Study variables

The impact of alcohol consumption on monthly medical care utilization and costs was examined. All life-style information was derived from the responses to the self-completed questionnaire in the 1994 baseline survey. The question on the amount of drinking by each subject was worded as: 'Do you drink alcoholic beverages?' and the subjects were asked to choose one of three options to describe their status: current drinker, former drinker or life-long abstainer. Current drinkers reported their frequency of consumption as one of four categories: almost daily, 3–4 days/week, 1–2 days/week and <1 day/week. Furthermore, they were asked which types and amounts of alcoholic beverages were consumed in a day; this information was recorded as '5 *go* or more', '4 *go*', '3 *go*', '2 *go*', '1 *go*' or 'less than 1 *go*' (a *go* is a traditional unit in Japan equal to approximately 180 mL of sake, containing 23 g of ethanol). Weekly ethanol consumption was calculated by multiplying the amount of ethanol consumed per day by the frequency of drinking per week. Alcohol intake was classified into five groups: life-long abstainers and current ethanol intakes of 1–149 g/week, 150–299 g/week, 300–449 g/week and ≥450 g/week.

Multivariate models included the following variables as covariates, as there was an association between alcohol consumption and the following variables: (1) age: continuous variable; (2) smoking status: never, ever smoked, currently smoking; (3) body mass index (BMI): weight, kg/height, m^2 (<21.0, 21.0–24.9 and ≥25.0 kg/m^2); and (4) time spent walking per day: <30 minutes, 30 minutes–1 hour, ≥1 hour.

Outcome measures

Data on medical care utilization and costs were collected prospectively for all individuals in the cohort between January 1995 and December 1998. The NHI claims history files were obtained from the Miyagi NHI Association. Claims history files included the beneficiary's ID number, the number of days and cost of out-patient care and the number of days and cost for in-patient care. Information on the diagnosis related to each episode of medical care was not available.

When a beneficiary was withdrawn from the NHI because of death or emigration, the date and reasons were recorded on the NHI withdrawal history file. From this file, survival and emigration status could be identified for all the study subjects. Both NHI claims and withdrawal history files were linked with our baseline survey data file based on the beneficiary's ID number as the key code. In order to protect the subjects' privacy, their names were deleted from the data files used for analysis.

Statistical analysis

The impact of alcohol consumption on per-month per-capita medical costs (in-patient and out-patient), hospital days and number of physician visits was examined by analysis of covariance (ANCOVA). Per-month values for each subject were calculated by dividing the accumulated values through observation by the number of months observed. We examined per-month values rather than accumulated values to avoid underestimating the medical care use and costs of the subjects who died or emigrated.

In this paper, monetary values are converted to pounds sterling (£) using an exchange rate of £1.00 = 180 Japanese Yen (2003 rate). Approximate variance formulae were used to calculate 95% confidence intervals (CI): differences at $P < 0.05$ were regarded as statistically significant. All statistical calculation was performed using SAS software (version 8.2, SAS Institute, Cary, NC, USA) [29].

RESULTS

Characteristics of the subjects

Table 1 lists the baseline characteristics of the subjects by categories of alcohol intake. The highest proportion of current drinkers (38.6%) were in the category consuming 1–149 g/week, and the proportions decreased with higher alcohol consumption. The mean age was highest for life-long abstainers, and decreased with the amount of alcohol consumed. Alcohol consumption was associated with cigarette smoking, BMI and walking time: the proportion of current smokers increased with alcohol consumption, and the proportions of those who had a BMI of more than 25.0 and those who walked for less than 30 minutes per day were greater among current drinkers consuming more than 450 g/week.

Among the subjects, 5355 men (30.6%) attended health check-ups provided by the municipality in 1995, and we compared the self-reported alcohol consumption at the baseline survey with the data from liver function tests obtained at the health check-up. Table 2 lists the mean levels of aspartate aminotransferase (AST), alanine aminotransferase (ALT) and γ-glutamyltransferase (GGT), according to the categories of self-reported alcohol consumption. A linear relationship was observed between the values from all liver function tests and the self-reported alcohol consumption level (P for trend: $P < 0.0001$). This relationship did not change after logarithmic transformation of the values. This finding suggests that the data for self-reported drinking habits at the baseline survey were sufficiently valid and accurate.

Table 1 Baseline characteristics by categories of alcohol intake in 17 497 men, Ohsaki NHI Cohort Study, Japan, in 1994.

	Life-long abstainers	*Current drinkers (g/week)*			
		1–149	*150–299*	*300–449*	*450 ≥*
Number of subjects (%)	3352 (19.2)	6749 (38.6)	5086 (29.1)	1823 (10.4)	487 (2.8)
Age (SD[a])	60.6 (10.7)	58.9 (10.7)	57.8 (9.9)	54.3 (9.4)	52.7 (9.4)
Smoking (%)					
Current	47.9	51.5	63.3	72.2	75.8
Ex-smoker	22.8	25.1	22.9	17.9	15.2
Never	29.3	23.4	13.7	9.9	9.0
BMI[b] (%)					
<21.0	21.8	20.0	18.9	20.4	21.5
21.0–24.9	53.5	54.6	55.8	52.8	50.3
≥25.0	24.7	25.4	25.3	26.8	28.2
Walking (%)					
<30 minutes/day	28.0	25.7	24.6	26.4	35.9
30–1 hour	24.1	24.6	23.5	19.6	17.8
≥1 hour/day	47.9	49.8	51.9	54.0	46.3

[a]SD, standard deviation. [b]BMI, body mass index.

Table 2 Liver functions data of the subjects by categories of alcohol intake in 5355 men, Ohsaki NHI Cohort Study, Japan, 1995.

	Life-long abstainers	*Current drinkers (g/week)*				
		1–149	*150–299*	*300–449*	*450 ≥*	*P-value*
Number of subjects(%)	937 (16.2)	2306 (40.0)	1624 (28.2)	411 (7.1)	77 (1.3)	
AST[a] mean (SD[b])	24.7 (9.0)	25.5 (9.4)	28.3 (17.1)	32.3 (21.9)	36.4 (28.4)	<0.001[c,d]
ALT[e] mean (SD[b])	22.6 (13.4)	22.5 (13.2)	24.4 (22.9)	28.1 (21.4)	32.0 (27.8)	<0.001[c,d]
GGT[f] mean (SD[b])	22.9 (18.5)	32.7 (31.9)	50.5 (58.5)	83.7 (97.5)	107.7 (143.8)	<0.001[c,d]

[a]AST, aspartate aminotransferase; [b]SD, standard deviation; [c]tested by analysis of variance (ANOVA); [d]*P* for trend < 0.0001; [e]ALT, alanine aminotransferase; [f]GGT, serum g-glutamyltransferase.

Drinking habits and medical costs

Per-capita per-month hospital days and in-patient cost showed U-shaped relationships with alcohol consumption, both for crude data and after adjustment for age, smoking status, BMI and walking (Table 3). Hospital days and in-patient cost were highest for subjects consuming more than 450 g/week (0.56 days, 95% CI: 0.40, 0.72; £74.96, 95% CI: 54.39, 95.52) and for life-long abstainers (0.58 days, 95% CI: 0.52, 0.64; £69.16, 95% CI: 62.08, 77.83), and lowest for subjects consuming 150–299 g/week (0.37 days, 95% CI: 0.32, 0.42; £51.69, 95% CI: 45.33, 58.04).

Out-patient care use did not show a U-shaped curve, but an inverse linear relationship with alcohol consumption for both crude data and after adjustment (*P* for trend: $P < 0.0001$). Per-month visits and per-month costs were highest for life-long abstainers (£78.31, 95% CI: 74.04, 82.57), and decreased with higher alcohol consumption.

Table 4 lists in-patient and out-patient use by age specific analysis. Per-capita per-month hospital days and in-patient cost showed a U-shaped relationship with alcohol consumption at all ages, but in-patient cost was lowest for those consuming 1–149 g/week in the less than 49 age group. Number of physician visits and out-patient costs also showed an inverse linear relationship with alcohol consumption among parts of all age groups.

DISCUSSION

This 4-year prospective observation study confirmed a U-shaped relationship between alcohol consumption and in-patient care use. In contrast, there was an inverse linear association between alcohol consumption and out-patient care use.

Our study had several methodological strengths. Under the NHI system, differences in access to medical care due to socio-economic status are unlikely. We followed-up a large number of subjects ($n = 17,497$) for 4 years. Because we collected a variety of life-style

Table 3 Per-capita per-month medical care utilization and its costs by alcohol intake categories in 17 497 men, Ohsaki NHI Cohort Study, Japan, 1995–98.

		Current drinkers (g/week)				
	Life-long abstainers	*1–149*	*150–299*	*300–449*	*450≥*	*P-value*
In-patient care						
Number of hospital days (95% CI[a])						
Crude	0.63 (0.56, 0.70)	0.45 (0.40, 0.50)	0.36 (0.30, 0.41)	0.36 (0.26, 0.45)	0.46 (0.28, 0.64)	<0.0001[b]
Adjusted mean[d]	0.58 (0.52, 0.64)	0.44 (0.39, 0.48)	0.37 (0.32, 0.42)	0.44 (0.36, 0.52)	0.56 (0.40, 0.72)	<0.0001[b]
Medical cost (£) (95% CI[a])						
Crude	77.12 (67.79, 86.45)	59.67 (53.09, 66.24)	50.63 (43.06, 58.21)	47.77 (35.12, 60.43)	58.94 (34.45, 83.43)	<0.0001[b]
Adjusted mean[d]	69.16 (62.08, 77.83)	57.97 (52.46, 63.47)	51.69 (45.33, 58.04)	60.03 (49.34, 70.72)	74.96 (54.39, 95.52)	<0.01[b]
Out-patient care						
Number of physician visits (95% CI[a])						
Crude	2.07 (1.99, 2.16)	1.90 (1.84, 1.96)	1.77 (1.70, 1.84)	1.35 (1.24, 1.47)	1.24 (1.02, 1.46)	<0.0001[b,c]
Adjusted mean[d]	1.87 (1.79, 1.94)	1.83 (1.78, 1.88)	1.82 (1.76, 1.88)	1.72 (1.63, 1.82)	1.74 (1.55, 1.93)	0.21[b,c]
Medical cost (£) (95% CI[a])						
Crude	85.97 (80.23, 91.71)	71.81 (67.76, 75.85)	65.10 (60.44, 69.76)	46.83 (39.05, 54.61)	45.58 (30.52, 60.63)	<0.0001[b,c]
Adjusted mean[d]	78.31 (74.04, 82.57)	69.37 (66.39, 72.36)	66.94 (63.49, 70.38)	60.21 (54.42, 66.01)	62.79 (51.65, 73.94)	<0.0001[b,c]

[a]CI, confidence interval; [b]tested by analysis of covariance (ANCOVA); [c]*P* for trend < 0.05; [d]adjusted for age (continuous variable), smoking status (never, ever or current), BMI (<21.0, 21–24.9, = 25.0), walking (<30 minutes, 30 minutes-1 hour or = 1 hour/day).

Table 4 Age-specific analysis of per-capita per-month medical care utilization and its costs by alcohol intake categories in 17 497 men, Ohsaki NHI Cohort Study, Japan, 1995–98.

			Current drinkers (g/week)				
	Age	*Life-long abstainers*	*1–149*	*150–299*	*300–449*	*450≥*	*P-value*
In-patient care							
Number of hospital days[a] (95%CI[b])							
	≤49	0.34 (0.23, 0.44)	0.15 (0.09, 0.22)	0.16 (0.09, 0.24)	0.19 (0.09, 0.30)	0.32 (0.14, 0.50)	0.026[c]
	50–59	0.45 (.034, 0.56)	0.27 (0.20, 0.35)	0.25 (0.17, 0.33)	0.28 (0.16, 0.40)	0.33 (0.08, 0.57)	0.045[c]
	≥60	0.78 (0.69, 0.87)	0.66 (0.59, 0.73)	0.52 (0.44, 0.60)	0.61 (0.45, 0.78)	0.82 (0.47, 1.18)	0.0009[c]
Medical cost (£)[a] (95%CI [b])							
	≤49	23.95 (15.19, 32.72)	13.20 (7.73, 18.67)	14.91 (8.66, 21.15)	27.61 (18.93, 36.30)	27.69 (12.46, 42.91)	0.018[c]
	50–59	57.86 (43.09, 72.63)	36.66 (26.63, 46.69)	33.14 (22.20, 44.08)	38.56 (21.97, 55.16)	42.68 (9.81, 75.56)	0.11[c]
	≥60	101.82 (89.33, 114.31)	91.04 (81.74, 100.35)	77.21 (66.15, 88.27)	76.73 (54.21, 99.26)	124.98 (76.64, 173.32)	0.019[c]
Out-patient care							
Number of physician visits[a] (95%CI[b])							
	≤49	0.87 (0.79, 0.96)	0.79 (0.74, 0.85)	0.75 (0.69, 0.82)	0.71 (0.62, 0.79)	0.77 (0.62, 0.92)	0.094[c,d]
	50–59	1.29 (1.16, 1.41)	1.31 (1.22, 1.39)	1.33 (1.24, 1.42)	1.26 (1.12, 1.40)	1.15 (0.88, 1.43)	0.76[c]
	≥60	2.71 (2.60, 2.84)	2.63 (2.54, 2.72)	2.54 (2.43, 2.64)	2.26 (2.05,2.48)	2.19 (1.72, 2.65)	0.0015[c,d]
Medical cost (£)[a] (95%CI[b])							
	≤49	40.80 (32.89, 48.72)	31.86 (26.92, 36.79)	27.59 (21.96, 33.23)	24.57 (16.73, 32.41)	26.07 (12.32, 39.81)	0.039[c,d]
	50–59	57.17 (46.84, 67.49)	53.82 (46.81, 60.83)	49.33 (41.68, 56.98)	43.50 (31.89, 55.10)	44.76 (21.79, 67.74)	0.42[c]
	≥60	109.59 (103.84, 115.35)	96.75 (92.46, 101.04)	93.39 (88.29, 98.49)	78.38 (68.01, 88.77)	80.12 (57.84, 102.39)	0.0001[c,d]

[a]Adjusted for smoking status (never, ever or current), BMI (<21.0, 21–24.9, ≥25.0), walking (<30 minutes, 30 minutes-1 hour or = 1 hour/day); [b]CI, confidence interval; [c]tested by analysis of covariance (ANCOVA); [d]*P* for trend <0.05.

information at the baseline survey, we were able to analyse the impact of alcohol consumption on medical cost after adjustment for possible confounders. Self-reporting of alcohol consumption was sufficiently valid and accurate, as evidenced by the high correlation with objective data from liver function tests (AST, ALT and GGT). The representativeness of our study was confirmed fully in a previous paper [22].

The association between alcohol consumption and use of in-patient care was inconsistent in previous studies, which is attributable partly to study limitations. First, most previous studies were based on hypothetical [18], cross-sectional [7,13,16] or retrospective [12,14,17] study designs. Secondly, some studies involved small sample sizes [10,20]. Thirdly, socio-economic status might have confounded the association between alcohol consumption and medical care use [30,31]; for example, some excessive drinkers might not have used medical care because they were un- or underinsured. Fourthly, most of the studies did not separate life-long abstainers from ex-drinkers [7,10,13,15,19,20], and a study by Tsubono *et al.* suggests that epidemiological studies of alcohol and total mortality may overestimate the lower risk in moderate drinkers if they do not separate life-long abstainers from ex-drinkers [32]. Some previous studies showed that abstainers had extremely high in-patient care use, but this could be explained by the fact that the abstainer group of ex-drinkers presumably includes people who ceased alcohol consumption because of illness (related or unrelated to drinking) [7,10,13,15,19,20].

Our study is a large-scale population-based cohort study in which every member had equal access to medical care services, and ex-drinkers were excluded as study subjects. This methodological advantage suggests that our finding of a U-shaped curve for in-patient use is more reliable than findings of previous studies. Furthermore, in-patient cost was lowest for individuals consuming 1–149 g/week in the less than 49 age group, followed by those consuming 150–299 g/week with an increase in age. Young people might be expected to show a stronger effect of alcohol consumption in relation to medical care utilization because of the smaller influence of chronic diseases unassociated with alcohol consumption. Moreover, the data for the less than 49-year age group showed the same tendency as the J- or U-shaped mortality curve [1–5].

Because out-patient care use is influenced more by patients' care-seeking behaviour [11], the association between alcohol consumption and in-patient care use may provide an appropriate clue to the question of whether alcohol consumption has beneficial or harmful effects. This 4-year prospective observation study confirmed a U-shaped relationship between alcohol consumption and in-patient care use. Our data support the known substantial health and social risks of consuming large amounts of alcoholic beverages. Armstrong *et al.* demonstrated that light drinkers (<1 drink/month) had a morbidity experience similar to that of life-long abstainers. Thus the suggestion that life-long abstainers might differ from light drinkers in some unknown way with respect to illness risk might not be plausible. Therefore, the higher in-patient cost among life-long abstainers than among light drinkers might indicate a beneficial effect of light drinking. A meta-analysis has demonstrated a beneficial influence of alcohol on coronary heart disease, ischaemic stroke and diabetes mellitus [6]. Furthermore, San José *et al.* have reported a U-shaped relationship between alcohol consumption and psychosocial health parameters such as perceived general health, health complaints, chronic conditions, mobility complaints, pain complaints, sleeping complaints, social isolation, emotional complaints and lack of energy complaints, that may indicate an influence of alcohol intake on health [33]. The U-shaped relationship observed in our study might reflect this association. Although alcohol consumption may have some beneficial effects, alcohol consumption increases the risk for some types of cancer, hypertension, haemorrhagic cancer, cirrhosis of the liver, etc. [6]. Thus, the present U-shaped association might have been the result of a heterogeneous relationship between alcohol consumption and health problems. Given that heterogeneity, we believe that public health recommendations for promotion of alcohol drinking to reduce medical care costs is not a reasonable strategy. Any encouragement of light or moderate drinking should be based on the characteristics of each individual.

In contrast to in-patient care use, out-patient use showed a linear inverse relationship with alcohol consumption. Past studies have also shown that use of out-patient care decreased with alcohol consumption [7–14]. There are several possible explanations for our results. First, alcohol consumption is associated positively with acute conditions such as road injuries, injuries due to falls, fires, excessive cold, drowning, occupational and machine injuries and suicide [6], which would yield more in-patient needs than out-patient needs. These acute conditions might partly explain the inverse linear association. Secondly, alcohol consumption is associated positively with depressive disorders [6]. People with depression are less likely to seek medical care in the early stage of their disease, which would lead to less use of out-patient care. Thirdly, although every individual had equal access to medical care services in our study, their financial status might have influenced their care-seeking behaviour. A person with a poor income, who may tend to be a heavy drinker, would be less likely to visit a physician. Future prospective studies should therefore exercise

care in adopting a wider variety of information at the baseline survey, including financial status.

Our study had another limitation. The 4-year follow-up period was probably not long enough. Consequently, we might have underestimated the health risks of those who were currently consuming a large amount of alcohol. However, we did observe a U-shaped relationship between alcohol consumption and in-patient cost.

The amount of alcohol consumed in Japan has been increasing rapidly since the end of World War II [34], and the current per-capita consumption of 6.6 l is almost the same as that of the United States (6.7 l) and United Kingdom (8.1 l) [35].

In conclusion, this large-scale prospective study, using a health insurance system providing every member with equal access to medical care services, demonstrated that days of hospitalization and in-patient care cost had a U-shaped relationship with alcohol consumption, and that the number of physician visits and out-patient cost had an inverse linear relationship with alcohol consumption.

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Joint impact of health risks on health care charges: 7-year follow-up of National Health Insurance beneficiaries in Japan (the Ohsaki Study)

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Abstract

Background. The objective of this study was to examine the joint impact of modifiable health-risk factors such as smoking, obesity, and physical inactivity on direct health care charges.

Method. We conducted a population-based prospective cohort study, with follow-up from 1995 to 2001. The participants were Japanese National Health Insurance (NHI) beneficiaries (26,110 men and women aged 40–79 years).

Results. 'No risk' group defined as never-smoking, body mass index (BMI) 20.0–24.9 kg/m^2, and walking for ≥1 h/day had mean health care charges of $171.6 after adjustment for potential confounders. Compared with this group, the presence of smoking (SM; ever-smoking) alone, obesity alone (OB; BMI ≥ 25.0 kg/m^2), or physical inactivity (PI; walking for <1 h/day) alone were associated with a 8.3%, 7.1%, or 8.0% increase in health care charges, respectively. The combinations of the risks of SM and OB, SM and PI, OB and PI, and SM and OB and PI were associated with a 11.7%, 31.4%, 16.4%, and 42.6% increase in charges, respectively.

Conclusion. Interventions to improve modifiable health-risk factors may be a cost-effective approach for reducing health care charges as well as improving people's health.

Keywords: Cohort studies; Health care charges; Japan; Joint exposure; Obesity; Physical inactivity; Smoking

Introduction

Smoking, obesity, and physical inactivity are related to a variety of chronic diseases such as cardiovascular disease [1–4], cancer [5,6], type II diabetes mellitus [7,8], and hypertension [9], which are major public health hazards [10–12] and impose a financial burden on health care systems. It is therefore essential that analyses of the impact of lifestyle on health care charges are used by the medical and public health communities and by policy makers to identify targets for expenditure reduction through cost-effective management programs and treatments.

The association between individual health risks and health care charges has been investigated [13–33], and the results are consistent with an association between the risk and increased health care charges. We also have provided evidence about real and substantial health care charge differences between subjects who have a health-risk factor and those who do not. Male smokers incurred 11% more medical charges than never smokers (subjects who have never smoked, as opposed to those who had smoked and given up) [34]. The mean total charges were 9.8% greater among subjects with a body mass index (BMI) of 25.0–29.9 and 22.3% greater among those with a BMI of 30.0 or more, relative to those with a BMI of 21.0–22.9 [35]. Per-person health care charges in those walking \for less than 1 h per day was 11% higher than for those walking for 1 h per day or more [36]. Nevertheless, an individual often possesses two or more health risks simultaneously and the combined risks may interact with each

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other. However, the data available regarding the joint impact of health risks on health care charges are limited. To our knowledge, only one study has investigated this, and that study was based on a prospective cohort design and followed the subjects for 1.5 years [37].

To examine the joint impact of smoking, obesity, and physical inactivity on health care charges, we conducted a population-based prospective cohort study in rural Japan. Our data were derived from a 7-year prospective observation of National Health Insurance (NHI) beneficiaries. The strengths of this study include a large sample size (n = 26,110) and a long follow-up of 7 years, coverage of almost all aspects of medical care under the NHI system, 100% monitoring of medical care utilization from claim history files, and comprehensive health and lifestyle information for each subject at baseline.

Method

Health insurance system in Japan

Health insurance is compulsory for everyone living in Japan, and is provided by one of two systems [38]; the first is for employees and their dependents, the second is a community-based health insurance system mainly used by farmers, the self-employed, pensioners, and their dependents. This second system is called the National Health Insurance (NHI) plan and covers 35% of the Japanese population. The NHI covers almost all aspects of medical treatment, including diagnostic tests, medication, surgery, supplies and materials, payment of physicians and other personnel, and most dental treatment. It also covers the home care services provided by physicians and nurses, but not by other professionals, such as home health aides. When medical providers treat a patient, they receive a copayment from the patient and then file a claim with the local NHI association for reimbursement. Payment to medical providers is made on a fee-for-service basis, where the price of each service is determined by a uniform national fee schedule. The local NHI association has a peer-review system to determine the level of reimbursement.

Study cohort

The details of the Ohsaki NHI Cohort study have been previously described [39,40]. In brief, this prospective cohort study started in January 1995, when we delivered a self-administered questionnaire on various health habits to all NHI beneficiaries, aged 40–79 years, living in the catchment area of Ohsaki Public Health Center, Miyagi Prefecture, northeast Japan (n = 54,996). Ohsaki Public Health Center, a local government agency, provides preventive health services for the residents of 14 municipalities in Miyagi Prefecture. The questionnaires were delivered to and collected from the subjects' residences by members of public health officials in each municipality. This procedure yielded a high response rate of 95% (n = 52,029). We excluded 774 subjects because they had withdrawn from the NHI before January 1, 1995, when we started the prospective collection of NHI claim history files. Thus, 51,255 subjects formed the study cohort. The study protocol was reviewed and approved by the Ethics Committee of Tohoku University School of Medicine. We considered the return of self-administered questionnaires signed by the subjects to imply their consent to participate in the study.

Exposure data

The questionnaire, which was used as a baseline survey, consisted of 93 items concerning 10 factors: past medical history, family medical history, physical health status, smoking habits, drinking habits, dietary habits (food frequency questionnaire), occupation, marital status, education, and reproductive history of the women. We defined current or former smokers as "smokers" according to the definition of "ever" or "never".

In assessing the obesity, we used the BMI, which is body weight adjusted for height. The baseline survey included questions on body weight and height; BMI was then calculated as the weight divided by the square of the height (kg/m^2). We grouped the subjects into two categories: BMI of 20.0–24.9 and BMI of 25.0 or more. We defined "obesity" as a BMI 25.0 or more because a BMI of 25.0 is the standard cutoff point for defining overweight individuals [41].

We evaluated the validity of the self-reported body weight and height measurements. Among the study subjects, 14,883 had their body weight and height measured during basic health examinations provided by local governments in 1995. The Pearson's correlation coefficients (r) for the self-reported and measured values were 0.96 for body weight, 0.93 for body height, and 0.88 for BMI. Thus, the self-reported weight and height measurements from the baseline questionnaire were considered sufficiently valid.

In assessing physical activity, we chose to focus on walking because it is the most common type of physical activity performed by middle-aged and older individuals in rural Japan. The question on walking time was worded as "How long do you walk a day, on average?", and the subjects were asked to choose one of three options: 30 min or less, between 30 min and 1 h, and 1 h or more. This assessment did not distinguish between household activities, occupational physical activities and leisure-time activities. We defined "physical inactivity" as a walking time of less than 1 h a day because almost half of the subjects walked 1 h or more per day (48.4% walked 1 h or more; 26.0% walked between 30 min and 1 h; 25.7% walked 30 min or less). The validity and reproducibility of this walking questionnaire has been reported elsewhere [42].

The subjects were finally classified into eight categories according to the presence of the three risk factors of smoking, obesity, or physical inactivity and their combinations.

Follow-up

We prospectively collected data on medical care utilization and its charges for all individuals in the cohort for the period from January 1, 1995, to the date of withdrawal from the NHI because of death, emigration, or loss of NHI qualification, or the end of the study period (December 31, 2001), by obtaining their NHI claims history files from the local NHI Association. When a beneficiary is withdrawn from the NHI, the date and reason are entered in the NHI withdrawal history files. Both NHI claims and withdrawal history files were linked to our baseline survey data files, using each beneficiary's identification number as the key code.

We excluded the subjects who had a BMI of less than 20.0 in the analysis in the present study to exclude a bias caused by lean subjects who had lost their weight by occult diseases (n = 8,953). In addition, we excluded from analysis those subjects who were capable of only moderate to low, but not vigorous activity, to exclude a bias caused by physically inactive subjects who could not walk because of their physical condition (n = 11,371). The physical functioning status of each subject was assessed using the six-item physical function measure of the Medical Outcome Study (MOS) Short-Form General Health Survey [43]. This measure examines the extent to which health interferes with a variety of physical activities ranging from strenuous exercise to basic self-care. The validity and reliability of the MOS questionnaire have been fully established [43–45]. Based on their responses, the subjects were classified into three groups: those who were able to perform vigorous activity (MOS score of 5–6), those who were capable of moderate, but not vigorous activity (MOS score of 2–4), and those considered to be of low physical ability (MOS score of 0–1).

We also excluded those subjects from our analysis who did not provide information about either smoking history, body weight, body height, or physical activity (n = 4,821). Thus, we analyzed 26,110 subjects (14,908 men and 11,202 women).

Assessment of health care charges

Monthly values for each subject were calculated by dividing the charges combined throughout the observation by the number of months observed. We used monthly values rather than cumulative values to avoid underestimating medical care utilization and charges for subjects who died or emigrated.

Statistical analysis

We chose, as did Hornbrook et al. [46] and Brown et al. [47], an ordinary least-squares model based on non-log-transformed data because the results in the original dollar units are more easily interpretable and because total charges for groups can be estimated from mean per-person charges. The impact of smoking, obesity, and physical inactivity on monthly per capita total health care charges were examined by analysis of covariance (ANCOVA). In these analyses, we regarded the following data as covariates: sex, age (continuous variable), alcohol drinking status (never, former, currently drinking less than 450 g ethanol/week, currently drinking 450 g ethanol or more/week), history of cancer, myocardial infarction, or stroke.

All statistical analyses were performed using SAS software [48]. We used approximate variance formulae to calculate the 95% confidence intervals (CI). All of the statistical tests that we report were two-sided. A level of $P < 0.05$ was accepted as statistically significant. In this paper, monetary values are converted to U.S. dollars ($) using an exchange rate of $1.00 = 120 Japanese yen (rate as at 2003). We adjusted all health care charges to reflect 1995 prices.

Table 1
Baseline characteristics of the Ohsaki Study subjects by health-risk categories in 1995, Japan

Health-risk categories			Number of subjects	Women (%)	Mean age (SD)	Alcohol intake more than 450 g/week (%)	History of cancer (%)	History of myocardial infarction (%)	History of stroke (%)
Smoking[a]	Obesity[b]	Inactivity[c]							
–	–	–	4191	75.5	57.5 (9.7)	0.4	2.2	1.2	0.6
+	–	–	4834	7.1	57.8 (10.4)	2.6	1.9	1.8	0.8
–	+	–	1962	73.7	58.1 (9.1)	0.5	2.1	1.9	0.7
–	–	+	4403	80.3	58.2 (9.9)	0.5	2.7	1.3	0.6
+	+	–	1646	9.1	56.1 (9.8)	3.9	1.2	3.0	1.1
+	–	+	4635	9.9	58.4 (10.7)	3.5	2.1	2.8	1.6
–	+	+	2357	79.3	58.7 (9.3)	0.6	2.6	2.1	1.0
+	+	+	2082	11.4	56.9 (10.5)	4.2	1.3	2.7	1.4

SD denotes standard deviation.
[a] Current and former smokers.
[b] Body mass index [weight (kg)/height (m)^2] more than or equal to 25.0.
[c] Time spent walking less than 1 h a day.

Results

Table 1 shows the baseline characteristics of the subjects according to the eight health-risk categories. Women were less likely to smoke and excess drinkers were more likely to be men. There were no apparent differences in mean age, the proportion of having history of cancer, myocardial infarction, or stroke among the health-risk categories.

Of 26,110 subjects, 25,249 (96.7%) used medical care and had nonzero charge for 7 years. During the follow up, 4.4% of the participants (1,161 subjects) died. The proportion of subjects who died in the different health-risk categories (shown in Tables 1–3), no risk, smokers, obese, physically inactive, smoker + obese, smoker + physical inactivity, obese + physical inactivity, and smoker + obese + physically inactive, were 8.1%, 23.8%, 4.6%, 11.4%, 6.5%, 28.6%, 6.2%, and 10.9%, respectively. A total of 11.7% of the participants (3,065 subjects) were lost to follow-up. The proportion of subjects who were lost to follow-up in the different health-risk categories (as listed above) were 18.4%, 17.0%, 8.1%, 19.2%, 6.2%, 15.0%, 9.8%, and 6.4%, respectively.

Table 2
Estimates of the independent contributions to health care charges of health risk categories, based on linear regression in the Ohsaki Study, Japan, 1995–2001

Variables			Parameter estimate	Standard error
Intercept			−344.9	31.1
Age (continuous variable)			9.7	0.4
Sex (women)			−35.1	10.6
Alcohol drinking status				
Never			referent	–
Former			128.9	15.0
Currently drinking 1–449 g ethanol/week			−14.1	8.8
Currently drinking ≥450 g ethanol/week			8.2	27.1
History of diseases (presence or absence)				
Cancer			115.4	24.7
Myocardial infarction			124.3	25.7
Stroke			95.9	36.9
Health-risk categories				
Smoking[a]	Obesity[b]	Inactivity[c]		
–	–	–	referent	–
+	–	–	14.2	13.9
–	+	–	12.2	15.6
–	–	+	13.6	12.3
+	+	–	20.0	17.9
+	–	+	53.8	13.9
–	+	+	28.1	14.7
+	+	+	73.1	16.6

[a] Current and former smokers.
[b] Body mass index [weight (kg)/height (m)^2] more than or equal to 25.0.
[c] Time spent walking less than 1 h a day.

Table 3
Average monthly health care charges over 7 years by health-risk categories in the Ohsaki Study, Japan, 1995–2001

Health-risk categories			Health care charges (U.S.$)	95% Confidence interval	Increasing rate (%)
Smoking[a]	Obesity[b]	Inactivity[c]			
–	–	–	171.6	153.2, 190.1	
+	–	–	185.8	168.3, 203.3	8.3
–	+	–	183.8	157.9, 209.8	7.1
–	–	+	185.3	166.9, 203.6	8.0
+	+	–	191.7	163.3, 220.0	11.7
+	–	+	225.4	207.8, 243.1	31.4
–	+	+	199.8	175.7, 223.8	16.4
+	+	+	244.7	219.5, 270.0	42.6
P value			<0.001		

Adjusted for sex, age (continuous variable), alcohol drinking (never, former, 1–449, or ≥450 g ethanol/week), history of cancer, myocardial infarction, or stroke.
Tested by analysis of covariance (ANCOVA) for mean health care charges.
[a] Current and former smokers.
[b] Body mass index [weight (kg)/height (m)^2] more than or equal to 25.0.
[c] Time spent walking less than 1 h a day.

Table 2 gives the results of regressing per capita per month health care charges categorized by age, sex, alcohol drinking status, history of diseases, and health-risk categories. Age, sex (women), former alcohol drinking, history of diseases (cancer, myocardial infarction, or stroke), and exposure to physical inactivity alone, smoking + physical inactivity, smoking + obesity + physical inactivity were significant predictors of the charges in the multivariate model.

Table 3 lists the monthly per capita total health care charges according to the health-risk categories. Health care charges increased significantly as the number of health risks increased. Never-smokers with a BMI of less than 25.0 and who walked for more than 1 h a day (defined as the 'no risk' group) had mean monthly health care charges of $171.6 (95% CI, 153.2–190.1) after adjustment for sex, age, alcohol drinking, history of cancer, myocardial infarction, or stroke. Relative to this group, among those who had only one health risk, the presence of smoking was associated with a 8.3% increase in health care charges, obesity was associated with an 7.1% increase, and physical inactivity with a 8.0% increase. The combinations of smoking + obesity, smoking + physical inactivity, and obesity + physical inactivity were associated with a 11.7%, 31.4%, and 16.4% increase in health care charges, respectively. Physically inactive obese smokers had mean monthly health care charges that were 42.6% greater than those for the no risk group.

There was no notable gender difference in these findings. Median charges were much lower than mean charges; thus, we carried out a further analysis of the data after log transformation. The findings from the transformed data (not shown) were consistent with those from the non-log-transformed analyses.

Discussion

Our prospective cohort study demonstrates that physically inactive obese smokers had mean monthly health care charges that were 42.6% greater than those for the no risk group after adjustment for sex, age, alcohol drinking, history of cancer, myocardial infarction, or stroke. The combination of smoking, obesity, and physical inactivity as risk factors appears to have more than an additive (multiplicative) effect on health care charges. The combination of smoking and physical inactivity also seems to have the same effect. These data provide useful evidence on which to base targets for expenditure reduction through cost-effective management programs and treatments.

Our study had several methodological advantages. We followed up a large number of subjects ($n = 26,110$) over a 7-year period. Our charge calculation was accurate because we obtained NHI Claim History files directly from the local NHI Association, which includes almost all available medical treatment. The study subjects were sufficiently representative of the target population because the response rate was 95%. We analyzed the joint impact of smoking, obesity, and physical inactivity on health care charges after adjustment of a variety of potentially confounding variables such as sex, age, alcohol drinking, history of cancer, myocardial infarction, or stroke. Under the NHI system, differences in individuals' access to medical care according to socioeconomic status are unlikely.

Another advantage to our study was the adequate control for physical functioning status by MOS scores. Some people are unable to walk because of illness or disability, which is a strong determinant of health care charges. We attempted to minimize this bias by excluding subjects who were capable of only moderate, but not vigorous activity (MOS score of 2–4), and those who considered to be of low physical ability (MOS score of 0–1). Because of this methodological advantage, it is plausible to interpret that the strong impact of physical inactivity on health care charges described here cannot be explained only by the interrelationship between physical function and walking.

Although many studies have investigated the association between individual health risks and health care charges, few studies have demonstrated the impact of a combination of health risks on the magnitude of health care charges. Our results are consistent with those of Pronk et al. [37], whose prospective study, to our knowledge, is the only one that has demonstrated the joint impact of smoking, obesity, and physical inactivity on the magnitude of health care charges. Their short-term (1.5 year) observation data indicate that never-smokers with a BMI of 25 kg/m^2 who participated in physical activity on 3 days per week would have mean annual health care charges 49% lower than those of physically inactive smokers with a BMI of 27.5 kg/m^2. Our results are derived from a long-term observation of 7 years.

Our methodology imposed some limitations on the study. First, we used self-administered weight and height at enrollment to calculate BMI. Although self-administered weight and height are highly correlated with measured weight and height in the present study, a small, generally systematic, error exists—an overestimation of height and underestimation of weight, especially at higher weights [49]. Thus, our measure of BMI probably underestimated the true BMI of overweight subjects, which might make our estimates of the effects of modifiable risks on charges conservative. Second, the measure of physical activity was simple. We asked the subjects to report only the time spent walking, and we neither ask for the pace of walking nor did we distinguish between walking for exercise and nonexercise. Thus, there is a possibility that we could not fully examine the effect of walking and other physical activities. However, because walking is the most common type of physical activity performed by middle-aged and older individuals in rural Japan, these effects may be relatively small. Third, the present study does not prove whether changing health risks can reduce health care charges. Further interventional studies are needed to fully clarify whether behavior change intervention strategies could lower health care charges along with health-risk reduction.

Our results indicate that joint exposure to health risks contribute substantially to higher health care charges. Primary prevention of smoking, reduced excess body weight, and increased physical activity appear to have a tremendous potential to maximize health returns relative to health care charges, as well as to improve the general health of the individual.

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飲酒習慣と医療費に関するコホート研究

－大崎国保加入者コホート研究による成人男性の分析－

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大崎国保加入者コホート研究をもとに、成人男性の飲酒習慣が入院および外来の医療費に及ぼす影響について分析した。その結果、入院医療費はU字曲線を示したが、外来医療費は飲酒量の増加と共に減少した。

【目的】　これまでの疫学研究により、飲酒習慣と死亡のリスクとの関連は、JまたはU字曲線を示すことが広く知られている。このことから、飲酒習慣と医療受診においても同様の影響を及ぼすと考えられるが、これまでの欧米を中心とした研究結果からは一定の結果が得られていない。この原因として、横断研究であること、サンプルサイズが小さい、受診に関する把握方法等研究デザイン上の限界が考察されている。そこで、本研究では、大崎国保加入者コホート研究をもとに、飲酒習慣が入院および外来の医療費に及ぼす影響を分析した。

【方法】　大崎国保加入者コホート研究は、宮城県大崎保健所管内に住む40歳から79歳の国保加入者52,029人を対象として、1995年1月以降の国保レセプトによる追跡に基づくものである。本研究では、男性のみを対象とし(n=24,574)、飲酒習慣に関する項目の無記入者、および調査時点で、脳卒中、心筋梗塞、肝疾患、癌に罹患している人を除外し、19,383人を分析対象とした。飲酒習慣については、飲酒頻度と1回量から1週間のエタノール摂取量を算出し、次の6段階に分類した：以前飲酒、非飲酒、現在1-149g/w飲酒、150-299g/w飲酒、300-449g/w飲酒、450g/w以上飲酒。分析にあたって、年齢、喫煙、BMI、1日の歩行時間、身体活動レベル、学歴、配偶者、既往歴の影響を多変量モデルにより補正した。医療費は4年間の入院・入院外別の医療費のデータを基に、1月あたり平均医療費（入院、外来）を用いた。

【結果】　1か月あたりの入院および外来医療費が最も高いのは、以前飲酒者であった。つまり、以前飲酒者の入院医療費は23436円（95%CI:21168, 25704)、外来医療費は25616円（95%CI:24315, 26917）であった。ベースライン調査時においても、以前飲酒者は既往歴を持つ人が多く、身体活動レベルやBMIも低く、病的状態にある人が多かった。そこで、以前飲酒者を除いて分析を行った。

1か月あたりの入院医療費が最も多いのは450g/w以上の多量飲酒者であり、13917円（95%CI:9558, 18276）であった。最も少ないのは150-229g/w飲酒者であり、10271円（95%CI:8919, 11624）であった。

一方、外来受診については飲酒量と直線的な関係を示した（p for trend <0.001)。つまり、1か月あたりの外来医療費は、非飲酒者が15425円（95%CI: 14463, 16385）が最も高く、飲酒量が多い群ほど低くなった。450g/w以上の飲酒者が11031円（95%CI:8530, 13531）と最も少なかった。

【結論】　以前の飲酒者は、他の集団とは異なって病的な状態にある人が多く、医療費が最も高い集団であった。以前飲酒者を除く集団では、飲酒習慣と入院医療費との関係は、死亡と同様にU字曲線を示したが、外来医療費は飲酒量の増加と共に減少した。

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動脈硬化危険因子と医療費：大崎国保コホート研究

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【目的】 我が国の地域住民の基本健康診査（基本健診）における動脈硬化危険因子（高血圧、脂質代謝異常、高血糖、肥満）とその集積が医療費に及ぼす影響を検討すること。

【方法】 大崎国保コホート研究では、宮城県大崎保健所管内 40～79 歳の国民健康保険（国保）加入者を対象にベースライン調査を平成 6 年に実施し、医療費の追跡を行っている。同研究参加者のうち平成 7 年の基本健診で採血、血圧測定、身体測定を受けた 13,257 名を解析対象者とした。

対象者について、国保レセプトとのリンケージにより平成 8 年 1 月から平成 14 年 12 月の医療費を算出し、国保異動記録より生存死亡を確認した。

基本健診結果から、高血圧、脂質代謝異常、高血糖、肥満を以下の条件で定義した。①高血圧：血圧値 140/90mmHg 以上又は高血圧既往歴あり、②脂質代謝異常：随時血清コレステロール値 220 mg/dl 以上、又は HDL40mg/dl 未満、③高血糖：随時血糖値 150mg/dl 以上又は糖尿病既往歴あり、④肥満：Body Mass Index 25 以上。

危険因子の集積数から、4 群（なし、1 個、2 個、3 個以上）に分類した。4 群別の全死因死亡リスクを Cox 比例ハザードモデルにて検討し、1ヶ月あたり平均医療費を共分散分析から算出した。4 群ごとの過剰医療費割合を以下の方法で計算した。

$$\text{過剰医療費割合} = \frac{\left[(\text{各群の平均医療費}) - (\text{危険因子なし群の平均医療費})\right] \times (\text{各群の観察人月})}{\text{対象者全体の7年間の累積医療費}}$$

【結果】 全死因死亡ハザード比および1ヶ月あたり平均医療費は危険因子の集積数とともに上昇した。危険因子集積数が3個以上の場合の1ヶ月あたり平均医療費は、危険因子を持たなかった場合に比べて男女ともに約 1.5 倍であった。動脈硬化危険因子による過剰医療費割合の合計は、男性では約 16%、女性では約 14%を占めた。

表. 動脈硬化危険因子の集積数と死亡リスク・医療費との関連

	男性				女性			
危険因子集積数 [a]	0	1	2	3+	0	1	2	3+
観察人月	95 122	142 148	99 254	44 456	114 840	178 497	139 801	69 447
死亡ハザード比 [b]	Ref	1.11	1.25	1.25	Ref	1.50	1.64	1.63
（95% 信頼区間）		(0.86-1.44)	(0.95-1.75)	(0.90-1.75)		(0.99-2.29)	(1.07-2.51)	(1.02-2.51)
平均医療費（千円/月）[b]	25.5	28.3	33.7	38.2	20.2	22.2	25.3	29.6
（標準誤差）	(1.5)	(1.2)	(1.4)	(2.1)	(0.88)	(0.70)	(0.79)	(1.1)
増加率 [c]	1.00	1.11	1.32	1.50	1.00	1.10	1.25	1.47
過剰医療費割合		3.5%	7.1%	4.9%		3.0%	5.9%	5.5%

a) 高血圧、脂質代謝異常、高血糖、肥満の合併数

b) 年齢（歳）、喫煙（現在/過去/非喫煙）、飲酒（現在/過去/非飲酒）、循環器疾患・がんの既往歴の有無で補正

c) 危険因子集積数0の場合の平均医療費と比較

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統合失調症における入院割合と医療費に関する地域相関研究

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【背景】「精神および行動の傷害」は平成 11 年度の傷病分類別入院受療率において他疾患と比し最も高く、同年の医療費は 1.5 兆円と推計されている。なかでも統合失調症は入院推計患者数が最も多く、統合失調症の入院により医療費に与える影響は著しく大きい。しかし、これまでに日本国内において統合失調症の地域における入院割合と医療費の関連を明らかにした研究は行われてはいなかった。

【目的】統合失調症患者の医療機関の受療状況と医療費構造を分析し、地域における統合失調症の入院割合と医療費との関連を明らかにすることである。

【方法】本研究は宮城県国民健康保険団体連合会が開発したレセプト全疾病登録を用いたものである。レセプト全疾病登録は、宮城県内 7 町を対象に平成 14 年 5 月診療分すべてのレセプトについて、全疾病名（上限 15 疾病）、入院・外来別受療日数、入院・外来別医療費、調剤費用、医療機関を記載したデータベースである。調査対象は国民健康保険加入者 17,992 人のうち、統合失調症またはパラノイアの疾患名がレセプトに記載されている 382 人（入院 104 人、外来 278 人）である。各地域ごとに 1 人当たりの平均医療費と入院割合（全患者に占める入院患者の割合）を相関分析により解析した。本研究は関係町長の承認により、個人同定可能情報を削除し連結不可能匿名化した上で宮城県国民健康保険団体連合会との業務委託契約に基づきデータ提供を受けた。また東北大学医学部倫理委員会の承認を得ている。

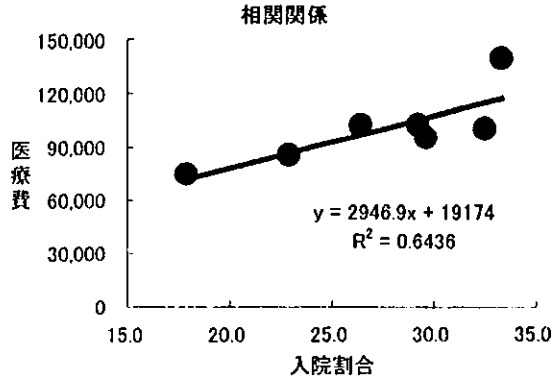
【結果および考察】統合失調症患者の総医療費のうち、入院患者が 82.8%を占めていた。表 1 に 7 町の統合失調症患者数、1 人当たりの平均医療費（SD）、入院割合を示す。入院割合と医療費について、7 町のなかで最も高い町と最も低い町を比べると、入院割合、医療費ともに 1.86 倍の差があった。図 1 に各地域の 1 人当たりの医療費と入院割合の相関を示す。医療費と入院割合には有意な相関関係が認められ [R^2=0.64, p=0.03]、入院割合の高い町ほど 1 人当たりの平均医療費が高くなった。

本研究により、地域における統合失調症の入院割合と 1 人当たりの平均医療費には高い相関関係が認められ、統合失調症の入院費用が医療費全体に与える影響が大きいことが明らかになった。

表1. 統合失調症患者の1人当たり平均医療費と入院割合

地域別	人数(人)	費用(円) (±SD)	入院割合(%)
A町	12	139,415 (197,514)	33.3
B町	27	95,312 (119,739)	29.6
C町	83	100,423 (130,971)	32.5
D町	47	102,156 (132,349)	29.2
E町	116	85,314 (120,880)	22.9
F町	69	102,008 (132,459)	26.4
G町	28	74,813 (117,517)	17.9

図1. 入院割合と1人当たり平均医療費の相関関係



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