob than Caucasians owing to limited insulin secretion capacity [14]. Additionally, differences between US and European health insurance systems have led to the estimation of cost burdens related to Ow/Ob in Japan independently to understand its impact on the medical economy.

To date, there have been 3 studies evaluating the association between body mass index (BMI) and medical expenditure in Japan [15–17]. These studies adopted statistical methods that assumed normal distributions, which was a possible drawback because typical data are substantially positively skewed and are sometimes characterised by including zero costs [9,18]. Additionally, the data employed for calculating the population attributable fraction (PAF) to Ow/Ob are dated by approximately 20 years [17].

According to a US-based study, a dominant contributor to increased obesity-related medical costs between 1998 and 2006 was the increased prevalence of this condition [9]. A study in China also reported that the PAF due to Ow/Ob had increased between 2000 and 2009 [13], while the prevalence of obesity in Japan has also increased over the last 2 decades, especially in men [7]. Thus, evaluating PAF due to Ow/Ob in the current Japanese population is of high importance. Furthermore, no studies evaluating the PAF among different age groups have been conducted to date. Since previous studies demonstrated that obesity variably impacts adverse health outcomes according to age [5,19–21], it would be instructive to determine the age-dependent PAF due to Ow/Ob.

The aims of this study were to determine whether there is an association between BMI and medical expenditure in Japan using health insurance claims submitted over a 4-year period, and to calculate the PAF due to Ow/Ob in Japanese individuals. Additionally, PAF differences between 40–59-year-old vs. 60–69-year-old individuals were evaluated.

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Materials and methods

The health insurance system in Japan

Japanese public health insurance provides universal coverage [22], and citizens are able to visit medical facilities at will. There are 3 major health insurance systems in Japan; the first two are for those under 75 years of age, one for employees and the other for self-employed workers, farmers, retirees, and the unemployed. The latter is referred to as the National Health Insurance (NHI). The third is the late-stage medical care system for elderly citizens aged 75 years and over. The public health insurance employs an age-dependent benefit system where copayments for beneficiaries under 6 years are 20% of the medical expense, those for beneficiaries aged 7–69 years are 30%, and those for beneficiaries 70 years and over are 10–30%.

Subjects

There were 121,716 NHI beneficiaries in Chiba City aged 40–69 years who were enrolled between April 1, 2012 and March 31, 2013. Of those, 34,547 individuals (28.4%) underwent an annual health check-up in fiscal year 2012. Individuals lacking weight and/or height data ($n = 10$) were excluded from the study. In total, 34,537 individuals (8252 men and 26,285 women) were investigated.

Ethics statement

As this was an observational study using existing data collated by Chiba City, consent was not required from each enrolled subject. The study protocol was approved by the Research Ethics Committee of the Graduate School of Medicine, Chiba University (approval number 1724). The study was performed in accordance with the principals of the Declaration of Helsinki and Ethical Guidelines for Medical and Health Research Involving Human Subjects.

BMI

Height and weight were measured as part of a government-led nationwide annual health check-up, and BMI was calculated using the following formula: weight (kg)/height (m) squared. BMI categories were based on the World Health Organization classifications as follows: underweight (<18.5 kg/m^2), normal weight (≥18.5 and <25.0 kg/m^2), overweight (≥25.0 and <30.0 kg/m^2), and obese (≥30.0 kg/m^2) [23].

Medical costs

Medical costs for each individual were obtained by summing the inpatient, outpatient, and prescription expenditures based on claims submitted between April 2012 and March 2016. To determine the follow-up period, we first determined whether each subject was an NHI beneficiary in Chiba City during each fiscal year; if so, each fiscal year was considered representative of 12 months of follow-up. If the subject withdrew from the NHI at any point during the fiscal year, the follow-up period for that year was considered 6 months. Medical expenditures per month in each subject were calculated using this follow-up scheme and analysed as dependent variables.

Other variables

Individual income data for the period between January 1 and December 31, 2011, were obtained from tax records retained at the Chiba City Hall. Equivalent household income was calculated using the following formula: household income divided by the square root of the total number of household members [24]; our methods for determining the household income and number of household members were described previously [25]. Annual equivalent household income was categorised as follows: 0.00, >0.00 and ≤1.00, >1.00 and ≤2.00, and >2.00 million yen; 1 US dollar was the equivalent of 109.53 Japanese yen based on the exchange rate on April 12, 2017. Additionally, smoking (which was self-reported during the 2012 annual health check-up) was analysed as a dichotomous variable (0 = non-smoker and 1 = current smoker). The prevalence of each of hypertension, DM, and dyslipidemia was also calculated. Hypertension was defined as systolic blood pressure ≥140 mmHg, diastolic blood pressure ≥90 mmHg, and/or taking hypertension medication. DM was defined by the National Glycohemoglobin Standardization Program (NGSP) as glycated hemoglobin (HbA1c) ≥6.5% and/or being under medication for diabetes. HbA1c according to the NGSP definition was calculated from the HbA1c value according to the Japan Diabetes Society (JDS) definition using the following formula: NGSP HbA1c = 1.02 × JDS HbA1c + 0.25. Dyslipidemia was defined as a low-density lipoprotein cholesterol level ≥140 mg/dL, high-density lipoprotein cholesterol level <40 mg/dL, and/or being medicated for dyslipidemia.

Statistical analysis

To evaluate the association between medical costs and BMI, 3 models were drawn based on the generalized linear mixed model (GLIMM) with the log link function and gamma distribution. In all 3 models, household was considered a random effect. The residence area was a random effect in model 1, a fixed effect in model 2, and not considered in model 3. All models included sex; age; BMI; 2-way interactions between sex and age, sex and BMI, and age and BMI as well as 3-way interactions between all these factors, equivalent household income; and smoking habit as fixed effects. As for the 269 subjects who had no costs over the 4 years (0.77%), 1 Japanese yen was added to their medical costs per month. Following the 'PAF as a risk factor' method [26], we calculated the fraction of medical costs due to Ow/Ob. The PAF was the percentage of reduced medical costs if Ow/Ob could be completely prevented, and depended not only on medical costs, but also on population composition.

The percentage of NHI beneficiaries in Chiba City who performed annual health check-ups in 2012, as proportioned by sex, age, and BMI, may be significantly different from those in the general Japanese population. For example, women and elderly persons were more likely to have check-ups than men and younger people [27]. To overcome this, we calculated the PAF using the percentage of each category estimated using data from the National Health and Nutrition Survey of 2012 and the National Census of 2015. We obtained the BMI categories in each sex and age group from the former (column A in Table 1), followed by the total population in each sex and age group from the latter (column B in Table 1), and then calculated the estimated population in each category by sex, age, and BMI (column C in Table 1). Using this number, the percentage of each category by sex, age, and BMI was assigned for the population (column D in Table 1).

The PAF in each sex and age group was calculated using the following formula:

$$\mathrm{PAF}_{ij} = \frac{\sum_{k=3}^{4}\{(Cost_{ijk} - Cost_{ij2}) \times A_{ijk}\}}{\sum_{k=1}^{4} Cost_{ijk} \times A_{ijk}}$$

where i is sex ($i = 1$ is men and $i = 2$ is women), j is age ($j = 1$ is 40–59 years and $j = 2$ is 60–69 years), k is BMI ($k = 1$ is underweight, $k = 2$ is normal weight, $k = 3$ is overweight, and $k = 4$ is obese), *Cost* is medical expenditure per month estimated by the GLIMM, and A is the proportions of BMI categories in each sex and age group shown