Original Article

Personal status of general health checkups and medical expenditure: A large-scale community-based retrospective cohort study

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A R T I C L E   I N F O

A B S T R A C T

Background: We sought to clarify the association between the personal utilization of general health checkups (GHCs) and medical expenditures (MEs) in a middle-aged Japanese population.
Methods: A retrospective cohort study was conducted. Subjects were 33,417 residents (15,819 males and 17,598 females) aged 48 years or older in 2010 who were invited to undergo GHCs every year. Official records on GHCs from 2002 to 2007 and MEs from 2008 to 2010 were provided by Soka City, Saitama Prefecture, Japan. The utilization of GHCs was divided into zero times (non-utilizers), 1—3 times (low-frequency utilizers), and 4—6 times (high-frequency utilizers). Tweedie distributions in the generalized linear model were used to analyze the association between MEs and the subgroups of GHC utilization after adjustment for age and sex.
Results: Of the 33,417 subjects, 20,578 (61.6%) were non-utilizers, 5,777 (17.3%) were low-frequency utilizers, and 7,062 (21.1%) were high-frequency utilizers, based on the attendance to GHCs from 2002 to 2007. Compared with the non-utilizers, the high-frequency utilizers showed significantly higher outpatient MEs (JPY394,700 vs. JPY373,100). The low- and high-frequency utilizers showed significantly lower inpatient MEs (JPY224,000 and JPY181,500 vs. JPY309,300) and total MEs (JPY610,600 and JPY580,700 vs. JPY689,600) than the non-utilizers based on the pooled data from 2008 to 2010.
Conclusions: This study suggests that the outpatient MEs rise when annual GHCs are increasingly attended (not including the GHC cost), but inpatient and total MEs are lower. To reduce MEs, increasing the rates of attendance at GHCs by the general public may be important.
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Introduction

Non-communicable diseases (NCDs) are the most important health and financial issues of the century worldwide. In 2008, 63% of global deaths were due to NCDs, and expenditure greater than $6.3 trillion United States dollars was estimated due to the five major NCDs: cardiovascular disease, diabetes, cancer, chronic obstructive pulmonary disease, and mental illness.[1,2] These health and economic burdens due to NCDs have been predicted to rise sharply by 2030 on a global scale.[2] In Japan, the burdens of increasing national health expenditures have caused major public health problems. According to the reports of the Japan's Ministry of Health, Labour and Welfare, the total medical expenditure (ME) in 2013 was 40.06 trillion yen, of which approximately 40% was attributable to NCDs, including cancer, coronary heart disease, and stroke.

Undergoing general health checkups (GHCs) is a common activity in many countries because the early diagnosis and treatment of NCDs is a principle of preventive medicine. Some previous studies have reported that not undergoing health checkups was associated with higher mortality in women,[3] and health checkups may increase survival[4] or decrease overall mortality among the elderly.[5] However, recent studies have indicated that health checkups for an adult population were not associated with lower rates of all-cause mortality in a systematic review and meta-analysis.[6—8] Therefore, the benefits of GHCs are still not clear.

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Some previous cross-sectional studies reported that an association between the rate of utilizing health checkups and the hospital inpatient fee or average MEs was found across municipalities.[9–11] Takeuchi et al. reported that examinees aged over 70 years who had undergone health checkups for the past 3 years had lower MEs per capita as outpatients and inpatients than non-examinees,[12] but this study did not investigate the individual frequency of heath checkups. For outpatient MEs, there was no reported difference between participants with low or high rates of health checkups in cities in one study.[13] Although one study among 1,811 middle-aged workers reported that the total medical expenditure was lower in those who had a higher frequency of health checkups over a period of 3 years,[14] the sample size was small and the study was limited to occupational health. To our knowledge, there have been insufficient studies to clarify the relationship between the rate of utilizing GHCs and MEs including outpatient, inpatient, and total fees in community populations involving large-scale cohort studies.

The aim of the present study was to clarify the association between the rate of undergoing GHCs and subsequent MEs using a large-scale retrospective cohort study in a middle-aged Japanese population living in the community.

Methods

Study design and subjects

A community-based retrospective cohort study was conducted in Soka City, Saitama Prefecture, Japan. Soka City is an urban area adjacent to the northeast of Tokyo, with a population of about 240,000. In Japan, there are two kinds of public health insurance for the whole nation: Employee Health Insurance for employees and their families and National Health Insurance for those not enrolling in the Employee Health Insurance system. In Soka City, approximately 30% of the population belong to the National Health Insurance, and the others belong to the Employee Health Insurance. A total of 77,265 residents enrolled as Soka City National Health Insurance subscribers, and 49,854 residents (24,547 males and 25,307 females) aged from 40 to 74 years old were invited to undergo health checkups in 2010. Of the 49,854 subjects, 8,056 residents who were under 40 years old in 2002 and 8,381 residents who were Soka City National Health Insurance subscribers after 2002 were excluded. The subjects analyzed in the present study (67.0%) were 33,417 residents (15,819 males and 17,599 females) with complete datasets based on the records of MEs from 2008 to 2010, and the data of general health checkups from 2002 to 2007, which were combined using the ID of the Soka City National Health Insurance subscribers.

Medical expenditures (MEs) and medical consultation (MC)

Records on MEs and MC in 2008, 2009, and 2010 were provided by Saitama National Federation of Health Insurance Societies, an agency of Soka City National Health Insurance. Per capita outpatient, inpatient, and total MEs were calculated with 2008, 2009, and 2010 data, and the 3-year data (2008–2009) were pooled. The MC was determined based on visiting a medical institute more than once as an outpatient or for hospitalization from 2008 to 2010.

Status of general health checkups (GHCs)

According to the Health Services for the Elderly Act in Japan, those aged 40 years old or older are recommended to undergo GHCs every year. Although GHCs are encouraged, each individual has no obligation to attend, and there is no penalty for not undergoing GHCs. In Soka City, the insurer pays about 10,000 yen

and individuals payed about 1,200 yen to undergo a GHC. Annual GHCs in Japan include the following: past medical history, anthropometric examination (weight, height, and blood pressure), laboratory examination (red blood cell count, hemoglobin concentration, packed cell volume, total serum cholesterol concentration, blood glucose concentration, aspartate aminotransferase and alanine aminotransferase activities, and serum uric acid), and electrocardiography. In this study, GHC utilization was assessed using 6-year records from 2002 to 2007, which were provided by Saitama National Federation of Health Insurance Societies, an agency of Soka City National Health Insurance, and three utilization subgroups were assigned: non-utilizers (zero times), low-frequency utilizers (1–3 times), and high-frequency utilizers (4–6 times).

Statistical analysis

The number of GHCs was counted from 2002 to 2007, non-utilizers were excluded, and the other two subgroups were divided using a cutoff point of 3.7 times (the median value). Per capita outpatient, inpatient, and total MEs of 2010, 2009, 2008, and the mean of the pooled 3-year data from 2008 to 2010, are expressed as means (ranges). In this study, cost equivalents are reported using exchange rates in which one United States dollar ($) was equivalent to 120 Japanese yen (JPY) and one euro was equivalent to JPY133 based on the rates in October 2015. The unit of Japanese yen (JPY) of the present study is one thousand. Because the frequency distributions of MEs are often zero, and others are continuous, MEs are mixed data that include compound Poisson and Gamma distributions. So, Tweedie distributions[15–17] in the generalized linear model (GLM) were used to analyze the association of MEs and MEs plus the GHC cost with the GHCs utilization subgroups after adjustment for age and sex. The estimated marginal mean and 95% confidence interval (CI) are shown, and three pairwise comparisons among utilization groups using the Bonferroni's post-hoc test in the GLM were employed. For analysis of medical consultation, a multivariate logistic regression model was used, with adjustment for age and sex.

All statistical analyses were performed using an assumed type I error rate of 0.05. Statistical analyses were performed using SPSS Statistics 22 for Windows (SPSS Japan Inc., Tokyo, Japan).

Ethical consideration

Ethical approval was given by the ethics committee at Dokkyo Medical University (University 27006). The identities of subjects remained anonymous, in compliance with the Ethical Guidelines for Epidemiological Research (Ministry of Education, Culture, Sports, Science and Technology, and Ministry of Health, Labour and Welfare, Japan, 2013).[18]

Results

Table 1 shows the characteristics of sex and age in 2002; the status of participation in health checkups; outpatient and inpatient MC; and per capita outpatient, inpatient, and total MEs in the 3-year period of 2008–2010. Of the 33,417 participants, 20,578 (61.6%) were non-utilizers, 5,777 (17.3%) were low-frequency utilizers, and 7,062 (21.1%) were high-frequency utilizers based on the number of GHCs in the 6-year period from 2002 to 2007.

Table 2 shows that, based on the results of the multivariate logistic regression model, undergoing more health checkups was significantly correlated with a higher frequency of any outpatient MC, and a lower frequency of any inpatient MC in 2008, 2009, and 2010. The trend tests on the adjusted OR of outpatient and inpatient

Table 1
Characteristics of study subjects.

	Total (N = 33,417)	
Sex		
Female	17,598	(52.7)
Male	15,819	(47.3)
Age in 2002, years		
40—49	5,118	(16.3)
50—59	13,222	(39.6)
60—67	15,077	(45.1)
Frequency of general health checkups[a]		
Zero times	20,578	(61.6)
1—3 times	5,777	(17.3)
4—6 times	7,062	(21.1)
Mean (SD) cost of general health checkups, thousand yen		
Zero times	0	(0.00)
1—3 times	17.6	(8.12)
4—6 times	53.3	(8.11)
Medical consultation rate		
2008		
Outpatient	27,404	(82.0)
Inpatient	2,291	(6.9)
2009		
Outpatient	27,660	(82.2)
Inpatient	2,476	(7.4)
2010		
Outpatient	27,944	(83.6)
Inpatient	2,965	(8.6)
Mean (range) per capita of medical expenditures,[b] *thousand yen*		
2008		
Outpatient	112.0	(0—8481.5)
Inpatient	73.0	(0—12,525.4)
Total	192.9	(0—12,525.4)
2009		
Outpatient	132.2	(0—817.2)
Inpatient	91.3	(0—20,359.4)
Total	223.6	(0—23,732.7)
2010		
Outpatient	137.5	(0—8002.7)
Inpatient	117.1	(0—15,657.9)
Total	254.6	(0—15,657.9)
Pooled 2008—2010		
Outpatient	389.6	(0—20,858.9)
Inpatient	281.5	(0—43,058.2)
Total	671.1	(0—44,550.7)

[a] Frequency of general health checkups over 6 years from 2002 to 2007.
[b] Cost unit is expressed as a thousand yen, with an exchange rate of 1,000 yen = 8.3 dollars or 7.5 euro.

MC were significant among the three GHC subgroups in 2008, 2009, and 2010.

Table 3 shows the association between the GHC attendance status and MEs using Tweedie analysis of GLM and the Bonferroni's post-hoc test, after adjustment for age and sex. For outpatient MEs, there were significant differences between high-frequency utilizers and non-utilizers in 2008 and 2009 and between high-frequency utilizers and low-frequency utilizers in 2009. Compared with non-utilizers, high-frequency and low-frequency utilizers showed significantly higher inpatient MEs in 2008, 2009, and 2010. Compared with low-frequency utilizers, high-frequency utilizers showed significantly higher inpatient MEs in 2009 and 2010. In 2008, 2009, and 2010, high-frequency and low-frequency utilizers showed significantly higher total MEs than non-utilizers. In 2010, high-frequency utilizers showed significantly higher total MEs than low-frequency utilizers.

Fig. 1 shows the pooled estimated marginal means and 95% CIs for 3-year MEs associated with the frequencies of GHC attendance using Tweedie analysis in the GLM, after controlling for age and sex. Compared with non-utilizers, high-frequency utilizers showed significantly higher outpatient MEs (JPY394,700 [95% CI, JPY385,200-JPY404,400] vs. JPY373,100 [95% CI, JPY367,800-JPY378,500]). Low- and high-frequency utilizers showed significantly lower inpatient MEs (JPY224,000 [95% CI, JPY205,400-JPY244,300] and JPY181,500 [95% CI, JPY166,900-JPY197,400], respectively, vs. JPY309,300 [95% CI, JPY296,200-JPY323,100]) and total MEs (JPY610,600 [95% CI JPY593,200-JPY628,200] and JPY580,700 [95% CI, JPY565,200-JPY596,600], respectively, vs. JPY686,600 [95% CI, JPY676,300-JPY697,200]) based on the pooled data from 2008 to 2010. Fig. 1 also reveals that the low- and high-frequency utilizers showed significantly higher outpatient MEs and GHC costs and lower inpatient and total MEs, as well as higher total GHC costs, than the non-utilizers. Compared with low-frequency utilizers, high-frequency utilizers showed significantly higher outpatient MEs and GHC costs.

Discussion

We assessed the associations of the three groups of GHC frequency from 2002 to 2007 and outpatient, inpatient, and total MEs of 2008, 2009, 2010, as well as pooled 3-year MEs, in a retrospective cohort study of Japanese residents. We found that outpatient MEs

Table 2
Frequency of any medical consultation according to subgroups of general health checkup utilization.

	Medical consultation[a] over 3 years from 2008 to 2010							
	Outpatient				Inpatient			
	N	(%)	OR[b]	95% CI	N	(%)	OR[b]	95% CI
2008								
Non-utilizers	15,415	(74.6)	1.00		1,440	(7.0)	1.00	
Low-frequency	5,276	(91.3)	2.90	(2.62—3.20)	400	(6.9)	0.88	(0.79 - 0.99)
High-frequency	6,713	(95.1)	4.71	(4.20—5.28)	451	(6.4)	0.81	(0.73—0.91)
p for trend				<0.001				<0.001
2009								
Non-utilizers	15,657	(76.1)	1.00		1,549	(7.5)	1.00	
Low-frequency	5,292	(91.6)	2.75	(2.49—3.04)	434	(7.5)	0.87	(0.78—0.98)
High-frequency	6,711	(95.0)	4.25	(3.79—4.76)	493	(7.0)	0.81	(0.73—0.90)
p for trend				<0.001				<0.001
2010								
Non-utilizers	15,865	(77.1)	1.00		1,837	(8.9)	1.00	
Low-frequency	5,340	(92.4)	2.90	(2.61—3.22)	476	(8.2)	0.79	(0.71—0.88)
High-frequency	6,739	(95.4)	4.37	(3.88—4.92)	552	(7.8)	0.75	(0.67—0.83)
p for trend				<0.001				<0.001

CI, confidence interval; OR, odds ratio.
[a] Medical consultation is defined as seeing a doctor in a period of 1 year.
[b] Using medical consultation (yes = 1, no = 0) as a dependent variable and general health check utilization (non = 0, low = 1, and high = 2) as an independent variable in a multivariate logistic regression model adjusted for age and sex.

Table 3
Comparison of medical expenditures according to subgroups of general health checkup utilization.

Per capita of medical expenditures[a]	Frequencies of general health checkups over 6 years from 2002 to 2007						*p*-value[c]	Post-hoc test[d]
	Non-utilizers		Low-frequency		High-frequency			
	(zero times) N = 20,578		(1–3 times) N = 5,777		(4–6 times) N = 7,062			
	Mean[b]	(95% CI)	Mean[b]	(95% CI)	Mean[b]	(95% CI)		
2008								
Outpatient	114.3	(112.5–116.2)	119.0	(115.5–122.6)	123.8	(120.5–127.2)	<0.001	H vs N: *p* < 0.001 L vs N: *p* = 0.067 H vs L: *p* = 0.139
Inpatient	79.6	(74.0–85.5)	61.7	(53.5–71.1)	55.1	(48.2–63.0)	<0.001	H vs N: *p* < 0.001 L vs N: *p* = 0.003 H vs L: *p* = 0.752
Total	194.5	(191.2–197.9)	181.2	(175.5–187.1)	180.2	(174.9–185.6)	<0.001	H vs N: *p* < 0.001 L vs N: *p* < 0.001 H vs L: *p* = 1.000
2009								
Outpatient	126.0	(124.0–128.1)	128.7	(125.0–132.6)	135.6	(132.0–139.3)	<0.001	H vs N: *p* < 0.001 L vs N: *p* = 0.068 H vs L: *p* = 0.026
Inpatient	101.5	(94.7–108.6)	74.3	(64.8–85.1)	56.2	(49.2–64.3)	<0.001	H vs N: *p* < 0.001 L vs N: *p* < 0.001 H vs L: *p* = 0.012
Total	228.6	(227.8–232.6)	203.9	(197.4–210.6)	193.5	(187.7–199.4)	<0.001	H vs N: *p* < 0.001 L vs N: *p* < 0.001 H vs L: *p* = 0.054
2010								
Outpatient	132.7	(130.6–134.9)	135.4	(131.5–139.5)	135.3	(131.7–139.0)	0.344	H vs N: *p* = 0.723 L vs N: *p* = 0.726 H vs L: *p* = 1.000
Inpatient	127.4	(119.6–135.8)	87.4	(77.0–99.3)	70.0	(61.7–79.2)	<0.001	H vs N: *p* < 0.001 L vs N: *p* < 0.001 H vs L: *p* = 0.039
Total	262.7	(258.3–267.2)	225.1	(218.0–232.5)	207.0	(200.7–213.3)	<0.001	H vs N: *p* < 0.001 L vs N: *p* < 0.001 H vs L: *p* < 0.001

CI, confidence interval.
[a] Cost unit is expressed as a thousand yen, with the exchange rate of 1,000 yen = 8.3 dollars or 7.5 euro.
[b] Using estimated marginal mean.
[c] Using Tweedie analysis in the generalized linear models (GLM) adjusted for age and sex.
[d] Using Bonferroni's post-hoc comparison tests in the GLM, H: High-frequency; L: low-frequency; N: Non-utilizers.

of high-frequency utilizers were high in comparison with those of non-utilizers in 2008, 2009, and the 3 pooled years, and inpatient and total MEs of low- and high-frequency utilizers were low in comparison with those of non-utilizers in 2008, 2009, 2010, and the 3 pooled years. To our knowledge, this is the first study to suggest that a higher frequency of attendance at GHCs may increase outpatient MEs but decrease inpatient and total MEs among Japanese in the community using a large-scale retrospective cohort study design.

Outpatient MEs were reported to be correlated negatively with GHC attendance in previous studies.[11,12,19,20] However, most of these studies used a cross-sectional design, preventing assessment of the association between GHCs and MEs. In this study, we obtained results that contradict those of previous studies: outpatient MEs increased with the frequency of GHC attendance. Meanwhile, we also observed higher outpatient MC with higher frequency of GHCs. A previous study[21] reported that the high rate of GHCs can increase outpatient care, and Krogsboll et al. also indicated that health checks may be associated with more diagnoses and more drug treatment,[6] so we consider these results in agreement with ours. Moreover, we found that inpatient or total MEs were negatively associated with attendance at GHCs, which is consistent with previous studies.[9–14] Meanwhile, we found that inpatient MC deceased with the higher frequency of GHCs, which could lead to lower inpatient MEs. According to Takeuchi[12] and Suka et al.,[14] early diagnosis facilitated by early outpatient consultation is more likely to lead to a slight increase in outpatient MEs but a decrease in

inpatient MEs for serious diseases, resulting in a decrease in the total cost of healthcare.

According to Fig. 1, per capita total MEs pooled over the 3 years for non-utilizers, low-frequency utilizers, and high-frequency utilizers of GHCs were 686.3, 610.6, and 580.7 thousand yen, respectively. The differences between non-utilizers and high-frequency utilizers were 105.6 thousand yen, and the differences between low-frequency utilizers and high-frequency utilizers were 29.9 thousand yen. Every year, an approximately 7.8 hundred million yen (≈6.5 million dollars or 5.9 million euro) decline can be estimated if non-utilizers and low-frequency utilizers become high-frequency utilizers among approximately 30,000 community residents. Considering the GHC cost, it is possible to save 4.5 hundred million yen (≈3.8 million dollars or 3.4 million euro) ever year. Although these savings would need to be confirmed through an intervention study in the future, encouraging attendance at GHCs is important to reduce MEs.

In this study, we also found the inpatient and total MEs over a 3-year period were significantly lower in high-frequency utilizers than in low-frequency utilizers. However, after the GHC cost was added, the 3-year inpatient and total expenditures of high-frequency utilizers become higher than those in low-frequency utilizers, although this difference was not significant. From an economic viewpoint, the low-frequency GHC utilizers may represent good cost-benefit performance. In addition, the high-frequency GHC utilizers had a less medical consultation as in-patients and the definition of MEs in Japan does not include the cost
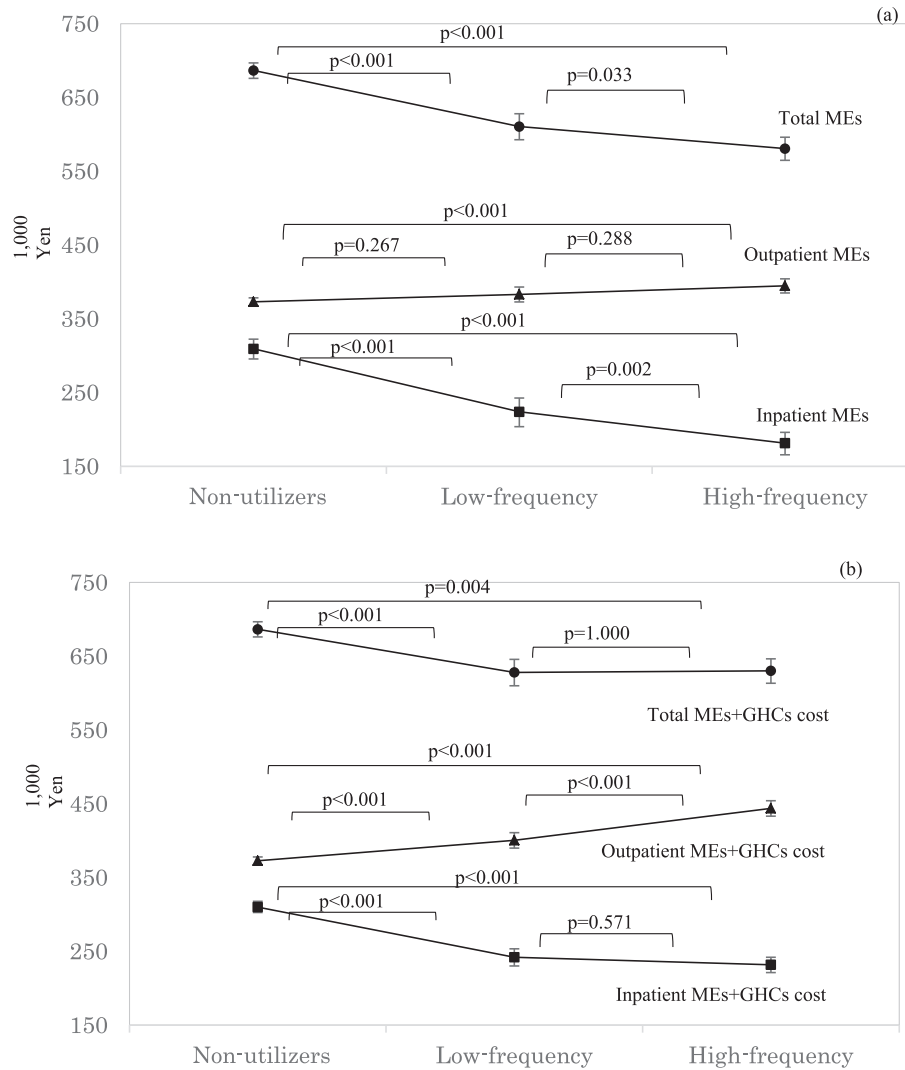
Fig. 1. Medical expenditures (MEs) (a) and MEs plus general health checkup costs (b) of the pooled 2008–2010 data by subgroups of GHCs. The estimated marginal mean and 95% confidence interval for expenditure are expressed using Tweedie analysis in the generalized linear models (GLM) adjusted for age and sex. *p*-values show the three pairwise comparisons among utilization groups, with Bonferroni's post-hoc test in the GLM. The cost unit is expressed as a thousand yen, with the exchange rate of 1000 yen = 8.3 dollars or 7.5 euro. GHC, general health checkup.

of preventive medicine, such as health checkups, vaccination, and normal delivery. Therefore, it is difficult to simply say whether low-frequency or high-frequency utilizers are preferable based on this study. More studies on the frequency of GHC attendance are necessary.

The strengths of the present study include the use of a retrospective cohort study design and inclusion of a large sample size, as well as the 6-year assessment of GHC attendance and 3-year MEs based on the official records of Japan National Health Insurance, which minimizes recall bias. Additionally, the pooled 3-year MEs were analyzed to account for individual changes from year to year. We used Tweedie distributions of a GLM, which are reported to facilitate favorable medical cost analysis,[22] to analyze MEs; outpatient, inpatient, and total MEs were assessed in the same period, and the relationship between MEs and GHC attendances was examined. Also, this is the first study to add the GHC cost to MEs, allowing us to interpret the difference of MEs among the subgroups of GHCs objectively, although MEs do not usually include the cost of GHCs in Japan.

There are some limitations to the present study that need to be considered. First, there were no data on subjects' socioeconomic

status (such as income level or education level), family members, health conditions, or behavioral elements, so we were unable to avoid the confounding bias caused by socioeconomic, health, and behavioral factors. Considering that these potential confounding factors could impact attending GHCs,[23–25] we should be careful in interpreting the results of this study. However, the bias of socio-demographic factors was minimized through adjustment for the age and sex in this study. Second, we did not know why about 60% of residents did not participate in annual GHCs, so the reasons for non-participation will be assessed in future research. Third, we were unable to distinguish the kinds of MEs, such as cardiovascular disease, infectious diseases, and dental practice. Finally, only one municipality was involved, so future research should focus on other municipalities to assess whether or not the findings are generalizable.

Conclusion

This study suggests that outpatient MEs rise when annual health check-ups are frequent and the GHC cost is not included, but inpatient MEs and total MEs are lower. Increasing the rates of

attendance at GHCs in community populations might be an important means of reducing healthcare expenditures.

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Conflicts of interest

None declared.

Acknowledgments

References

1. World Health Organization (WHO). *Global Status Report on Non-communicable Diseases*. World Health Organization website; 2010 [cited 2015 November 1]. Available from: http://www.who.int/nmh/publications/ncd_report2010/en/.
2. World Economic Forum and the Harvard School of Public Health. Global Economic Burden Non Communicable Diseases. [cited 2015 November 1]. Available from: http://www3.weforum.org/docs/WEF_Harvard_HE_GlobalEconomic BurdenNonCommunicableDiseases_2011.pdf#search='Global+Economic+ Burden+NonCommunicable+Diseases+2011'.
3. Franks P, Gold MR, Clancy CM. Use of care and subsequent mortality: the importance of gender. *Health Serv Res.* 1996;31:347–363.
4. Nakanishi N, Tatara K, Tatatorige T, Murakami S, Shinsho F. Effects of preventive health services on survival of the elderly living in a community in Osaka, Japan. *J Epidemiol community health*. 1997;51:199–204.
5. Nakanishi N, Tatara K, Nishina M, Nakajima K, Naramura H, Yoneda H. Relationships of disability, health management and psychosocial conditions to cause-specific mortality among a community-residing elderly people. *J Epidemiol*. 1998;8:195–202.
6. Krogsboll LT, Jorgensen KJ, Gotzsche PC. General health checks in adults for reducing morbidity and mortality from disease. *JAMA*. 2013;309:2489–2490.
7. Krogsboll LT, Jorgensen KJ, Gronhoj Larsen C, Gotzsche PC. General health checks in adults for reducing morbidity and mortality from disease: cochrane systematic review and meta-analysis. *BMJ*. 2012;345:e7191. http://dx.doi.org/10.1136/bmj.e7191.
8. Lim LS. ACP Journal Club. Review: general health checks in adults do not reduce all-cause, cardiovascular, or cancer mortality. *Ann Intern Med*. 2013;158:JC2. http://dx.doi.org/10.7326/0003-4819-158-2-201301150-02002.
9. Tatara K, Shinsho F, Suzuki M, Takatorige T, Nakanishi N, Kuroda K. Relation between use of health checkups starting in middle age and demand for inpatient care by elderly people in Japan. *BMJ*. 1991;302:615–618.
10. Fukuda H, Ida O, Yamada A, et al. Relationship of utilization rate of health examination under the Elderly Act to medical expenditure and days of medical care for the elderly. *Nihon koshu eisei zasshi*. 1998;45:905–914 [in Japanese].
11. Matsuda S. Regulatory effects of health examination programs on medical expenditures for the elderly in Japan. *Soc Sci Med*. 1996;42:661–670.
12. Takeuchi K. The relationship between undergoing a basic health checkup based on the Health and Medical Services Law for the Aged and medical expenditure covered under the National Health Insurance in Japan. *Nihon eiseigaku zasshi*. 2002;56:673–681 [in Japanese].
13. Shinsho F, Fukuda H, Murakami S, Takatorige T, Nakanishi N, Tatara K. Analysis on the relationship between use of health checkups and medical care by elderly patients. A study on urban cities with high health check-up rates. *Nihon koshu eisei zasshi*. 2001;48:314–323 [in Japanese].
14. Suka M, Yoshida K, Matsuda S. Effect of annual health checkups on medical expenditures in Japanese middle-aged workers. *J Occup Environ Med*. 2009;51:456–461.
15. Smyth GK, Jørgensen B. Fitting Tweedie's compound Poisson model to insurance claims data: dispersion modelling. *Astin Bull*. 2002;32:143–157.
16. Dunn PK, Smyth GK. Series evaluation of Tweedie exponential dispersion model densities. *Stat Comput*. 2005;15:267–280.
17. Frees EW. *Regression Modeling with Actuarial and Financial Applications*. New York: Cambridge University Press; 2009.
18. Ministry of Education, Culture, Sports, Science and Technology, and Ministry of Health, Labour and Welfare of Japan. The Ethical Guidelines for Epidemiological Research [cited 2015 November 1]. Available from: http://www.mhlw.go.jp/seisakunitsuite/bunya/hokabunya/kenkyujigyou/i-kenkyu/dl/02–02.pdf [in Japanese)].
19. Sekiyama M, Hirano W, Watanabe Y, Miura Y, Kawaguchi T. Relationship between medical expenditures and government-sponsored medical check-ups for the aged. *Nihon koshu eisei zasshi*. 1996;43:965–973 [in Japanese].
20. Une H. Medical expenditure for the elderly and factors related to its geographical variations within Fukuoka Prefecture. *Nihon koshu eisei zasshi*. 1996;43:28–36 [in Japanese].
21. Ozasa K, Higashi A, Yamasaki M, et al. Association of participation in health checkups with medical service utilization in a rural town. *Nihon koshu eisei zasshi*. 1997;44:568–573 [in Japanese].
22. von Lengerke T, John J, Mielck A. KORA Study Group. Excess direct medical costs of severe obesity by socioeconomic status in German adults. *Psychosoc Med*. 2010;7. http://dx.doi.org/10.3205/psm000063. Doc01.
23. Brunner-Ziegler S, Rieder A, Stein KV, Koppensteiner R, Hoffmann K, Dorner TE. Predictors of participation in preventive health examinations in Austria. *BMC Public Health*. 2013 Dec 5;13:1138. http://dx.doi.org/10.1186/1471-2458-13-1138.
24. Dryden R, Williams B, McCowan C, Themessl-Huber M. What do we know about who does and does not attend general health checks? Findings from a narrative scoping review. *BMC Public Health*. 2012 Aug 31;12:723. http://dx.doi.org/10.1186/1471-2458-12-723.
25. El Bcheraoui C, Tuffaha M, Daoud F, et al. Low uptake of periodic health examinations in the Kingdom of Saudi Arabia. *J Fam Med Prim Care*. 2013;2015(4):342–346.