

Original Article

Impact of Hypertension on Medical Economics: A 10-Year Follow-Up Study of National Health Insurance in Shiga, Japan

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Hypertension and related cardiovascular diseases may lead to an increase in medical costs for patients. We attempted to clarify the relationship between hypertension and long-term medical costs by a cohort study utilizing existing data as well as baseline blood pressures and medical costs over a 10-year period. The participants included 4,191 Japanese National Health Insurance beneficiaries aged 40–69 years, living in one area, who were not taking anti-hypertensive medication and did not have a history of major cardiovascular disease. They were classified into four categories according to their blood pressure. We evaluated the mean medical costs per month, cumulative hospitalization, and all-cause mortality for each blood pressure category. Hypertension-related medical costs attributable to hypertensive individuals, as compared to normotensive individuals, were estimated. There was a positively graded correlation between blood pressure and personal total medical costs, especially for men. The odds ratio for cumulative hospitalization and hazard ratio for all-cause mortality in severe hypertensive men were also higher than those in normotensive men. However, the hypertension-related medical costs for mild to moderate hypertensives were higher than those for severe hypertensives. The hypertension-related medical costs for all hypertensives accounted for 23.7% of the total medical costs for the Japanese population. In conclusion, high blood pressure was a useful predictor for excess medical costs; moreover, concomitant hypertension, regardless of the grade, increased the medical costs of Japanese National Health Insurance beneficiaries. (*Hypertens Res* 2005; 28: 859–864)

Key Words: hypertension, medical costs, Japan, National Health Insurance

Introduction

Hypertension is a major risk factor for cardiovascular disease (1–3). In Japan, the mortality rate from cardiovascular dis-

ease, especially stroke, is high (4). Furthermore, stroke patients often become bed-ridden (4, 5) and need long-term hospitalization or home nursing care. In 2001, the medical costs of cardiovascular disease, including hypertension, in the Japanese population aged 45–69 years, was 20.4% of the total

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national medical costs, which was greater than those of any other disease group (4).

Although there have been several cohort studies regarding the relationship between hypertension and medical costs (6), the follow-up periods of these studies were short, and the populations were limited to Westerners. The objective of the present study was to clarify the relationship between hypertension and long-term medical costs in the general Japanese population.

Methods

Study Design and Participants

To clarify the relationship between hypertension and long-term medical costs, we conducted a cohort study utilizing medical cost data from Japanese beneficiaries of National Health Insurance who were living in a single area. Medical insurance is compulsory for everyone living in Japan and consists of two systems: the first system is for employees and their dependants, and the National Health Insurance system is for self-employed people such as farmers and fishermen, as well as those who are retired, and their dependants (4). The National Health Insurance system covers 34.7% of the total Japanese population (4).

Participants in the study included 4,535 National Health Insurance beneficiaries aged 40–69 years living in 7 rural towns and one village in Shiga Prefecture, West Japan, who underwent a baseline survey in 1989–1991. The study was performed as part of a research project conducted by the Health Promotion Research Committee of the Shiga National Health Insurance Organizations. After excluding participants taking anti-hypertensive medication and those with a history of major cardiovascular disease at baseline, 4,191 participants were considered eligible for the present analysis.

National Health Insurance claims were linked with baseline survey data files at the Shiga National Health Insurance Organizations. The participants' names were deleted from the linked data in order to protect their privacy. Thus, we analyzed the data without identifying individual participants. The study was approved by the Institutional Review Board of Shiga University of Medical Science for ethical issues (No. 16–15).

Data Collection

The baseline survey, conducted from 1989–1991, was performed using standardized methods according to the Manual for Health Check-ups under the Medical Service Law for the Aged in 1987 (7). Blood pressure was measured using a standard mercury sphygmomanometer on the right arm of each participant in the sitting position after at least a 5-min rest. Body height and body weight were measured, and body mass index was calculated as body weight (kg) divided by the square of body height (m^2). The smoking and drinking habits

of the participants, use of anti-hypertensive medication, and any history of major cardiovascular disease or diabetes were evaluated from interviews with well-trained public health nurses. Serum total cholesterol was measured by an enzymatic method.

Referring to the seventh report of the Joint National Committee (8), the participants were classified into four categories: systolic blood pressure <120 mmHg and diastolic blood pressure <80 mmHg (normotension), systolic blood pressure 120–139 mmHg or diastolic blood pressure 80–89 mmHg (pre-hypertension), systolic blood pressure 140–159 mmHg or diastolic blood pressure 90–99 mmHg (stage 1 hypertension), and systolic blood pressure \geq 160 mmHg and diastolic blood pressure \geq 100 mmHg (stage 2 hypertension).

We calculated the medical cost per person in each blood pressure category over a 10-year period. We obtained medical insurance costs for each participant beginning from April in the year following the health check-up to March 2001, using the monthly claim history files of the Shiga National Health Insurance Organizations. Costs were expressed in Japanese yen (*i.e.* 100 Japanese yen=0.89 US dollars or 0.73 euro, at the foreign exchange rate on August 1, 2005). Data obtained regarding the medical costs for each participant differed depending upon the period of enrollment in National Health Insurance. Therefore, information on beneficiaries who withdrew from the National Health Insurance system or those who died was obtained using monthly claim files. The medical cost for each participant was divided by the period of enrollment, and was expressed as costs per month of the follow-up period. If a beneficiary withdrew or died, the follow-up period was terminated at that point. For a beneficiary who withdrew and then re-enrolled in National Health Insurance, the follow-up period was reinitiated. Reasons for withdrawal from the National Health Insurance system included moving to an area outside of Shiga Prefecture or transfer to another insurance system.

Data Analysis

Because medical costs are generally different for men and women, sex-specific analyses were performed (9). Logarithmic transformations of actual medical costs were performed to normalize the distribution, and the results were expressed as geometric means. For the participants with 0 yen (per month), logarithmic transformations were performed by replacing 0 yen with 1 yen. There were 5 men and 10 women with total medical costs of 0 yen and 6 men and 10 women with outpatient medical costs of 0 yen. For comparison of the total medical costs and outpatient medical costs per person in each blood pressure category, we performed an analysis of covariance, which included age, body mass index, smoking habit (non-smoker or current smoker), drinking habit (non-, current occasional or current daily drinker, using two dummy variables with non-drinkers as a reference), serum total cholesterol, and history of diabetes as covariates. Due to the fact

Table 1. Baseline Risk Characteristics of 4,191 National Health Insurance Beneficiaries in Shiga, Japan, in 1989–1991, Grouped by Sex and Blood Pressure

	Blood pressure category				<i>p</i> value
	Normal	Pre-	Stage 1	Stage 2	
Men					
No. of participants	347	858	450	164	
(Distribution [%])	(19.1)	(47.2)	(24.7)	(9.0)	
Age (years)*	51.7±8.4	53.1±8.2	54.9±8.2	56.5±7.0	<0.01
Blood pressure (mmHg)*					
Systolic	110.5±6.4	128.6±6.4	142.9±7.7	167.8±14.2	<0.01
Diastolic	68.4±5.9	79.0±6.1	87.6±6.9	99.0±9.8	<0.01
Body mass index (kg/m ²)*	21.4±2.3	22.5±2.5	23.0±2.8	24.0±3.0	<0.01
Smoking habit (%) [†]					0.49
Non-smoker	35.7	40.3	38.4	40.9	
Current smoker	64.3	59.7	61.6	59.1	
Drinking habit (%) [†]					<0.01
Non-drinker	27.4	19.5	20.3	12.9	
Occasional drinker	24.3	23.1	17.9	15.9	
Daily drinker	48.3	57.4	61.8	71.2	
Total cholesterol (mg/dl)*	180.0±31.5	189.1±34.4	190.3±37.7	189.1±37.4	<0.01
History of diabetes (%) [†]	3.2	4.8	4.4	3.7	0.63
Women					
No. of participants	546	1,135	527	164	
(Distribution [%])	(23.0)	(47.9)	(22.2)	(6.9)	
Age (years)*	51.6±8.1	53.8±7.9	56.1±7.6	58.3±7.2	<0.01
Blood pressure (mmHg)*					
Systolic	111.0±5.8	128.3±6.2	145.0±7.0	166.3±11.4	<0.01
Diastolic	68.7±5.8	77.8±6.2	85.7±7.0	94.2±9.0	<0.01
Body mass index (kg/m ²)*	21.9±2.7	22.8±2.8	23.9±3.1	24.5±2.9	<0.01
Smoking habit (%) [†]					0.16
Non-smoker	95.0	96.5	97.1	98.1	
Current smoker	5.0	3.5	2.9	1.9	
Drinking habit (%) [†]					0.72
Non-drinker	78.4	80.0	78.2	82.6	
Occasional drinker	17.3	16.5	17.0	13.0	
Daily drinker	4.3	3.5	4.8	4.4	
Total cholesterol (mg/dl)*	193.5±33.7	202.5±34.2	209.5±35.4	210.6±41.5	<0.01
History of diabetes (%) [†]	0.5	1.9	2.7	3.7	0.02

Mean±SD. *One way analysis of variance. [†] χ^2 test.

that there were 953 men and 1,470 women with inpatient medical costs of 0 yen, no logarithmic transformations were performed. The odds ratio in each blood pressure category, as compared to the lowest category (normotension), was calculated using a logistic regression model for cumulative hospitalization during the follow-up period. The logistic regression model was utilized, because the date of initial hospitalization was not available. The hazard ratio was calculated using a Cox proportional hazards model for all-cause mortality.

The analyses were repeated, dividing the entire follow-up period into the first half and the latter half, because a single blood pressure measurement at baseline could potentially show different associations between medical costs or all-

cause mortality after stratification of the follow-up period.

Finally, we defined and calculated hypertension-related medical costs attributable to pre-, stage 1, and stage 2 hypertensive participants, as compared to those of normotensive participants. The hypertension-related medical costs were estimated as follows: (arithmetic mean of total medical costs in pre-, stage 1 and stage 2 hypertension – arithmetic mean of total medical costs in normotension) × number of pre-, stage 1 and stage 2 hypertensive participants, respectively. Furthermore, we examined the percentages of pre-, stage 1, and stage 2 hypertension-related medical costs for the whole population when both sexes were combined. The total medical cost of the entire population was expressed in Japanese yen per 1,000

Table 2. Medical Costs per Person, Cumulative Hospitalization and All-Cause Mortality Grouped by Sex and Blood Pressure Category, after a 10-Year Follow-Up, from 1990 to 2001, in National Health Insurance in Shiga, Japan

Blood pressure category	No. of participants	Medical costs per person (Japanese yen per month)					Cumulative hospitalization		All-cause mortality	
		Total		Outpatient		Inpatient	No.	Adjusted odds ratio [§] (95% CI)	No.	Adjusted hazard ratio [¶] (95% CI)
		Arithmetic mean	Adjusted geometric mean [‡]	Arithmetic mean	Adjusted geometric mean [‡]	Arithmetic mean				
Men										
Normal	347	15,009	6,694	7,940	4,846	7,068	147	1.00	17	1.00
Pre-Stage 1	858	18,973	6,995	9,023	4,846	9,962	399	1.10 (0.84–1.43)	63	1.33 (0.77–2.30)
Stage 2	450	22,378	8,325	11,452	5,665	10,926	215	1.05 (0.77–1.42)	32	1.21 (0.66–2.21)
	164	45,947	15,756	17,436	9,302	28,511	105	1.96 (1.29–2.98)	27	3.19 (1.67–6.08)
			<i>p</i> <0.01		<i>p</i> <0.01					
Women										
Normal	546	14,222	7,723	8,804	6,039	5,507	194	1.00	10	1.00
Pre-Stage 1	1,135	17,944	7,848	9,826	6,106	8,110	438	1.04 (0.83–1.29)	26	1.23 (0.57–2.66)
Stage 2	527	16,998	7,801	11,498	6,419	5,500	194	0.85 (0.65–1.11)	14	1.32 (0.55–3.17)
	164	23,332	9,887	14,258	7,662	9,074	76	1.14 (0.78–1.66)	4	1.06 (0.31–3.60)
			<i>p</i> =0.18		<i>p</i> =0.12					

[‡]Multivariate analysis of covariance adjusted for age, body mass index, smoking habit, drinking habit, serum total cholesterol and a history of diabetes. [§]Multivariate analysis of a logistic regression model adjusted for age, body mass index, smoking habit, drinking habit, serum total cholesterol and a history of diabetes. [¶]Multivariate analysis of a Cox proportional hazards regression model adjusted for age, body mass index, smoking habit, drinking habit, serum total cholesterol and a history of diabetes. CI, confidence interval.

persons per month.

The statistical analysis package SPSS 11.0J for Windows was used for statistical processing. All probability values were two-tailed, and the significance level was set at *p*<0.05.

Results

Most of the baseline risk characteristics of the participants were positively associated with blood pressure, as shown in Table 1. For men, the mean systolic and diastolic blood pressures at baseline were 132.2±17.3 mmHg (mean±SD) and 80.9±10.8 mmHg, respectively. For women, the mean systolic and diastolic blood pressures were 130.6±16.5 mmHg, 78.6±9.7 mmHg, respectively. The mean age and body mass index at baseline were 53.6±8.2 years and 22.6±2.7 kg/m² for men, and 54.1±8.0 years and 23.0±3.0 kg/m² for women, respectively.

The total number of person-years was 37,775; the mean follow-up period was 9.0 years. Mean total medical costs per month were higher in the higher blood pressure categories, as shown in Table 2. Among men, a significant difference in mean total medical costs was observed. However, this result was not seen among women. For men, both the odds ratio for cumulative hospitalization and the hazard ratio for all-cause mortality in participants with stage 2 hypertension were significantly higher than those in normotensive participants.

When the analyses were repeated, the pattern of results

obtained by dividing the entire follow-up period into a first half and a latter half was generally similar to that shown in Table 2 (stratified data not shown in the table).

The hypertension-related medical costs per month attributable to pre-, stage 1, and stage 2 hypertensive participants were calculated to be 3,401,492 yen, 3,316,041 yen, and 5,073,770 yen for men, respectively; and 4,224,237 yen, 1,463,100 yen, and 1,493,965 yen for women, respectively (data not shown in the table).

The percentages of pre-, stage 1, and stage 2 hypertension-related medical costs for the whole population (*i.e.*, both sexes combined), with costs expressed in Japanese yen per 1,000 persons per month, are shown in Fig. 1. The hypertension-related medical costs for combined pre- and stage 1 hypertensive participants were higher than those for stage 2 hypertensive participants. The hypertension-related medical costs for all hypertensive participants accounted for 23.7% of the total medical costs.

Discussion

In the present study, there was a positively graded correlation between blood pressure and personal total medical costs, especially among men. However, the hypertension-related medical costs attributable to mildly to moderately hypertensive individuals (combined pre- and stage 1 hypertensives) were higher than those attributable to severely hypertensive

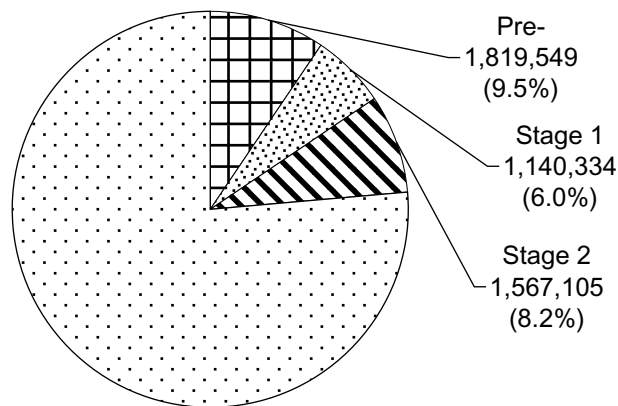


Fig. 1. Medical costs (Japanese yen per 1,000 persons per month) and percentages of pre-, stage 1, and stage 2 hypertension-related medical costs for the whole population (19,090,468 Japanese yen per 1,000 persons per month [100%]), after a 10-year follow-up period from 1990 to 2001, enrolled in National Health Insurance in Shiga, Japan (men and women combined).

individuals (stage 2 hypertensives). The hypertension-related medical costs attributable to all hypertensive individuals accounted for 23.7% of the total medical costs.

Cardiovascular mortality after hospitalization for events related to hypertension, such as stroke, may increase medical costs. From an individual viewpoint, medical costs increase as blood pressure increases. However, from the viewpoint of the entire population, mild to moderate hypertension has a large impact on medical economics, because the number of mildly to moderately hypertensive individuals is much greater than that of severely hypertensive individuals. We would expect a 23.7% reduction in total medical costs of the population if each individual were to become normotensive by making lifestyle modifications such as reducing dietary sodium intake, decreasing body weight, and reducing alcohol intake (8, 10–20). Furthermore, it is apparent that anti-hypertensive medications can lower the risk of cardiovascular mortality in hypertensive individuals (21). However, the roles played by anti-hypertensive medications in the reduction of hypertension-related medical costs remain to be determined.

The present study has several limitations. Although the participants were selected from a community-based population with a relatively typical health status (4), they were limited to National Health Insurance beneficiaries in one area of Shiga Prefecture (4). The socio-economic status and lifestyle of these beneficiaries may have had an effect on their health. Additionally, the excess medical costs attributable to hypertension may be associated with metabolic syndrome, which is characterized by a combination of hypertension, high body mass index, diabetes, hyperlipidemia, and other features (22). Interestingly, the mean body mass index for those with stage

2 hypertension was the highest among the four blood pressure categories for both sexes, and the prevalence of participants with a history of diabetes with stage 2 hypertension was also the highest among women. However, the present study clearly revealed that hypertension is an important predictor of medical costs in a Japanese population with an extremely low mean body mass index compared to that of Western populations (23). In the present study, the details regarding the participants' medical diagnosis (e.g., stroke), medical treatment, and cause of mortality were not available. Thus, it remained unclear which disease in particular directly increased medical costs and events among the hypertensive participants. Furthermore, the extent to which anti-hypertensive medications were effective at reducing hypertension-related medical costs remained unclear with respect to the entire population. Further studies are thus warranted in order to answer such questions. Finally, the results of the present study may not be directly relevant or adaptable to Western populations.

In conclusion, high blood pressure can be a useful predictor of excess medical costs; moreover, hypertension, regardless of grade, may increase the total national medical costs in Japan. In order to reduce hypertension-related medical costs, efforts should be made to prevent hypertension on the basis of both a high-risk strategy and a population strategy.

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Appendix

The Health Promotion Research Committee of the Shiga National Health Insurance Organizations

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Secretary Members: Yukio Tobita, Kanehiro Okamura, Kiminobu Hatta, Takao Okada, Michiko Hatanaka (the Shiga National Health Insurance Organizations).

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