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Alcohol Consumption, Hospitalization and Medical Expenditure: A Large Epidemiological Study on the Medical Insurance System in Japan

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Abstract — Aims: This study investigated the relationship between alcohol drinking habits and the onset of high medical expenditure in a Japanese male population. **Methods:** The cohort comprised 94,307 male beneficiaries 40–69 years of age of the Japanese medical insurance system, who had daily alcohol drinking habits. The likelihood of incurring high medical expenditure, defined as the ≥90th percentile of the medical expenditure distribution in the study population 1 year after baseline, as well as the likelihood of undergoing hospitalization that year were compared among the participants grouped according to their alcohol consumption amount (<2, 2–3.9, 4–5.9, ≥6 drinks/day). **Results:** Participants who ranked in the top 10% medical expenditure group within the 1 year after baseline each incurred at least 2152 euros/year. The top 10% medical expenditure group accounted for 61.1% of the total medical expenditure in the study population. The odds ratios (95% confidence intervals) for ranking in the top 10% group during the 1-year period, compared with the <2 drinks (23 g of alcohol)/day group, were 1.08 (1.02–1.15) for 2–3.9 drinks/day, 1.11 (1.05–1.19) for 4–5.9 drinks/day, and 1.31 (1.18–1.45) for ≥6 drinks/day after adjustment for age, body mass index, and smoking and exercise habits. The adjusted odds ratios for undergoing hospitalization were 1.11 (1.04–1.19), 1.14 (1.06–1.24) and 1.39 (1.24–1.56), respectively. **Conclusion:** The likelihood of incurring high medical expenditure and undergoing hospitalization increased with daily alcohol consumption amount.

INTRODUCTION

Excessive alcohol consumption is an undesirable behaviour that causes various diseases including liver disease, cancer and alcoholism, as well as injuries and accidents (Fujiwara *et al.*, 1997; Ikeda *et al.*, 1998; Lin *et al.*, 2005; Osaki *et al.*, 2005; Yamada *et al.*, 2005; Morita *et al.*, 2006). In addition, it leads to hypertension and diabetes, which subsequently contribute to the development of cardiovascular diseases including coronary heart disease and stroke (Tsumura *et al.*, 1999; Nakanishi *et al.*, 2001; Kokubo *et al.*, 2008, 2010; Higashiyama *et al.*, 2013). Therefore, excessive alcohol consumption may have an effect on medical economics, mainly due to its various associated diseases that often require medical assistance. In fact, a few epidemiological studies demonstrated a positive relationship between alcohol drinking habits and the mean medical expenditure after long-term follow-up (Musich *et al.*, 2003; Kanda *et al.*, 2005). Many unexpected results have also been reported, mostly from cross-sectional or short-term cohort studies (Goetzel *et al.*, 1998; Hunkeler *et al.*, 2001; Anzai *et al.*, 2005; Lynch *et al.*, 2005; Mukamal *et al.*, 2006). However, these unexpected results should be interpreted with caution. Compared with non- and light drinkers, heavy drinkers in general are less keen to seek medical assistance for non-symptomatic, non-urgent diseases that are usually treated in outpatient departments, despite their unhealthier conditions (Anzai *et al.*, 2005; Nakamura *et al.*, 2007). For example, Anzai *et al.* (2005) reported that Japanese heavier drinkers, who had unhealthier clinical profiles such as higher serum liver enzyme levels, visited outpatient departments less frequently over a 4-year follow-up period. Nakamura *et al.* (2007) found that Japanese heavier drinkers had a higher prevalence of hypertension and a lower likelihood of treating the hypertension. Such a negative health attitude may have resulted in an underestimation of the theoretical medical expenditure anticipated in heavy drinkers, based on a standard statistical procedure used to calculate means and variance, which is often found in cross-sectional or short-term cohort studies.

A unique statistical procedure is available for medical expenditure research (Edington *et al.*, 1997; Goetzel *et al.*, 1998; Musich *et al.*, 2003; Lynch *et al.*, 2005; Nakamura *et al.*, 2013). This procedure is in agreement with the concept proposed by Moturu *et al.* (2010), who suggested that an important strategy for reducing the medical economic burden is to identify and manage individuals expected to incur high medical expenditure in the near future; such individuals, despite their small numbers, account for a substantial percentage of the future total medical expenditure incurred in a population. In short, this statistical procedure is used to determine the individuals who tend to fall in the high medical expenditure group. Since few studies have attempted to elucidate whether heavy drinkers are more likely to incur high medical expenditure, compared with non-heavy drinkers (Edington *et al.*, 1997; Goetzel *et al.*, 1998; Lynch *et al.*, 2005), we investigated this topic in a large Japanese male population. One advantage of this study was that all Japanese residents are required to enrol in the Japanese medical insurance system that regulates medical service costs nationwide (Okamura *et al.*, 2005; Yoshida *et al.*, 2010; Health and Welfare Statistics Association, 2013; Nakamura *et al.*, 2013). The aim of the study was to examine the relationship of interest in Japanese males, among whom heavy drinkers are prevalent (World Health Organization (WHO), 2014).

METHODS

Medical expenditure

The medical insurance system in Japan requires all Japanese residents to enrol in one of three insurance groups, with eligibility for each group depending on the individual's age and occupation (i.e. 'health-insurance-for-all') (Okamura *et al.*, 2005; Yoshida *et al.*, 2010; Health and Welfare Statistics Association, 2013; Nakamura *et al.*, 2013). All residents 75 years of age or older are enrolled in the Advanced Elderly Medical Service (coverage rate 11%), while those younger than 75 years are enrolled in either the Employee's Health Insurance (58%) or National Health Insurance schemes (31%) according to their occupation. The Employee's Health Insurance scheme covers employees and their dependents, while the National Health Insurance scheme covers the remaining population, such as self-employed individuals (e.g. farmers and fishermen) and retirees and their dependents. Each insurance group consists of local insurance organizations based on a company or region. Everyone is entitled to many of the medical services offered at the outpatient and inpatient departments of all clinics and hospitals granted approval. The system, however, does not cover some medical services, including health check-ups for asymptomatic individuals or inoculations; rather, annual health check-ups are available free of charge or at fairly low charges in communities and worksites. The national government sets a fee schedule that strictly regulates prices at all approved clinics and hospitals and is applied to the three insurance groups equally. Prices are determined on a 'fee-for-service' basis, with an exception of ~20% of acute care hospitals that use a flat-fee per day payment system applied to hospitalized patients according to the diagnosis and procedure undertaken (Diagnosis Procedure Combination/Per-Diem Payment System). The clinic or hospital requests the insurance organization to pay 70–90% of fees with no taxes imposed, and the beneficiary to pay the remaining balance himself/herself. The fees are recorded monthly in an insurance claim history file. In this report, medical expenditure is defined as the total fees paid by both the insurance organization and the beneficiary and is confined to the fee schedule range used in the medical insurance system in Japan.

Study design and participants

A total of 21 local insurance organizations recruited throughout Japan participated in this study, which aimed to investigate the relationships among lifestyle, cardiovascular risk factors and medical expenditure; the cohort profile has been reported elsewhere (Nakamura *et al.*, 2013). Of the 2,270,694 beneficiaries between the ages of 40 and 69 years among the 21 local insurance organizations ($n = 2{,}077{,}769$ in nine local Employee's Health Insurance organizations and $n = 192{,}925$ in 12 local National Health Insurance organizations), 589,718 beneficiaries ($n = 549{,}889$ and $n = 39{,}829$, respectively) underwent an annual health check-up in 2008 (participation rate 26.0%), and were then followed up for 1 fiscal year (April 2009 to March 2010). In this report, only male participants were evaluated ($n = 345{,}074$) because of the low prevalence of daily alcohol consumption among female participants (11.8%, 244,644). Furthermore, of the 345,074 male participants, we excluded those who reported non- and occasional drinking habits at study entry ($n = 63{,}178$ and 62,634, respectively), using a self-administered questionnaire on current alcohol use (daily drinker, occasional drinker or non-drinker) (Ministry of Health, Labour and Welfare of Japan, 2007), as well as those who did not select any of these three questionnaire choices ($n = 116{,}523$). This was because of the lack of data on whether the non- and occasional drinkers were lifelong abstainers/occasional drinkers or were daily drinkers previously, and the lack of data on whether illness was a cause of their drinking habits. The present study was approved by the Institutional Review Committee of the Japan Anti-Tuberculosis Association for Ethical Issues.

Of the 102,739 potential male participants who reported daily drinking at study entry, 8432 were excluded due to one or more of the following criteria: possibly inappropriate data on body mass index at baseline due to extremely low or high values, defined as the <0.01 or >99.99th percentile of the original study population distribution (body mass index, <13.7 or >45.8 kg/m^2) ($n = 53$); missing data at the time of the baseline survey ($n = 8375$); and participant dropout before the follow-up survey ($n = 4$). The remaining 94,307 male participants were considered eligible for the analyses.

Data collection

The baseline data were obtained at an annual health check-up performed using standardized methods in accordance with the Basic Guidelines for Health Checkups and Healthcare Advice with a Particular Focus on the Metabolic Syndrome, issued by the Ministry of Health, Labour and Welfare of Japan (2007). Data collected via a self-administered questionnaire at study entry included age and alcohol drinking, smoking and exercise habits. The daily drinking participants reported the quantity of alcoholic beverages consumed per day by selecting only one of the following four choices: <2 drinks/day, 2–3.9 drinks/day, 4–5.9 drinks/day or ≥6 drinks/day. One drink, defined as containing 11.5 g of alcohol, is nearly equal to one 'standard' drink in most countries (International Center for Alcohol Policies (ICAP), 1998). Two drinks (23 g of alcohol) are roughly equivalent in alcohol content to the following alcoholic beverage units typically consumed in Japan: 180 ml (i.e. 1 'gou', a traditional Japanese drinking unit) of sake (Japanese rice wine), 500 ml (a mid-sized bottle or a large-sized can) of beer, 60 ml (double shot) of whisky, 240 ml of wine, or 110 ml (25% alcohol) or 80 ml (35% alcohol) of 'shochu' (Japanese distilled spirits made from barley, sweet potato, rice or any combination of these). A smoker was defined as one who currently smokes. Exercise was defined as physical activity with sweating for 30 min or longer at least twice per week. Body height and weight were measured to calculate the body mass index (weight in kilograms divided by the square of the height in meters).

Data on medical expenditure for the 1-year follow-up period were obtained from the monthly insurance claim history files of each insurance organization. The insurance claim history files of the participants were linked with the baseline survey data files at each local organization. In order to protect the participants' privacy, names were deleted from the linked data files. The data obtained from the local organizations were compiled for analysis at the study centre. The medical expenditure for each participant was expressed in euros (100 Japanese yen = 0.72 euros, based on the foreign exchange rate on 1 July 2014).

Table 1. Baseline characteristics of the 94,307 male beneficiaries of the medical insurance system in Japan (2008) with daily alcohol drinking habits

		Alcohol drinking habits (2 drinks defined as 23 g of alcohol)				
	Overall (n = 94,307)	<2 drinks/day (n = 20,588)	2–3.9 drinks/day (n = 43,635)	4–5.9 drinks/day (n = 24,196)	≥6 drinks/day (n = 5888)	P-values
Age, years	53.6 ± 7.6	54.2 ± 8.0	53.9 ± 7.6	53.1 ± 7.3	51.3 ± 7.1	<0.01
Body mass index, kg/m^2	23.4 ± 3.2	23.3 ± 2.9	23.4 ± 2.9	23.4 ± 3.1	23.4 ± 3.2	<0.01
Current smokers, %	53.5	44.9	53.0	59.2	63.9	<0.01
Exercisers, %	21.5	23.3	21.8	20.1	18.8	<0.01

Data are presented for the overall study population as well as four different groups according to the quantity of alcoholic beverages consumed per day.
Values represent means ± standard deviations, or the percentages of participants in that group.
P-values were calculated using one-way analysis of variance or the chi-square test to compare each risk characteristic among the four alcohol drinking groups.

Data analysis

Initially, we calculated the mean ± standard deviation and median (interquartile range) medical expenditure during the 1-year follow-up period after baseline for the participants classified in the following four alcohol drinking groups: <2 drinks/day, 2–3.9 drinks/day, 4–5.9 drinks/day or ≥6 drinks/day. We compared the onset of high medical expenditure among the four alcohol drinking groups. We defined high medical expenditure as the ≥90th percentile of the medical expenditure distribution among the study population during the 1-year follow-up (Yen *et al.*, 1994; Edington *et al.*, 1997; Goetzel *et al.*, 1998; Musich *et al.*, 2003; Lynch *et al.*, 2005). We calculated the odds ratio for ranking in the top 10% medical expenditure group during that year for each alcohol drinking group using a logistic regression model, setting the <2 drinks/day group as the reference. The logistic regression model incorporated the following variables as covariates: age (years), body mass index (kg/m^2), smoking habits (current or no smoking) and exercise habits (≥30 min twice/week or no exercise). To explore whether our hypothesis is also applicable to extremely high levels of medical expenditure, we further applied the following three cut-off levels: the ≥95th, ≥98th and ≥99th percentiles of the medical expenditure distribution. We calculated the odds ratios for ranking in these top 5, 2 and 1% medical expenditure groups for each alcohol drinking group, compared with the <2 drinks/day group.

Next, to test the assumption that heavier drinkers more frequently incur high medical expenditure as a result of more frequent hospitalization, we compared the use of medical services (i.e. outpatient department visits and hospitalization) during the 1-year follow-up among each alcohol drinking group. We calculated the odds ratios for visiting outpatient departments and undergoing hospitalization for each alcohol drinking group using a similar logistic regression model to that described above. The odds ratios for visiting outpatient departments without hospitalization to be differentiated from outpatient department visits accompanying hospitalization, were also calculated.

Because the onset of certain alcohol-related diseases, including cancer and cardiovascular diseases depends largely on age (Kita *et al.*, 1999; Yoshida *et al.*, 2005; Matsuda *et al.*, 2012), we conducted similar analyses in participants stratified by age (40–54 and 55–69 years at baseline), using pre-defined cut-off levels for high medical expenditure. We then tested the heterogeneity in the relationship between alcohol drinking habits and any outcome between these two age groups using likelihood ratio tests (Woodward, 2005).

To avoid the potential confounding effects of other lifestyle factors on the onset of high medical expenditure, similar analyses were conducted in participants stratified according to the presence or absence of obesity, defined as a body mass index ≥25.0 kg/m^2 (Examination Committee of Criteria for 'Obesity Disease' in Japan, Japan Society for the Study of Obesity, 2002), smoking or exercise. The interactions between alcohol drinking habits and each of these three statuses were then evaluated with regard to the onset of high medical expenditure using likelihood ratio tests.

The statistical analyses were performed using the Statistical Package for the Social Sciences Version 17.0J for Windows (SPSS Japan Inc., Tokyo, Japan). All probability values were two-tailed, and the significance level was set at $P < 0.05$.

RESULTS

Characteristics of the study population

The baseline characteristics of the 94,307 male study participants and of the study population grouped according to alcohol drinking habits are summarized in Table 1. The mean age at study entry was 53.6 years. Alcohol consumers of <2, 2–3.9, 4–5.9 and ≥6 drinks/day accounted for 21.8, 46.3, 25.7 and 6.2% of the study population, respectively. The mean age was correlated inversely with the increase in the quantity of daily alcoholic beverage consumption. Heavier drinkers tended to smoke more and exercise less.

Alcohol drinking habits and medical expenditure

The majority of the participants were followed up until the end of the 1-year period after baseline, with the exception of 0.66% (n = 626) who dropped out mid-study. There was little variation in the dropout rate across the alcohol drinking groups: 0.71, 0.73, 0.57 and 0.37% in the <2, 2–3.9, 4–5.9 and ≥6 drinks/day consumers, respectively.

Participants who were classified in the top 10% medical expenditure group during the 1 year after baseline (n = 9430) each incurred at least 2152 euros/year in medical expenditures. The top 10% medical expenditure group accounted for 61.1% of the total medical expenditure in the study population, and hospitalization generated 57.5% of the medical expenditure in this group (Fig. 1). The odds ratio for ranking in the top 10% medical expenditure group during the year after baseline increased with the quantity of alcoholic beverages consumed per day (Table 2).

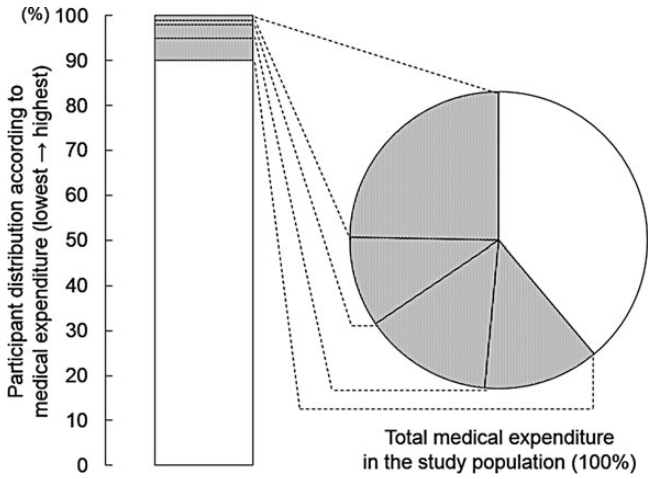

Fig. 1. Distribution of the participants ($n = 94,307$) according to medical expenditure during the 1 year after baseline (bar), as well as the total medical expenditure in the study population (100,604,539 euros/year [13,972,852,571 Japanese yen/year]) (circle).

Participants who were placed in the top 5, 2 and 1% medical expenditure groups during the year after baseline each incurred ≥3485 ($n = 4715$), ≥7952 ($n = 1886$) and ≥13,782 euros/year ($n = 943$), respectively. The top 5, 2 and 1% medical expenditure groups accounted for 48.5, 34.5 and 24.7% of the total medical expenditure in the study population, respectively (Fig. 1). Hospitalization comprised 68.4, 78.0 and 80.4% of the medical expenditure in the top 5, 2 and 1% medical expenditure groups, respectively. The odds ratios for ranking in each of these top medical expenditure groups also increased with daily alcohol consumption amount.

Either or both the mean and median (interquartile range) medical expenditure values increased greatly with daily alcohol consumption amount in participants both 40–54 and 55–69 years of age (Table 2).

As for high medical expenditure onset, the positive dose–response relationship we observed overall was similar between the two age groups. There was no significant heterogeneity in the relationship between alcohol drinking habits and high medical expenditure onset between the age groups (*P*-values for heterogeneity: 0.11 for ≥2152 euros/year (pre-defined top 10% overall), 0.65 for ≥3485 euros/year (pre-defined top 5% overall), 0.79 for ≥7952 euros/year (pre-defined top 2% overall) and 0.79 for ≥13,782 euros/year (pre-defined top 1% overall)).

Alcohol drinking habits and use of medical services

During the 1-year follow-up period, 76.41% ($n = 72,059$) of participants visited an outpatient department at least once, and 6.60% ($n = 6222$) underwent hospitalization. Hospitalized participants had mean and median medical expenditures of 7737 euros/year [1,074,625 Japanese yen/year] and 4330 euros/year [601,500 Japanese yen/year], respectively. The hospitalized group accounted for 47.9% of the total medical expenditure in the study population. The odds ratio for undergoing hospitalization increased with daily alcohol consumption amount (Table 3). On the other hand, the odds ratio for outpatient department visits without hospitalization was ~1 for each alcohol drinking group, despite an increased odds ratio for outpatient department visits overall, with or without hospitalization, among heavy drinkers.

Participants both 40–54 and 55–69 years of age showed a similar pattern in the relationship between alcohol drinking habits and use of medical services (Table 3), without significant heterogeneity between the two age groups (*P*-values for heterogeneity: 0.22 for outpatient visits overall, 0.49 for outpatient visits without hospitalization and 0.51 for hospitalization).

Alcohol drinking habits, other lifestyle factors and medical expenditure

There were similar positive dose–response relationships between alcohol drinking habits and high medical expenditure onset, regardless of the presence or absence of obesity, smoking or exercise (Fig. 2, illustrated only for the ≥2152 euros/year (pre-defined top 10% overall) group). There was no significant interaction between alcohol drinking habits and obese status or smoking habits for any of the high medical expenditure groups (*P*-values for interaction: 0.46 for obese status and 0.38 for smoking habits, shown only for ≥2152 euros/year (pre-defined top 10% overall)). Similarly, there was also no significant interaction between alcohol drinking habits and exercise habits, except for the ≥2152 euros/year (pre-defined top 10% overall) group (*P*-values for interaction = 0.05).

DISCUSSION

The present epidemiological study examined the relationship between the quantity of alcoholic beverages consumed per day at baseline and the onset of high medical expenditure during the 1 year after baseline among Japanese male daily drinkers. The likelihood of incurring various levels of high medical expenditure (i.e. the top 10, 5, 2 and 1% medical expenditure groups) increased with daily alcohol consumption amount. Consumers of ≥6 drinks daily had an ~30% higher likelihood of incurring high medical expenditure, compared with consumers of <2 drinks daily. The likelihoods of undergoing hospitalization and incurring high medical expenditure both also increased with excessive alcohol drinking. These positive dose–response relationships were consistent between the age groups, without any statistically significant heterogeneity detected between the middle-aged and presenile participants.

A relevant cohort study involving 796 US employees found a non-significantly, marginally higher likelihood of ranking in the top 10% medical expenditure group over a 3-year follow-up period among current heavy drinkers who consume ≥21 drinks/week, compared with light and non-drinkers (including lifetime abstainers and ex-drinkers) (Edington *et al.*, 1997). On the other hand, another cohort study conducted in 46,026 US employees found a non-significantly lower likelihood of ranking in the top 10% medical expenditure group over a 3-year follow-up period among heavy drinkers who consume ≥5 drinks/day ≥2 days/week, compared with light and non-drinkers (including lifetime abstainers and ex-drinkers) (Goetzel *et al.*, 1998). In a cross-sectional study evaluating 6543 Japanese employees, those consuming >5 drinks almost daily experienced high medical expenditure, defined as the ≥90th percentile, less frequently than did light and non-drinkers (including lifetime abstainers and ex-drinkers) (Lynch *et al.*, 2005). Compared with these previous studies, our study involved a larger number of

Table 2. Mean and median medical expenditure values and adjusted odds ratios for ranking in the high medical expenditure groups during the 1 year (2009) after baseline among the 94,307 male daily alcohol consuming participants, grouped according to the alcohol quantity consumed per day at baseline

	Alcohol drinking habits (2 drinks defined as 23 g of alcohol)			
	<2 drinks/day	2–3.9 drinks/day	4–5.9 drinks/day	≥6 drinks/day
Overall	(*n* = 20,588)	(*n* = 43,635)	(*n* = 24,196)	(*n* = 5888)
Medical expenditure				
Mean ± SD, euros/year	1041 ± 3184	1086 ± 3290	1047 ± 3199	1094 ± 4348
[Japanese yen/year]	[144,570 ± 442,222]	[150,892 ± 456,980]	[145,366 ± 444,332]	[152,007 ± 603,926]
Median (IQR), euros/year	285 (37–1025)	297 (37–1077)	290 (32–1055)	271 (31–993)
[Japanese yen/year]	[39,560 (5110–142,390)]	[41,270 (5090–149,520)]	[40,230 (4420–146,520)]	[37,670 (4350–137,910)]
≥2152 euros/year (top 10%)				
Rate, % (cases, *n*)	9.85 (2027)	10.22 (4460)	9.76 (2361)	9.88 (582)
Adjusted odds ratio (95% CI)	1.00 Reference	1.08 (1.02–1.15)	1.11 (1.05–1.19)	1.31 (1.18–1.45)
		P < 0.01	*P* < 0.01	*P* < 0.01
≥3485 euros/year (top 5%)				
Rate, % (cases, *n*)	9.85 (1003)	10.22 (2223)	9.76 (1188)	9.88 (301)
Adjusted odds ratio (95% CI)	1.00 Reference	1.08 (1.00–1.17)	1.12 (1.02–1.22)	1.33 (1.17–1.53)
		P = 0.05	*P* = 0.01	*P* < 0.01
≥7952 euros/year (top 2%)				
Rate, % (cases, *n*)	4.87 (400)	5.09 (866)	4.91 (501)	5.11 (119)
Adjusted odds ratio (95% CI)	1.00 Reference	1.04 (0.92–1.17)	1.15 (1.00–1.31)	1.27 (1.03–1.56)
		P = 0.53	*P* = 0.04	*P* = 0.03
≥13,782 euros/year (top 1%)				
Rate, % (cases, *n*)	0.93 (191)	1.06 (462)	0.94 (228)	1.05 (62)
Adjusted odds ratio (95% CI)	1.00 Reference	1.16 (0.97–1.37)	1.08 (0.89–1.32)	1.37 (1.03–1.84)
		P = 0.10	*P* = 0.43	*P* = 0.03
Participants 40–54 years of age	(*n* = 10,039)	(*n* = 21,912)	(*n* = 13,231)	(*n* = 3823)
Medical expenditure				
Mean ± SD, euros/year	658 ± 2429	707 ± 2475	742 ± 2457	808 ± 2774
[Japanese yen/year]	[91,399 ± 337,390]	[98,209 ± 343,782]	[103,110 ± 341,211]	[112,279 ± 385,285]
Median (IQR), euros/year	148 (0–562)	159 (0–638)	178 (0–707)	186 (0–723)
[Japanese yen/year]	[20,580 (0–78,010)]	[22,100 (0–88,660)]	[24,750 (0–98,210)]	[25,890 (0–100,380)]
≥2152 euros/year (top 10%)				
Rate, % (cases, *n*)	5.21 (523)	5.80 (1271)	6.12 (810)	6.75 (258)
Adjusted odds ratio (95% CI)	1.00 Reference	1.10 (0.99–1.22)	1.16 (1.03–1.30)	1.35 (1.16–1.58)
		P = 0.07	*P* = 0.01	*P* < 0.01
≥3485 euros/year (top 5%)				
Rate, % (cases, *n*)	2.74 (275)	2.92 (639)	3.08 (408)	3.58 (137)
Adjusted odds ratio (95% CI)	1.00 Reference	1.04 (0.90–1.21)	1.10 (0.94–1.29)	1.35 (1.09–1.66)
		P = 0.56	*P* = 0.24	*P* < 0.01
≥7952 euros/year (top 2%)				
Rate, % (cases, *n*)	1.08 (108)	1.20 (264)	1.32 (175)	1.39 (53)
Adjusted odds ratio (95% CI)	1.00 Reference	1.08 (0.86–1.36)	1.17 (0.92–1.50)	1.29 (0.93–1.80)
		P = 0.50	*P* = 0.20	*P* = 0.13
≥13,782 euros/year (top 1%)				
Rate, % (cases, *n*)	0.55 (55)	0.60 (131)	0.62 (82)	0.71 (27)
Adjusted odds ratio (95% CI)	1.00 Reference	1.05 (0.76–1.44)	1.07 (0.76–1.51)	1.29 (0.81–2.04)
		P = 0.77	*P* = 0.70	*P* = 0.29
Participants 55–69 years of age	(*n* = 10,549)	(*n* = 21,723)	(*n* = 10,965)	(*n* = 2065)
Medical expenditure				
Mean ± SD, euros/year	1405 ± 3728	1469 ± 3908	1414 ± 3880	1624 ± 6265
[Japanese yen/year]	[195,171 ± 517,787]	[204,032 ± 542,818]	[196,354 ± 538,928]	[225,556 ± 870,095]
Median (IQR), euros/year	573 (82–1430)	607 (84–1461)	569 (67–1435)	600 (81–1472)
[Japanese yen/year]	[79,600 (11,340–198,610)]	[84,250 (11,700–202,870)]	[78,980 (9360–199,320)]	[83,310 (11,240–204,490)]
≥2152 euros/year (top 10%)				
Rate, % (cases, *n*)	14.26 (1504)	14.68 (3189)	14.15 (1551)	15.69 (324)
Adjusted odds ratio (95% CI)	1.00 Reference	1.07 (1.01–1.15)	1.09 (1.01–1.18)	1.28 (1.12–1.46)
		P = 0.04	*P* = 0.03	*P* < 0.01
≥3485 euros/year (top 5%)				
Rate, % (cases, *n*)	6.90 (728)	7.29 (1584)	7.11 (780)	7.94 (164)
Adjusted odds ratio (95% CI)	1.00 Reference	1.10 (0.99–1.20)	1.12 (1.01–1.24)	1.30 (1.09–1.56)
		P = 0.05	*P* = 0.04	*P* < 0.01
≥7952 euros/year (top 2%)				
Rate, % (cases, *n*)	2.77 (292)	2.77 (602)	2.97 (326)	3.20 (66)
Adjusted odds ratio (95% CI)	1.00 Reference	1.02 (0.88–1.17)	1.12 (0.95–1.32)	1.24 (0.95–1.63)
		P = 0.84	*P* = 0.16	*P* = 0.12
≥13,782 euros/year (top 1%)				
Rate, % (cases, *n*)	1.29 (136)	1.52 (331)	1.33 (146)	1.69 (35)
Adjusted odds ratio (95% CI)	1.00 Reference	1.19 (0.98–1.46)	1.07 (0.84–1.35)	1.40 (0.96–2.04)

Continued

Table 2. *Continued*

	Alcohol drinking habits (2 drinks defined as 23 g of alcohol)			
	<2 drinks/day	2–3.9 drinks/day $P = 0.09$	4–5.9 drinks/day $P = 0.60$	≥6 drinks/day $P = 0.08$

Data are presented for the overall population as well as stratified according to age at baseline.
100 Japanese yen = 0.72 euros, 0.58 pounds sterling and 0.99 US dollars, based on the foreign exchange rate on 1 July 2014.
Each participant in the top 10, 5, 2 and 1% medical expenditure groups incurred [≥298,930], [≥484,070], [≥1,104,430] and [≥1,914,170 Japanese yen/year], respectively.
Odds ratios (95% CIs) were calculated using a logistic regression model with multivariate adjustments for age, body mass index, and smoking and exercise habits.
SD, standard deviation; IQR, interquartile range; CI, confidence interval.

Table 3. Adjusted odds ratios for visiting outpatient departments and undergoing hospitalization during the 1 year (2009) after baseline among the 94,307 male daily alcohol consuming participants, grouped according to the alcohol quantity consumed per day at baseline

	Alcohol drinking habits (2 drinks defined as 23 g of alcohol)			
	<2 drinks/day	2–3.9 drinks/day	4–5.9 drinks/day	≥6 drinks/day
Overall	($n = 20,588$)	($n = 43,635$)	($n = 24,196$)	($n = 5888$)
Outpatient department visit				
Rate, % (cases, *n*)	76.67 (15,785)	76.62 (33,432)	75.91 (18,368)	75.99 (4474)
Adjusted odds ratio (95% CI)	1.00 Reference	1.04 (0.99–1.08) $P = 0.08$	1.05 (1.00–1.10) $P = 0.05$	1.13 (1.05–1.21) $P < 0.01$
Outpatient visit without hospitalization				
Rate, % (cases, *n*)	70.59 (14,533)	69.99 (30,541)	69.43 (16,799)	68.80 (4051)
Adjusted odds ratio (95% CI)	1.00 Reference	1.00 (0.97–1.04) $P = 0.91$	1.01 (0.97–1.05) $P = 0.75$	1.01 (0.95–1.08) $P = 0.76$
Hospitalization				
Rate, % (cases, *n*)	6.16 (1270)	6.72 (2932)	6.59 (1595)	7.22 (425)
Adjusted odds ratio (95% CI)	1.00 Reference	1.11 (1.04–1.19) $P < 0.01$	1.14 (1.06–1.24) $P < 0.01$	1.39 (1.24–1.56) $P < 0.01$
Participants 40–54 years of age	($n = 10,039$)	($n = 21,912$)	($n = 13,231$)	($n = 3823$)
Outpatient department visit				
Rate, % (cases, *n*)	72.28 (7256)	72.45 (15,875)	72.87 (9641)	73.19 (2798)
Adjusted odds ratio (95% CI)	1.00 Reference	1.03 (0.98–1.09) $P = 0.25$	1.07 (1.01–1.14) $P = 0.02$	1.12 (1.03–1.22) $P < 0.01$
Outpatient visit without hospitalization				
Rate, % (cases, *n*)	68.35 (6862)	68.00 (14,900)	68.21 (9025)	67.72 (2589)
Adjusted odds ratio (95% CI)	1.00 Reference	1.01 (0.96–1.06) $P = 0.71$	1.04 (0.98–1.10) $P = 0.23$	1.03 (0.95–1.12) $P = 0.45$
Hospitalization				
Rate, % (cases, *n*)	3.99 (401)	4.49 (984)	4.76 (630)	5.52 (211)
Adjusted odds ratio (95% CI)	1.00 Reference	1.10 (0.98–1.24) $P = 0.11$	1.16 (1.02–1.32) $P = 0.02$	1.40 (1.18–1.66) $P < 0.01$
Participants 55–69 years of age	($n = 10,549$)	($n = 21,723$)	($n = 10,965$)	($n = 2065$)
Outpatient department visit				
Rate, % (cases, *n*)	80.85 (8529)	80.82 (17,557)	79.59 (8727)	81.16 (1676)
Adjusted odds ratio (95% CI)	1.00 Reference	1.05 (0.99–1.11) $P = 0.11$	1.03 (0.96–1.11) $P = 0.37$	1.17 (1.04–1.33) $P = 0.01$
Outpatient visit without hospitalization				
Rate, % (cases, *n*)	72.72 (7671)	72.00 (15,641)	70.90 (7774)	70.80 (1462)
Adjusted odds ratio (95% CI)	1.00 Reference	1.00 (0.94–1.05) $P = 0.86$	0.98 (0.92–1.04) $P = 0.46$	0.98 (0.88–1.09) $P = 0.75$
Hospitalization				
Rate, % (cases, *n*)	8.24 (869)	8.97 (1948)	8.80 (965)	10.36 (214)
Adjusted odds ratio (95% CI)	1.00 Reference	1.12 (1.03–1.21) $P = 0.01$	1.12 (1.02–1.24) $P = 0.02$	1.38 (1.17–1.61) $P < 0.01$

Data are presented for the overall population as well as stratified according to age at baseline.
Odds ratios (95% CIs) were calculated using a logistic regression model with multivariate adjustments for age, body mass index, and smoking and exercise habits.
CI, confidence interval.

study subjects from a general population and categorized current habitual drinkers in more detail. In addition, we used various cut-off levels to define high medical expenditure and observed a positive dose–response relationship of interest, irrespective of the cut-off level. The most expensive 10% of individuals accounted for a smaller percentage of the total medical expenditure in the present Japanese population, compared with populations in the USA (~70–80%) (Yen *et al.*, 1994; Musich *et al.*, 2003). Moreover, age did not appear to affect this positive dose–response relationship,

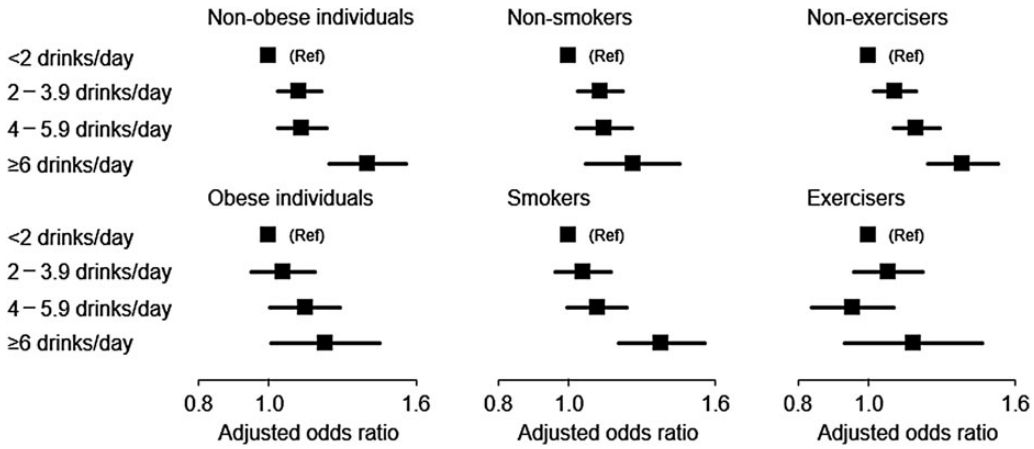

Fig. 2. Adjusted odds ratios for ranking in the top 10% medical expenditure group (≥2152 euros/year [≥298,930 Japanese yen/year]) during the 1 year (2009) after baseline among the 94,307 male daily alcohol consuming participants, grouped according to the alcohol quantity consumed per day (2 drinks = 23 g of alcohol) at baseline and stratified according to the presence or absence of obesity (body mass index ≥25.0 kg/m^2), smoking or exercise. Odds ratios and 95% confidence intervals (lines) were calculated using a logistic regression model with multivariate adjustments for age and the two residual variables.

suggesting that alcohol cessation from a medical economics viewpoint is necessary regardless of age. Although the likelihood ratio tests detected borderline significance only for the interaction between alcohol drinking habits and exercise habits for the ≥2152 euros/year (pre-defined top 10% overall) group, it was difficult to support the respective interaction, based on the results illustrated in Fig. 2 and the relevant results for the other cut-off levels. Therefore, other lifestyle factors also did not appear to modify this positive dose–response relationship. These strengths of the present study may help to provide reliable and important information on this topic.

A Japanese cohort study found that the mean inpatient, but not outpatient, medical expenditure increased greatly with weekly alcohol consumption amount after adjustment for major confounders over a 4-year follow-up period (Anzai *et al.*, 2005). On the other hand, a study in another Japanese cohort found that the mean medical expenditure, including outpatient and inpatient medical expenditures, was significantly higher in heavy drinkers, defined as those consuming ≥6 drinks/day, compared with occasional and light drinkers, with an increased risk of all-cause mortality; this remained true even after adjustment for major confounders over the first half of the 10-year follow-up period (Kanda *et al.*, 2005). An Australian 5-year cohort study also found a non-significant increase in the mean medical expenditure in heavy drinkers, compared with light and non-drinkers (including lifetime abstainers and ex-drinkers) (Musich *et al.*, 2003). In contrast to these long-term follow-up studies, our study was conducted over a 1-year period only, but it also demonstrated that heavy drinkers, compared with light drinkers, incurred high medical expenditures more frequently. However, it may be possible to assume that such annual medical expenditure surges occur more frequently in heavier drinkers, consequently contributing to the positive dose–response relationship between alcohol drinking habits and medical expenditure over a long-term follow-up period. In fact, our age-stratified data also crudely showed that heavier drinkers had either or both higher mean and median medical expenditure values. Hospitalization may be a key contributor to medical expenditure, since our data indicated that substantial increases in total medical expenditure were incurred during hospitalization periods.

The present study had several limitations. First, we could not identify the specific diseases or diagnostic and therapeutic procedures that directly contributed to the high medical expenditure incurred by heavy drinkers. Second, the participants may have been misclassified due to self-reported alcohol drinking habits at the time of the baseline survey. Since such misclassification usually leads to an underestimation of the true differences in high medical expenditure incurred between heavy drinkers and light drinkers, the positive dose–response relationship of interest may have been greater than observed. Third, the analyses were conducted only in daily drinkers due to the lack of data on the detailed characteristics of the non- and occasional drinkers, which would influence the medical expenditure in these individuals (Hunkeler *et al.*, 2001). Fourth, since we had no data on disease history prior to study entry, we could not take such into account. However, participants with a history of serious diseases may have largely comprised the non- or occasional drinkers, who were not included among the study subjects in this report. Finally, this study simply presented mean and median (with interquartile ranges) medical expenditure values for each alcohol drinking group, but it could not allow for confounders such as age and other lifestyle factors to compare medical expenditures among the alcohol drinking groups. Our medical expenditure data showed a positively skewed distribution with 22.9% of the participants incurring no costs, which restricted statistical procedures.

In conclusion, this study suggests that excessive alcohol consumption leads to high medical expenditure, resulting mainly from the development of diseases requiring hospitalization. Because excessive alcohol consumption is a modifiable risk factor, it may be possible to prevent the high medical expenditure associated with it, which may lead to reducing the alcohol-related medical economic burden. An effective strategy is required to modify excessive alcohol consumption and prevent this undesirable behaviour in populations.

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Conflict of interest statement. None declared.

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