Original Article

Association between obesity and medical care expenditure among Taiwanese adults

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The aim of this study is to evaluate the relationships between obesity and medical care expenditure among Taiwanese adults and to assess the influence of sex, age and socioeconomic status. Our study sample consisted of 12,250 adults aged 18 years or older from the 2001 National Health Interview Survey (NHIS), who had consented to the linking of their survey responses with their NHI claims records. Obesity was defined by Body Mass Index based on the WHO-Asia Pacific categories. Adjusted expenditure for obese class II and class I men were, respectively, 44.6% (95%CI: 27.1%-68.7%) and 39.5% (95%CI: 39.4%-41.2%) greater than normal weight men. For obese class II and class I women, the adjusted expenditure were, respectively, 93.3% (95%CI: 69.9%-114.6%) and 56.1% (95%CI: 50.4%-61.4%) greater than normal weight women. After adjusting for other factors, higher medical care expenditure was associated with a higher BMI for each age group. The relative magnitude of the association became more apparent as age increased. Annual medical care expenditure increased as the BMI increased among women, which was particularly apparent among low socioeconomic status women. On the other hand, the relationship between BMI and medical care expenditure in men varied by household income. In conclusion, there is a strong positive relationship between higher BMI and increased medical care expenditure and this varies according to sex, age and socioeconomic status. Our findings suggest that projections of future health care costs attributable to obesity will need to take into consideration the demographic make-up of the obese population.

Key Words: obesity, body mass index, medical care expenditure, socioeconomic status, Taiwan

INTRODUCTION

Obesity is one of the main threats to public health. The prevalence of overweight and obesity has increased significantly in Western countries, as well as in Asian countries.[1-4] In recent years, as the lifestyles of the Asian population and diets become more westernized, the prevalence of overweight and obesity has increased.[3-6]

A great body of evidence is available to indicate that obesity is strongly associated with an increased risk of premature death and susceptibility to various chronic diseases such as type 2 diabetes, coronary heart disease, stroke, hypertension, gallbladder disease, some forms of cancer, sleep apnea, and osteoarthritis.[7,8] These diseases are major public health hazards and impose a financial burden on the health care systems.[9-11] Previous researchers have examined the effect of obesity on health care costs using a range of different methodologies. It is generally accepted that health care costs for obese persons are higher than that for non-obese persons,[12] and there is a dose-response relationship between Body Mass Index (BMI) and health care costs.[13-15] On average, 2% to 7% of the total health care expenditure has been estimated to be attributable to obesity worldwide.[16-18]

Thus, while there is a general acceptance that there is a positive relationship between higher BMI and increased expenditure, available published literature that consider demographic and socioeconomic status, body weight and health care expenditures is limited and mostly from Western countries.[19-22] There are only two reports that consider these questions for Asian countries and both are from Japan.[15,23] These studies used a cohort study approach to examine the association between BMI and medical care expenditure under the Ohsaki National Health Insurance Scheme. The evidence from the Japanese studies suggests that the impact of excess body weight upon medical care costs in Japan is as large as in Western countries although the Japanese population has a much lower mean BMI. However, since the Ohsaki National Health Insurance

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Scheme is a type of community-based health insurance that involves special subgroups, farmers, the self-employed, pensioners and their dependents, the findings for such a unique population may not be generalizable to the general working population and their dependents or to general Asian populations. In addition, these two studies only included adults aged from 40 years to 79 years and therefore the results also may not be generalizable to populations outside of this age range. Based on the above, it is therefore important to examine the relationship between BMI and medical care expenditure across a broad range of age and socioeconomic status.

Taiwan may serve as an interesting example; whereas it is a typical oriental country which share many similar ethnic, culture, physical activity habits, and health care system characteristics with other Asian countries, obesity has also been shown to be more prevalent in Taiwan. For example, in 2001, the prevalence of overweight and obesity were 20.7% and 27.4% in Taiwan using the WHO-Asian's criteria.[5] The Taiwan National Health Insurance (NHI) program was implemented in March 1995. The total medical care expenditure increased from NT$190 billion in 1995 to NT$411 billion in 2004. In 2004, men spent 14% more medical care expenditure than women, and elderly persons spent 48% more than the population average medical expenditure. There were, on average, 14 visits per person per year, and each person spent NT$825 per visit. The average number of prescription per visits was 4.1. The percentages of total medical expenditure for outpatient and inpatient services were 60% and 40%, respectively. Inpatient admission increased from 10.1 to 13.6 admissions per 100 persons, and expenditures for inpatient per admission increased 60% between 1995 to 2004.[24] Therefore, understanding the relationship between obesity and medical care expenditure in Taiwan extent the existing research to oriental populations and enrich international community's comparative.

Some studies have suggested that the higher risks of adverse health consequences attributable to obesity are blunted among certain demographic subgroups or may become more sharp among other demographic subgroups.[25-27] Hence, it is reasonable to hypothesize that differences in obesity-related disease burdens in different subpopulations may lead to differences in medical care expenditure attributable to being overweight. Furthermore, understanding the influence of demographic and socioeconomic factors on the costs attributable to obesity will facilitate more accurate projections of current and future medical care expenditure. This, in turn, will help the development of effective preventive and welfare programs targeted at disadvantaged populations whom are disproportionately affected by the obesity epidemic.[21] The aim of this study was to examined annual medical care expenditure associated with obesity, defined according to the Asia-Pacific BMI classification, among general Taiwanese adults and assessed the influences of sex, age and socioeconomic status.

METHODS

Data Source

In 2001, the National Health Research Institutes (NHRI) in Taiwan conducted the National Health Interview Survey (NHIS). This involved a multistage stratified systematic sampling design, which was based on the degree of urbanization, geographic location and administrative boundaries, and was used by the NHRI to select a representative sample. The survey data provided information on the date of birth, sex, height, weight, education, household income, ethnicity, smoking, alcohol consumption and chronic diseases. The response rate was 91.4% for households and 93.8% for individuals. About 86% of the respondents signed a consent form that permitted access to their medical claim data from the Bureau of National Health Insurance (NHI). Details of the design and sampling scheme have been reported elsewhere.[28-30]

Survey data for those who had given consent were linked to NHI claim data between 2002 and 2004, including their NHI ambulatory care claims file, their NHI inpatient file and their NHI major diseases database. The ambulatory care claims file includes diagnosis, date of medical service, procedure/treatment conducted during the visit, the hospital/clinic, the physician providing the service and the medical care expenditure. The inpatient file includes diagnostic and procedure codes, date of admission, date of discharge, length of stay, and medical care expenditure. The major diseases database was used to identify individuals with major medical diseases. In Taiwan, patients who have a catastrophic illness, can apply for a "major disease/injury card.", which are provided by the Bureau of NHI. The Bureau uses the Injury Severity Score (ISS) to identify an official list of severe diseases.[31] The ISS is a widely recognized and anatomically based injury classification scheme.[32] The linkage of the datasets was conducted by the Bureau of National Health Insurance (BNHI) using personal identification numbers and dates of birth. This process followed the government's confidentiality regulations during the linkage processes. The personal identification numbers were encrypted into the analytical files and therefore no patient or admitting hospital could be identified from the analytical data set.

Study sample

Study subjects were selected from the general population in Taiwan and consisted of those who participated in the National Health Interview Survey in 2001 (n=22121). Of the 22121 NHIS participants, 19021 (86%) gave consent to link their questionnaire to their NHI records. We excluded 4981 persons aged below 18 years. We also excluded all persons who did not have their weight, height or gender included on the database (n=1178). Furthermore, for this study, we excluded 342 persons who were defined as registered as having a catastrophic illness. Thus, we analyzed 12520 subjects aged 18 years or older (6427 men and 6093 women) in this study.

Measures

BMI Categories

BMI has been widely used in many studies of obesity and provides a useful indicator of obesity. The International Obesity Task Force (IOTF) has recommended different BMI cut-off points for Asian adults.[33] Based on the IOTF-Asia Pacific BMI classification, we categorized individuals into the following categories: underweight (less than 18.5 kg/m^2), normal weight (18.5-22.9 kg/m^2), overweight

(23.0-24.9 kg/m^2), obese class I (25.0-29.9 kg/m^2), obese class II (≥30.0 kg/m^2). The reference group used in this study was the group of people with normal weight, which was consistent with the reference groups used in the studies investigating Asian populations.[6,34,35] Sensitivity analyses has been conducted for various different BMI cut-offs criteria and those recommended by the Department of Health (DOH) of Taiwan are overweight (24.0-26.9 kg/m^2) and obese (≥27.0 kg/m^2).

Medical care expenditure

Taiwan NHI is a single-payer NHI scheme. It is financed by a combination of premium and tax revenue through government subsidies. The NHI premium was collected in two ways: (1) waged-based premiums for those regular wage earners, and (2) fixed premiums for those without a well-defined monthly wage. Under the NHI program, for every encounter, total medical care expenditure includes NHI reimbursable expenditure, copayments and out-of-pocket expenditures. Due to data limitations, we only included NHI reimbursable expenditure and copayments in this study. The average annualized medical care expenditure for the period 2002 though 2004, including inpatient, outpatient, emergency services, copayment, and prescription medications medical care expenditure were calculated.

Other Important Independent Variables

We considered a range of potential confounding factors that might affect the relationship between BMI and medical care expenditure. These factors included sex, age (18-34, 35-49, 50-64, ≥65), education (illiterate, literate, elementary, junior, senior, college or above), household income (low, middle, high), smoking (never, former, current), alcohol consumption (never, less than once a week, more than once a week), ethnicity, and chronic diseases. Chronic diseases (hypertension, diabetes, dyslipidemia) were classified as yes versus no. In the National Health Interview Survey, each interviewer needed to identify his/her ethnicity from one of the following categories: Fujianese, Hakka, aborigines, and others. We combined Fujianese, Hakka, or others into one variable, which contained two categories: aborigines and non-aborigines. Household income and education were used to represent socioeconomic status (SES). Household income was adjusted for household structure (number of individuals aged ≤20 and number of individuals aged ≥70) according to the equivalence scale proposed by Aronson et al. (1994) and Buhmann et al. (1988):[36,37] Thus $e_h=(A_h + \Phi K_h)^\theta$ where e_h is the equivalence factor for household h, A_h is the number of adults in household h and K_h is the sum of number of children aged ≤20, and the number of individuals aged ≥70. Since there is no empirical study available involving Taiwan to determine the two parameters, Φ and θ, we followed Wagstaff et al. (1999) and set the two parameters to a value of 0.5.[38] Then we divided the household-structure-adjusted household income by the number of household members to get a per capita household income. Individuals were grouped into trisections.

Statistical analysis

Because of the high proportion of non-users in any year and therefore we used a two-part model to analyze the association between obesity and medical care expenditure. In the first part, the probability of incurring any expenditure was estimated using logistic regression and adjusting for the above potential confounding factors. The second part of the model used linear regression to obtain a prediction for the level of cost conditional upon incurring any expense. Since the distribution of medical care expenditure is highly skewed, the natural logarithm of expenditure was used in the model. The predicted log medical care expenditure was then-transformed into a raw scale in order to calculate the predicted total medical expenditure using the smearing technique.[39] The two-part model does not allow statistical tests of equivalence for overall predicted expenditure; therefore, we used bootstrapping with 1000 repetitions to arrive at 95% confidence intervals (CIs). Both models were adjusted for sex, age, ethnicity, socioeconomic status, smoking, alcohol consumption and chronic disease. For each BMI category, we calculated the percentage of annual expenditure associated with abnormal body weight (annual expenditure for the BMI category minus annual expenditure for the normal-weight reference group) by annual expenditure for the BMI category.[9,40] All analyses were conducted using the SAS 9.1 and STATA 8.0 statistical software packages.

RESULTS

Of the 12520 adults 18 years or older in our study sample, 16.6% of the women were overweight and of these 17.1% had class I obesity, and 3.6% had class II obesity. Among the men, 23.4% were overweight, 27.5% of these individuals had class I obesity and 4.5% had class II obesity. Amongst the age groups, obesity was more prevalent among old women than young women, while obesity was most prevalent among middle-age men. Furthermore, obesity was more prevalent among low income women than among high income women. On the other hand, the pattern was different for men. Obesity was more prevalent among high income men than among low income men. Lower educational attainment was also associated with higher prevalence of obesity in women, but, in contrast, educational attainment did not differ across the various BMI categories among men. Among aborigines, 43.3% of women were obese, while 53.6% of men were obese. With regard to lifestyle, being a former smoker was seen more often among class II obesity persons, both women (10.7%) and men (5.5%). The prevalence levels of obesity were higher for those who had hypertension, diabetes and dyslipidemia than among those who were without chronic disease and this was true for both women and men (Table 1).

Before adjustment, the averaged outpatient and inpatient expenditures for overweight, obese class I, and obese class II were greater than that for normal weight adults. After adjusted for demographic factors, socioeconomic status, lifestyle and chronic diseases, obese class II adults had 41.3% (95%CI: 35.2%-46.6%) and 19.7% (95%CI: 0.0%-33.6%) higher inpatient and outpatient expenditure than normal weight adults (Table 2). Before adjusting for other potential confounders, the averaged annualizes ex-

Table 1. Characteristics of subjects including sex

variables	Men					Women				
	BMI<18.5	BMI 18.5-22.9	BMI 23.0-24.9	BMI 25.0-29.9	BMI ≧30	BMI<18.5	BMI 18.5-22.9	BMI 23.0-24.9	BMI 25.0-29.9	BMI ≧30
	n=233	n=2631	n=1502	n=1770	n=291	n=686	n=3137	n=1009	n=1039	n=222
% of all men/women	3.6	40.9	23.4	27.5	4.5	11.3	51.5	16.6	17.1	3.6
Age										
18-34	4.9	52.2	18.2	20.0	4.7	20.7	59.6	9.1	8.1	2.5
35-49	1.8	32.0	25.7	35.2	5.3	5.4	51.7	20.4	18.9	3.6
50-64	2.8	30.7	29.8	32.4	4.4	2.9	38.0	24.0	29.1	5.9
≧65	5.9	42.6	25.7	24.2	1.6	5.2	35.6	23.1	30.9	5.2
Household income										
Low	5.2	41.4	21.9	25.4	6.2	8.5	43.7	19.9	21.8	6.1
Middle	2.8	42.3	22.8	27.9	4.2	10.6	52.2	16.3	17.5	3.5
High	3.8	39.2	24.7	28.1	4.3	13.1	54.0	15.6	14.5	2.9
Ethnicity										
Non-aborigine	3.7	41.5	23.3	27.1	4.4	11.4	52.0	16.5	16.8	3.4
Aborigine	0.6	19.3	26.5	44.0	9.6	7.4	31.1	18.2	29.1	14.2
Education										
Elementary or below	3.5	35.3	27.1	30.5	3.6	3.6	36.5	23.1	30.4	6.5
Junior/senior	3.6	41.1	22.5	27.6	5.2	10.9	54.4	16.3	15.0	3.3
College or above	3.8	44.0	22.6	25.7	3.9	19.3	61.3	10.7	7.4	1.4
Smoking										
Never	3.9	40.9	24.8	26.2	4.2	11.1	51.4	16.7	17.1	3.7
Former	2.1	33.6	21.7	37.1	5.5	7.1	50.0	25.0	7.1	10.7
Current	3.6	42.0	22.2	27.5	4.7	15.2	52.7	13.0	16.6	2.5
Alcohol consumption										
Never	4.6	43.6	23.1	24.4	4.3	11.3	51.7	16.4	16.9	3.7
Less than once a week	2.1	38.9	23.6	30.6	4.8	12.8	49.3	18.3	16.5	3.1
More than once a week	2.6	36.2	23.9	32.6	4.8	8.4	47.6	16.8	24.1	3.1
Hypertension										
No	3.9	43.6	23.2	25.4	3.9	12.3	54.1	16.0	14.7	3.0
Yes	1.8	23.0	24.5	42.1	8.7	1.7	28.9	21.1	38.4	9.9
Diabetes										
No	3.7	41.7	23.4	26.9	4.3	11.6	52.3	16.3	16.4	3.3
Yes	2.0	26.4	23.8	39.5	8.4	2.4	30.8	24.2	32.7	10.0
Dyslipidemia										
No	4.1	44.8	23.4	24.3	3.3	12.4	54.1	15.6	15.0	3.0
Yes	1.2	20.5	24.7	43.8	9.7	2.4	33.4	23.6	31.8	8.9

Table 2. Annual medical care expenditures by BMI categories, for outpatient and inpatient.

BMI category	Outpatient						Inpatient					
	Unadjusted		Adjusted[a]		Adjusted expenditures associated with abnormal body weight		Unadjusted		Adjusted[a]		Adjusted expenditures associated with abnormal body weight	
	NT$	95 % CI	NT$	95 % CI[b]	%	95 % CI[b]	NT$	95 % CI	NT$	95 % CI[b]	%	95 % CI[b]
Underweight	8800	7720-9890	8710	8010-9390	-13.3	(-18.4) - (-9.2)	3780	2670-4890	5300	4200-6650	-5.3	(-16.4) - 2.1
Normal weight	9340	8980-9710	9870	9490-10260	0.0	-	3840	3290-4390	5580	4890-6510	0.0	-
Overweight	11690	11050-12340	12370	11590-13080	20.2	18.1 - 21.6	5530	4260-6810	7110	5950-8510	21.5	17.9 - 23.5
Obesity class Ⅰ	12990	12320-13660	13840	13030-14740	28.7	27.2 - 30.4	6120	4740-7490	7270	6040-8870	23.2	19.1 - 26.5
Obesity class Ⅱ	14650	12560-16750	16810	14650-19200	41.3	35.2 - 46.6	6230	3070-9390	6950	4890-9800	19.7	0.0 - 33.6

[a] Predicted expenditures measures have been adjusted for sex, age, household income, education, ethnicity, smoking status, alcoholic consumption, hypertension, diabetes, dyslipidemia based on a two-part model.
[b] 95% confidence intervals based on 1,000 bootstrap replications.

Table 3. Annual medical care expenditures by BMI categories, for men and women.

BMI category	Men						Women					
	Unadjusted		Adjusted[a]		Adjusted expenditures associated with abnormal body weight		Unadjusted		Adjusted[a]		Adjusted expenditures associated with abnormal body weight	
	NT$	95 % CI	NT$	95 % CI[b]	%	95 % CI[b]	NT$	95 % CI	NT$	95 % CI[b]	%	95 % CI[b]
Underweight	13980	9990-18060	14360	10890-18670	-1.4	(-21.0) - 14.4	12110	10270-13950	11090	10120-12160	-20.1	(-24.6) - (-16.1)
Normal weight	13780	12380-15170	14560	13180-15990	0.0	-	12680	12020-13330	13320	12610-14130	0.0	-
Overweight	16580	14540-18620	18240	16320-20350	20.2	19.2 - 21.5	18190	15720-20660	18590	16960-20390	28.3	25.6 - 30.7
Obesity class Ⅰ	17290	15530-19050	20310	18370-22570	28.3	28.2 - 29.2	22200	18920-25480	20790	18960-22810	35.9	33.5 - 38.1
Obesity class Ⅱ	19630	12930-26320	21060	16750-26980	30.9	21.3 - 40.7	22540	18120-26950	25750	21430-30320	48.3	41.1 - 53.4

[a] Predicted expenditures measures have been adjusted for age, household income, education, ethnicity, smoking status, alcoholic consumption, hypertension, diabetes, dyslipidemia based on a two-part model.
[b] 95% confidence intervals based on 1,000 bootstrap replications.

Table 4. Annual medical care expenditures by BMI categories, for age groups.

BMI category	18-34						35-49					
	Unadjusted		Adjusted[a]		Adjusted expenditures associated with abnormal body weight		Unadjusted		Adjusted[a]		Adjusted expenditures associated with abnormal body weight	
	NT$	95 % CI	NT$	95 % CI[b]	%	95 % CI[b]	NT$	95 % CI	NT$	95 % CI[b]	%	95 % CI[b]
Underweight	8570	7570-9570	9820	8860-10760	4.3	1.1 - 7.5	13760	8890-18630	11280	9030-14320	-1.1	(-16.7) - 13.2
Normal weight	8500	8060-8940	9400	8770-9950	0.0	-	10390	9600-11180	11400	10540-12430	0.0	-
Overweight	9490	7350-11640	8530	7710-9400	-10.2	(-13.8) - (-5.9)	12180	10180-14190	11760	10560-13070	3.1	0.3 - 4.9
Obesity class Ⅰ	8810	7780-9830	8530	7680-9450	-10.2	(-14.3) - (-5.3)	12910	11350-14480	13360	12080-14830	14.7	12.8 - 16.2
Obesity class Ⅱ	11100	6560-15650	10770	8770-13230	12.7	0.0 - 24.8	14130	11230-17040	18620	14760-22920	38.8	28.6 - 45.8

BMI category	50-64						≥65					
	Unadjusted		Adjusted[a]		Adjusted expenditures associated with abnormal body weight		Unadjusted		Adjusted[a]		Adjusted expenditures associated with abnormal body weight	
	NT$	95 % CI	NT$	95 % CI[b]	%	95 % CI[b]	NT$	95 % CI	NT$	95 % CI[b]	%	95 % CI[b]
Underweight	21950	11700-32210	20040	12630-29520	-13.4	(-57.9) - 12.9	42660	26840-58470	48790	32540-71820	8.0	(-16.4) - 27.7
Normal weight	19790	16900-22690	22720	19940-25710	0.0	-	44150	37690-50620	44870	37880-51900	0.0	-
Overweight	22140	18950-25330	24890	21850-28500	8.7	8.8 - 9.8	45300	36860-53750	55610	47090-65770	19.3	19.6 - 21.1
Obesity class Ⅰ	25550	21990-29120	27010	23740-30780	15.9	16.0 - 16.5	54340	43500-65200	65390	55550-76970	31.4	31.8 - 32.6
Obesity class Ⅱ	40880	24390-57380	41700	31940-56020	45.5	37.6 - 54.1	49610	28670-70550	54590	33830-82130	17.8	(-12.0) - 36.8

[a] Predicted expenditures measures have been adjusted for sex, household income, education, ethnicity, smoking status, alcoholic consumption, hypertension, diabetes, dyslipidemia based on a two-part model.
[b] 95% confidence intervals based on 1,000 bootstrap replications.

penditure for overweight, obese class I, and obese class II were greater than for normal weight adults in both men and women. The averaged medical care expenditure for obese class II women (NT$22,540) are 15% higher than men (NT$19,630). After adjustment for other potential confounders, the average expenditure for obese class II women was NT$12,430 more than for normal weight women (an increase of 93.3%; 95%CI: 69.9%-114.6%). For men, the averaged annualizes expenditure for obese class II men were 44.6% (95%CI: 27.1%-68.7%) greater than for normal weight men. We estimated that 28.3% (95%CI: 25.6%-30.7%), 35.9% (95%CI: 33.5%-38.1%) and 48.3% (95%CI: 41.1%-53.4%) of the participant's expenditure were associated with excess body weight among overweight, obese class I and obese class II women, respectively (Table 3).

For each age-specific group, obese class II individuals had higher medical expenditures than normal weight individuals in both unadjusted and adjusted models. The difference in medical expenditure between obese class II adults and normal weight adults in each age group was: 12.7% (95%CI: 0.0%-24.8%) for ages 18-34 years, 38.8% (95%CI: 28.6%-45.8%) for ages 35-49 years, 45.5% (95%CI: 37.6%-54.1%) for ages 50-64 years, and 17.8% (95%CI: -12.0%-36.8%) for those 65 years or older (Table 4). The results remained robust using different BMI cut-offs.

The averaged annualizes expenditure rose in a stepwise fashion with a higher BMI among all age groups (Figure 1). The relative rise was more substantial among those 65 years or older than among other age groups for both women and men. After adjusting for the other factors, the averaged annualizes expenditure among women 65 years or older were NT$53,860 (95% CI: NT$40,960-NT$ 69,360) for the underweight group, NT$58,990 (95% CI: NT $57,560-NT$77,800) for the normal weight group, NT$68,020 (95% CI: NT$59,050-NT$77,850) for overweight group, NT$68,020 (95% CI: NT$59,050-NT$ 77,850) for the obese class I group, and NT$92,990 (95% CI: NT$64,410-NT$129,430) for the obese class II group. By comparison, the adjusted expenditure for women aged 18-34 years in the underweight, normal weight, over-

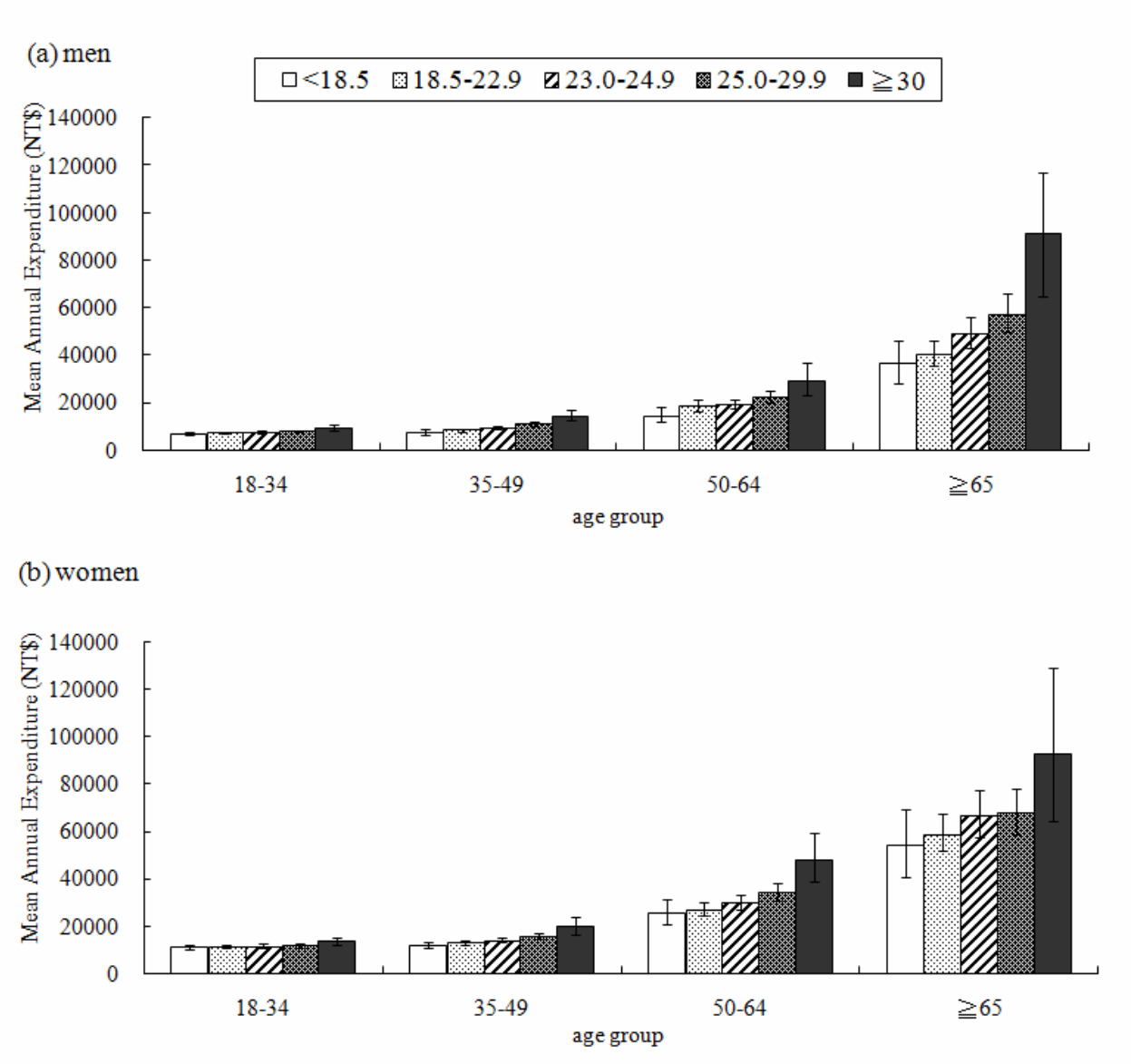

Figure 1. Adjusted medical care expenditure according to BMI, by age group, for men (a) and women (b). Predicted average medical care expenditure measures have been adjusted for household income, education, ethnicity, smoking status, alcoholic consumption, hypertension, diabetes, dyslipidemia.

weight, obesity class I and obesity class II groups were NT$11,030, NT$11,230, NT$11,620, NT$ 11,840 and NT$13,250, respectively. For men in this part of the study, the association between BMI and medical care expenditure among the various age groups were similar to that of the women.

However, the effects of BMI on medical care expenditure analyzed by income were different among men and women (Figure 2). The annual medical care expenditure increased as BMI increased among women and this was particularly apparent among low income women. The averaged annualized expenditure among the low income group was NT$14,300 for underweight women, NT$ 20,290 for normal weight women, NT$29,660 for overweight women, NT$33,410 for obese class I women, and NT$45,480 for obese class II women. By comparison, the adjusted expenditure for underweight, normal weight, overweight, obesity class I and obesity class II groups for high income women were NT$13,070, NT$15,300, NT$ 20,570, NT$25,890 and NT$27,120, respectively. In contrast, the relationship between BMI and medical care expenditure in men varied by household income. The rise in medical care expenditure associated with higher BMI was similar for both the middle and high income groups of men but these differed from that of low income men.

The relative increase in medical care expenditure was similar for all education groups for both men and women (Figure 3). Obese men and women from the low education group had more medical care expenditure than non-obese persons. The adjusted expenditure for obesity class II, obesity class I, overweight, normal weight and underweight groups among lowest educational level men were, respectively, NT$32,840, NT$26,670, NT$25,560, NT$ 23,840 and NT$22,380. For obesity class II, obesity class I, overweight, normal weight and underweight groups among lowest educational level women, the adjusted expenditure were, respectively, NT$47,140, NT$35,620, NT$32,840, NT$29,060 and NT$25,830. In addition, the rise in medical care expenditure associated with higher BMI increased only slightly in parallel to the subject's higher education group for both men and women.

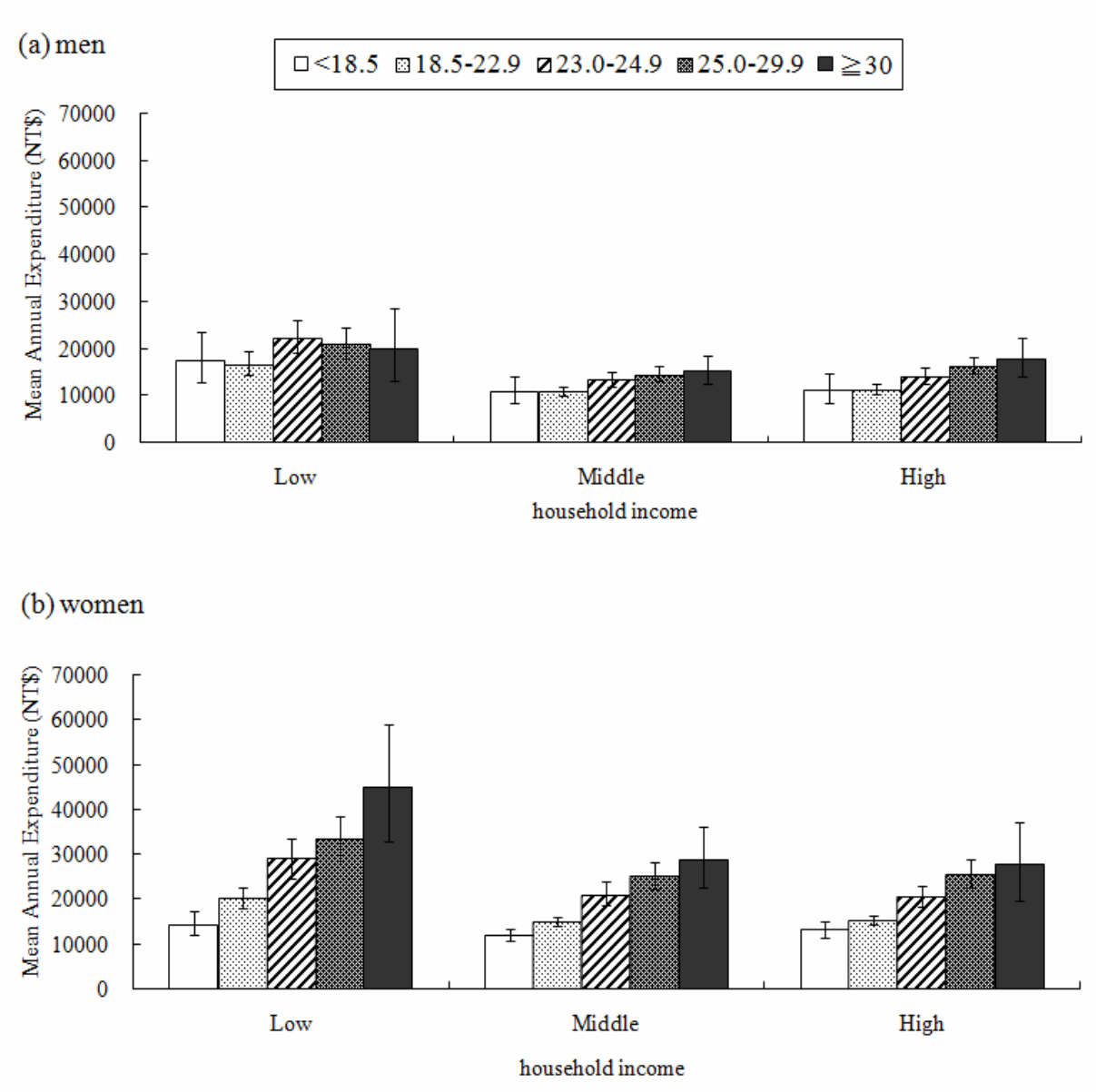

Figure 2. Adjusted medical care expenditure according to BMI, by household income, for men (a) and women (b). Predicted average medical care expenditure measures have been adjusted for age, education, ethnicity, smoking status, alcoholic consumption, hypertension, diabetes, dyslipidemia.

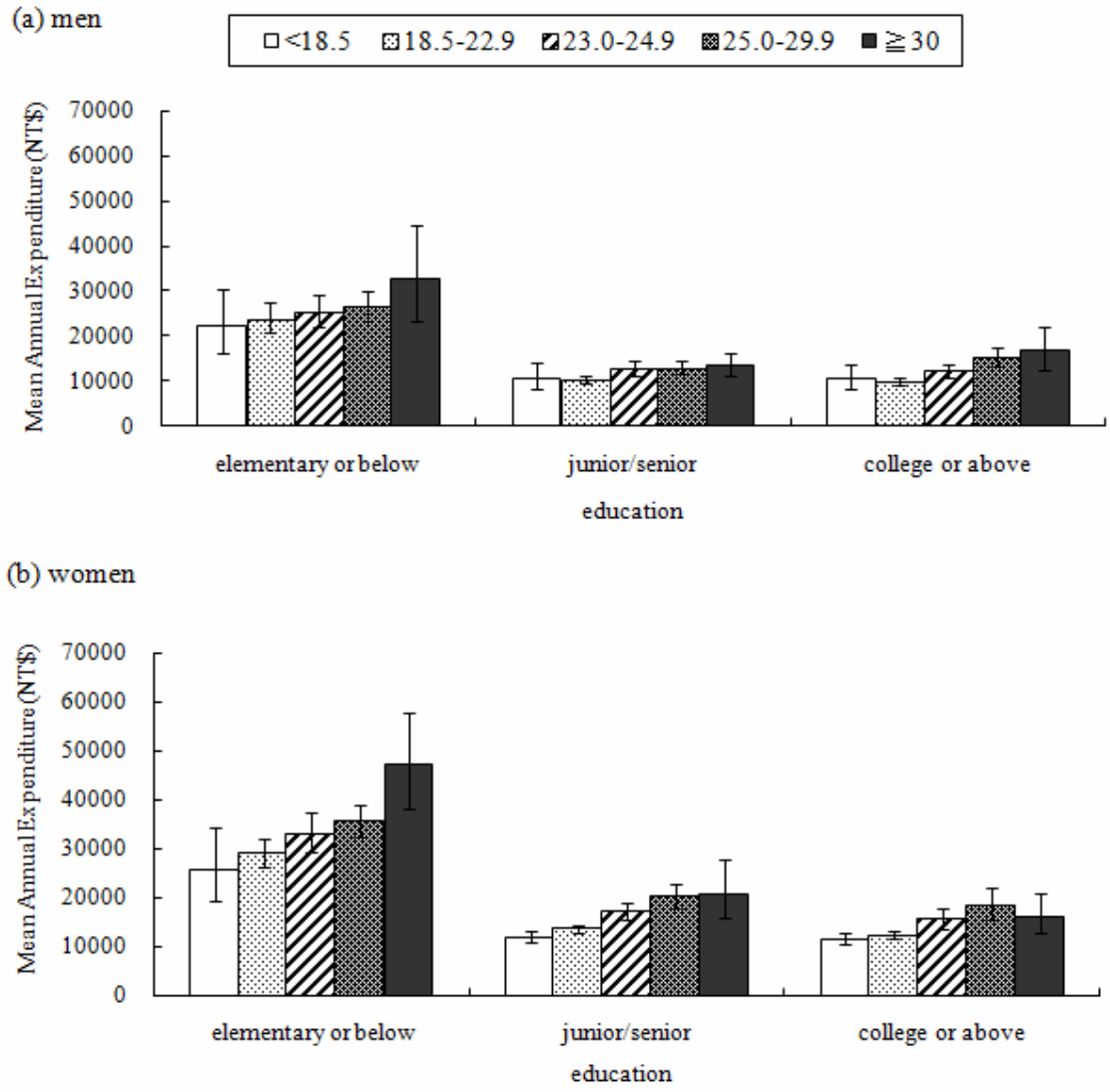

Figure 3. Adjusted medical care expenditure according to BMI, by education, for men (a) and women (b). Predicted average medical care expenditure measures have been adjusted for age, household income, ethnicity, smoking status, alcoholic consumption, hypertension, diabetes, dyslipidemia.

DISCUSSION

Consistent with previous research, after adjusting for various possible confounders, we found a positive relationship between BMI and medical care expenditure in a general Asian adult population.[10,11,14,23,41] Previous national studies in the Unites States using the 1998 Medical Expenditure Panel Survey data indicated that obese adults (BMI≥30 kg/m^2) incurred an annual medical expenditure that was 36-37% higher than normal weight adults.[40,42] We found that adults with obesity class II was associated with a 45% (men) or 93% (women) higher medical care expenditure than normal weight individuals, which is similar to other studies.[19,43] The average total NHI medical expenditure per year during the study period was NT$369.7 billion in Taiwan. The excess medical expenditure per year observed among overweight and obese adult population were NT$ 30.1 billion, which was approximately 8% of total medical expenditure per year under the NHI program. The number is slightly higher than the 2%-7% found in previous literature.[16-18] There might be three plausible explanations: first, since we were unable to decompose the excess medical expenditure into obesity-related conditions or obesity non-related conditions, our estimate might have been higher than the figures found in other countries. Second, the difference in scope of health care expenditure and medical care expenditure may also lead to a difference between our estimate and other international statistics. Third, the difference in the WHO recommended cut-offs for Western and Asians might have also contributed to the difference between our results and the numbers observed in western populations.

We also found that the effect of BMI on medical care expenditure was very conspicuous among women. Relative to men, overweight and obese women showed higher medical care expenditure. The results of our study are consistent with a previous study, which showed that there is a difference by gender when health care costs are analyzed in relation to obesity class. It is notably that an increase in health care cost was found between severe (35≤BMI<40 kg/m^2) and extreme obesity (BMI≥40 kg/m^2) for women, but not men in that particular study.[20] It may thus be concluded that women suffer a disproportionately

greater burden of disease attributable to obesity than men.[44] This finding should alert health practitioners to promote wellness programs and raise women's health consciousness about the adverse effects of obesity.

Similar to previous studies, we found that there was a significant dose-response relationship between medical care expenditure and BMI for all age groups. More specifically, a greater effect of BMI on medical care expenditure was observed among the elderly.[21,22] One possible reason for this is that a high BMI is strongly associated with chronic diseases[8] and adverse health outcomes among the elderly.[45] Therefore, obesity may be an adverse factor for morbidity in old age[46] and this imposes a financial burden on the health care systems.[9-11] Literature also indicates that being overweight or obese in young adulthood and middle age is significantly and positively associated with total medical health care charges in older age.[11,19] Based on our data, people in obese class II had higher annual medical expenditures than people in the normal weight class for each age-specific group. This pattern was particularly apparent among those aged 35-64. The primary prevention of weight gain should not only focus on the elderly but also on individuals in middle-age group.

Our study found a negative association between obesity and SES among women, which is consistent with previous studies.[47-49] More importantly, we observed that the effects of being overweight and obese among adults had negative implications and resulted in greater medical care expenditure especially for the lower SES group. Nonetheless, the positive dose response between BMI and medical care expenditure was not as apparent among low income men as among men of a lower education level. Social Economic Status is most often measured by the use of both education and income.[50] However, while household income and education may be significantly related, they represent different dimensions or phases of the individual's SES.[51] Education is considered to be most strongly related to social status in adulthood and permanent income over a life time.[51,52] On the other hand, compared to education, income is likely to measure an individual's wealth as a single snapshot or over a short period.[51] Hence, the different SES indicators at different levels (such as individual versus household) may be associated in slightly different ways with obesity and medical care expenditure as we observed between men with low education and low household income. Based on our data, the relationship between obesity and medical care expenditure differed between men and women in low income groups. It may be important for future research to uncover possible reasons for such a difference.

Our study has several limitations that should be noted. Firstly, our study includes a single measurement of BMI and does not include data on weight change. Therefore, we were not able to evaluate an association between weight change and medical care expenditure. Secondly, the study uses self-reported weight and height information and, in particular, women tend to show a trend to underreport body weight,[53] especially overweight and obese individuals.[54] However, the type of face-to-face interview used to collect the data is considered valid and reliable for self reported height and weight. Nonetheless, even if obese women underreported their weight, this would only underestimate our findings and lead to the results being more conservative than reality. Thirdly, we did not use other indices to detect obesity. BMI has been widely accepted and is the most commonly used. However, it should noted that waist circumference provides information about regional adiposity and has been shown to correlate with health care costs significantly better than BMI.[55] Based on this, we may have underestimated some medical care expenditure that tends to be associated with central obesity.

Fourth, 14% NHIS participants didn't sign a consent form to allow the link with NHI data. The distributions of sex and BMI categories were similar between consenters and non-consenters. However, according to our previous study,[30] the elderly, the illiterate, and those with a lower income were more likely to deny consent. Hence, whereas obesity was more prevalent among elderly, low education and low income subjects, this might have led to underestimations of true differences. Fifth, 10% of people had missing information on height or weight. Females, elderly, and those with low education and low income were more likely to have missing information on height or weight. As obesity was more prevalent among these groups, and these people had higher medical care expenditures than those with complete information, our findings would underestimate true differences and be more conservative than reality. Sixth, due to data limitations and challenges in finding an appropriate disease classification algorithm, we are unable to attribute or not attribute the difference in the excess expenditure to obesity-related conditions. Future research is needed to estimate the proportion of the excess medical expenditure attributable to obesity-related conditions. Finally, due to data limitations, we included both reimbursable expenditure and copayments, but not out-of-pocket expenses. According to previous literature, obese and overweight individuals are more likely to be involved in situations that incur out-of pocket expenditures.[56] Hence, the difference in excess medical expenditure of the obese might be underestimated in this study.

In conclusion, this is the first study to examine the relationship between BMI and medical care expenditure that considers demographic and socioeconomic status among a general Asian population. There is a strong positive relationship between the level of obesity and medical care expenditure and this varied according to sex, age and socioeconomic status. Our findings have important implications for health policy makers and health insurance providers. Given that the rise in obesity disproportionately affects different population groups, our finding suggests that obesity interventions are needed to fully clarify the effects of demographic and socioeconomic factors on obese persons. Moreover, public health efforts need to include population-wide strategies and resources so that weight management programs are available from early life onwards with the goal of reducing the prevalence of obesity and of changing people's lifestyles

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AUTHOR DISCLOSURES

Hsiao-Yun Hu, Yiing-Jenq Chou, Pesus Chou, Cheng-Hua Lee, Miaw-Chwen Lee and Nicole Huang, no conflicts of interest.

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Original Article

Association between obesity and medical care expenditure among Taiwanese adults

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臺灣成人肥胖與醫療費用之關係

本研究之目的為評估臺灣成人肥胖與醫療費用之關係，並進一步分析性別、年齡及社經地位之影響。研究樣本為 2001 年國民健康訪問調查中有簽署同意連結健保資料庫之 18 歲以上受訪者，共計 12250 人。依據亞太地區身體質量指數作為肥胖定義。研究顯示二級肥胖與一級肥胖的男性相對於正常男性分別高出 44.6% (95%CI: 27.1%-68.7%) 及 39.5% (95%CI: 39.4%-41.2%)的醫療費用。而二級肥胖與一級肥胖的女性分別比正常女性高出 93.3% (95%CI: 69.9%-114.6%)及 56.1% (95%CI: 50.4%-61.4%)的醫療費用。在控制相關因素後，每個年齡層皆呈現 BMI 越高醫療費用越高，且年齡層越高越明顯。在不同的社經地位也顯示隨著 BMI 增加醫療費用皆逐漸增加，此現象在低社經地位的女性特別明顯，但卻沒有出現於低收入的男性。整體而言 BMI 與醫療費用有顯著正相關，且隨著性別、年齡及社經地位有明顯之變化。建議未來擬定肥胖相關醫療費用策略時應進一步考慮相關人口學因素。

關鍵字：肥胖、身體質量指數、醫療費用、社經地位、臺灣