Original Article

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Trends in stroke, cardiovascular disease, and medical expenditure under a community-based long-term stroke prevention program

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Background: Evidence on the effects of preventive measures for noncommunicable disease is urgently needed for low-income and middle-income countries suffering from stroke epidemics along with population aging.

Objectives: We sought to examine the impact of a community-based stroke prevention program on incidences of stroke and ischemic heart disease, mortality from cardiovascular disease, and medical expenditure.

Methods: Trends in the incidences of stroke and ischemic heart disease were documented in a Japanese rural community, Kyowa, from 1981 through 2015. Trends in mortality from cardiovascular disease and in medical expenditures were compared between Kyowa and its surrounding municipalities from 1981 through 2004.

Results: In Kyowa, the age-and-sex-adjusted incidences of stroke and of ischemic heart disease decreased by half (from 4.1 to 1.9 and from 1.5 to 0.7 per year/1000 persons, respectively) over the past 35 years. A similar decreasing trend was observed for the age-and-sex-adjusted mortality from cardiovascular disease, and this decreasing trend occurred earlier than that in the surrounding municipalities. The medical expenditures for cardiovascular disease became lower in Kyowa than in the surrounding municipalities over time.

Conclusion: Our study's findings suggest that a community-based stroke prevention program augmented the decline in the incidences of stroke and ischemic heart disease, mortality from cardiovascular disease, and attenuated the increase in medical expenditures for cardiovascular disease.

Keywords: Circulatory Risk in Communities Study, community intervention, epidemiology, prevention, preventive measures

Abbreviations: CIRCS, Circulatory Risk in Communities Study; ICD, International Classification of Disease and Related Health Problem; SMR, standardized mortality ratio

INTRODUCTION

Evidence on the effect of preventive measures for noncommunicable disease is urgently needed, especially for low and middle-income countries that have suffered from epidemics of stroke and ischemic heart disease along with population aging. Today, Japan is ranked as the country with the highest life expectancy and the highest healthy life expectancy in the world [1], but was not so in the past [2]. The major contributor to this longevity was reduction in mortality from stroke [3]. In the 1960s, Japan had the highest mortality from stroke and the lowest mortality from ischemic heart disease in the world, owing to a high prevalence of hypertension (high sodium intake) and a low prevalence of dyslipidemia (low meat and dairy intakes) [4]. Our research team launched preventive measures for hypertension, including a population screening for hypertension and an educational program for dietary improvement in several municipalities, which have been ongoing since the 1960s [5]. These intensive measures led to a lower prevalence of untreated hypertension; lower blood pressure levels at population levels; and lower incidence, prevalence, and mortality from stroke as well as improved cost-effectiveness as compared with those of other municipalities [6–10].

In Kyowa, a Japanese rural community, the municipal government, community organizations, medical associations, public health centers, and health services associations have been cooperating systematically since 1981 to

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implement primary and secondary stroke prevention measures, such as hypertension management through health checkups and health education campaigns that emphasize reducing salt intake and eating a balanced diet. We reported that these campaigns contributed to a reduction in salt intake in the population [11]. The primary purpose of this program was to reduce the age-and-sex-adjusted incidence of stroke by half. Because of a municipal merger in 2005, we sought to determine the impact of these preventive measures between 1981 and 2004 on the incidences of stroke and ischemic heart disease, as primary outcomes. Cardiovascular disease mortality and the medical expenditures of Kyowa and its surrounding municipalities were compared, as secondary outcomes.

METHODS

Study area

The studied community was Kyowa (presently constituting the district of Chikusei City, Ibaraki Prefecture; the census population in 1985 was 16 792), one of the study areas of the Circulatory Risk in Communities Study (CIRCS) [5], where we conducted a systematic community-based stroke prevention program from 1981. The proportions of the working population by economic sectors were 17.6% for the primary sector, 36.8% for the secondary sector, and 45.5% for the tertiary sector in 2000. The main industry in the primary sector is rice farming as well as greenhouse farming of vegetables and fruits. The community has one general hospital with a neurosurgery department. The proportions of migration-in and migration-out remained at 2–3% for each annually.

This preventive program included a blood pressure detection and control program, and a community-wide health education campaign to reduce the amount of salt intake [12]. One of the major components of the blood pressure detection and control program was health checkups. Until 1991, health checkups were conducted in two stages: primary checkups were available to all residents aged 40 years or older, and detailed checkups were mainly for those who had abnormalities detected in the primary checkups. However, from 1983, the residents were given the opportunity to have the detailed checkups once every 4 years. In 1992, the primary and detailed health checkups were combined into basic health checkups that included health interviews, body and blood pressure measurements, blood and urine tests, electrocardiography and fundoscopy tests, examinations by a physician, and some other specific tests. The 5-year cumulative participation in the health checkups for those aged 40–69 years since 1983, calculated by the number of participants in any of the annual health checkups (detailed checkups and basic health checkups) divided by the number of residents, was 74% in 1983–1987, 54% in 1988–1992, 55% in 1993–1997, and 52% in 1998-2002.

As one of the important services of the community, various measures were provided to encourage more residents to participate in the health checkups, including notifications to those who were eligible for the checkups, distribution of flyers to all households, and posters made by elementary school students to raise awareness of the checkups that were displayed at public facilities, supermarkets, and other familiar places. During the period of the health checkups, the municipal government notified those who had not participated in the checkups in real time and promoted the health checkups using public relations vehicles and community broadcasts. In addition, physicians, public health nurses, and nutritionists worked together to provide thorough guidance on reducing salt intake and eating a balanced diet to the residents who participated in the health checkups. After the checkups, participants with cardiovascular risk factors (such as hypertension) needing medical treatment were referred to local physicians, and the public health nurses called or visited and encouraged them to receive medical treatment. For other participants, the importance of salt intake reduction was repeatedly stressed at the postcheckup briefing sessions and health education classes.

The health education campaign was performed mainly through media campaigns, through use of banners, signboards, posters, and calendars with health catchphrases. The catchphrases were adopted from the public and were made as visible as possible to the residents. For example, a huge banner with a catchphrase was placed on the outside wall of the municipal office, and approximately 250 signboards with the catchphrase were made and placed in various places in the community. We distributed health calendars with the catchphrase to all the households and put the catchphrase on the envelopes of the town office for official use. Health festivals were held annually or periodically to enhance health consciousnesses and to improve health behaviors. Some of the posters and calligraphy regarding health were painted or drawn by elementary schoolchildren as part of their education. Health education classes for adults and elementary schoolchildren were also provided. Other activities included fostering health volunteer organizations; providing a health textbook that focused on salt intake reduction for schoolchildren; and cooperating with medical associations, health centers, school boards, food associations, and neighborhood associations. Most of these aspects of the programs were continued until 2005 when the community was merged with three of the surrounding municipalities, and some aspects were continued after the merger.

The surrounding municipalities were located in the same healthcare area (secondary medical area) as that of Kyowa. The industrial structure is largely similar to that of Kyowa. Preventive measures provided there were legislated ones and were considered not as strong as those in Kyowa.

Incidences of stroke and ischemic heart disease

We launched a community-wide systematic registry system of incident cases of stroke and ischemic heart disease that have occurred since 1981. All stroke and ischemic heart disease (myocardial infarction and sudden cardiac death) cases in Kyowa occurring at age of 30 years or older were registered. We investigated the following ascertainment sources in addition to all hospitalized cases: annual health examinations; death certificates; ambulance records; national insurance claims; and reports from local physicians, public health nurses, and health volunteers. To validate the diagnoses, either living patients were visited or invited to

participate in the baseline surveys or else their medical histories were obtained from their families. Trained physicians reviewed the medical records from the local clinics and hospitals. In the cases of deceased participants, the histories were obtained from their families and/or attending physicians, and the medical records were reviewed. Modified criteria of the National Survey of Stroke [13] and the WHO Expert Committee [14] were used for the diagnoses of stroke and ischemic heart disease (myocardial infarction and sudden cardiac death within 24 h), respectively. Computed tomography and/or magnetic resonance images were available in approximately 60% of the stroke cases in the 1980s and in over 90% of the cases thereafter, and these images were used to classify the cases into subtypes on the basis of the affected site [15].

Mortality from total cardiovascular disease

Data for annual mortality at age 30 years or older in Kyowa and the three surrounding municipalities (merged ones in 2005) between 1981 and 2004 were based on the National Vital Statistics database provided by the Ministry of Health, Welfare and Labour. Underlying causes of death were coded according to the *International Classification of Diseases and Related Health Problems, 9th Revision* (ICD-9) between 1981 and 1994 and according to the ICD-10 between 1995 and 2004. Codes 390 to 459 in the ICD-9 and I00 to I99 in the ICD-10 were used to define mortality from total cardiovascular disease.

National health insurance medical expenditures

For Kyowa and the seven surrounding municipalities in the same prefecture, annual National Health Insurance medical expenditures between 1981 and 2004 were collected on the basis of the Ibaraki Prefecture National Health Insurance Disease Classification Statistics [16]. These statistics provided medical expenditures by disease group for 1 month, with May of each year as the representative month. We multiplied them by 12 to obtain the annual medical expenditures. Disease groups were determined on the basis of the 99-item Disease Classification Table for the Social Insurance Table Chapter and were defined as follows: cardiovascular diseases (codes B41-49 between 1981 and 1994 and 0901-0912 between 1995 and 2004), hypertensive diseases (B42 and 0901), heart diseases (B43-44 and 0902-0903), cerebrovascular diseases (B45-47 and 0904-0908) and noncardiovascular diseases (other than the above codes). The numbers of insured persons were derived from the annual reports of the All-Japan Federation of National Health Insurance Organizations [17].

Of note, in the universal health insurance system of Japan, the National Health Insurance covers mainly the self-employed and farmers and their families. The coverage proportions in Kyowa were 54.6% in 1985 and 47.8% in 2000; those in the surrounding municipalities varied from 43.2 to 65.9% (average 50.9%) in 1985 and from 38.5 to 53.3% (average 43.4%) in 2000.

Statistical analyses

Although the preventive measures are still ongoing as of 2022, we compared trends in the sex-specific age-adjusted and age-and-sex-adjusted mortalities from total cardiovascular disease and medical expenditure between Kyowa and the surrounding municipalities between 1981 and 2004 because of a municipal merger in March 2005, resulting in preventive measures being extended to surrounding municipalities afterwards. However, we extended the observation period through 2015 to examine trends in the incidence of stroke and ischemic heart disease in Kyowa. The 5-year cumulated sex-specific age-adjusted and age-and-sex-adjusted incidences per year/1000 persons of stroke and ischemic heart disease for men and women aged at least 30 years in Kyowa between 1981–1985 and 2011–2015 were calculated using the direct standardization method referring to the 1985 Model Population of Japanese [18]. Similarly, the 5 (or 4)-year cumulated annual sex-specific age-adjusted and age-and-sex-adjusted mortalities from cardiovascular disease for persons aged at least 30 years in Kyowa and the three surrounding municipalities between 1981 and 2004 were calculated using direct methods. To compare the mortality from cardiovascular disease between Kyowa and the surrounding municipalities, we calculated the standardized mortality ratio (SMR) of Kyowa using the surrounding municipalities as the reference population. Differences in the incidence between 1981 and 1985 and the other time periods and in the SMR between Kyowa and the surrounding municipalities were examined by use of the SAS STDRATE procedure. Trends in total and disease-specific National Health Insurance medical expenditures for all ages in Kyowa and the seven surrounding municipalities between 1981 and 2004 were examined. The time periods for the trend analysis were 1981–1985, 1986–1990, 1991–1995, 1996–2000, and 2001–2004.

Ethical considerations

Individual consent was not required for the analysis of this study because it was conducted as a secondary use of data obtained for public health practice on cardiovascular disease prevention in Kyowa and the merged city, Chikusei. The study was approved by the institutional review boards of the University of Tsukuba and Osaka University.

RESULTS

Despite the aging of the population during this period, the crude incidence of stroke in Kyowa decreased over time for both men and women aged at least 30 years (Table 1). The age-and-sex-adjusted incidence of stroke declined substantially, by approximately 43% between 1981–1985 and 2001–2005 and by 54% between 1981–1985 and 2011–2015 (Fig. 1 and Table 1). The crude incidence of ischemic heart disease in Kyowa did not change over time, but the age-and-sex-adjusted incidence of ischemic heart disease declined over time, by approximately 30% between 1981–1985 and 2001–2005 and by 54% between 1981–1985 and 2011–2015.

As the registry of stroke and ischemic heart disease was available only in Kyowa, we compared mortality from total cardiovascular disease in Kyowa and in the surrounding municipalities between 1981–1985 and 2001–2004. The age-and-sex-adjusted mortality from total cardiovascular disease declined more in Kyowa than in the surrounding municipalities and the SMRs from total cardiovascular disease were significantly lower after 1990: 80 (69–90) in

TABLE 1. Trends in the incidence (95% confidence interval) of stroke and ischemic heart disease, 1981–2015, Kyowa

Years	1981–1985	1986–1990	1991–1995	1996–2000	2001–2005	2006–2010	2011–2015
Number at risk							
Men	4290	4736	5079	5360	5514	5657	5565
Women	4564	5001	5416	5707	5852	6012	5971
Number of incident stroke (5-year cumulative)							
Men	93	111	80	95	102	99	94
Women	83	78	79	95	97	73	88
Crude stroke incidence per year/1000 persons							
Men	4.3	4.7	3.2	3.5	3.7	3.5	3.4
Women	3.6	3.1	2.9	3.3	3.3	2.4	2.9
Total	4.0	3.9	3.0	3.4	3.5	2.9	3.2
Sex-specific age-adjusted and age-and-sex-adjusted stroke incidence per year/1000 persons							
Men							
Incidence	4.9 (3.9–5.9)	4.9 (3.9–5.8)	3.0 (2.3–3.7)†	3.0 (2.4–3.6)†	2.9 (2.3–3.5)‡	2.5 (2.0–3.0)‡	2.3 (1.8–2.9)‡
Percent change		−0.9	−38.8	−38.7	−41.5	−49.7	−52.3
Women							
Incidence	3.4 (2.7–4.1)	2.7 (2.1–3.3)	2.1 (1.6–2.6)†	2.0 (1.6–2.5)†	1.8 (1.4–2.2)‡	1.1 (0.8–1.4)‡	1.5 (1.0–1.9)‡
Percent change		−21.6	−38.5	−40.3	−46.7	−67.7	−56.9
Total							
Incidence	4.1 (3.5–4.7)	3.7 (3.1–4.2)	2.5 (2.1–2.9)‡	2.5 (2.1–2.8)‡	2.4 (2.0–2.7)‡	1.8 (1.5–2.1)‡	1.9 (1.6–2.2)‡
Percent change		−10.8	−38.8	−39.8	−42.9	−57.4	−54.3
Number of incident ischemic heart disease							
Men	45	37	40	53	55	47	60
Women	22	18	26	17	37	32	21
Crude ischemic heart disease incidence per year/1000 persons							
Men	2.1	1.6	1.6	2.0	2.0	1.7	2.2
Women	1.0	0.7	1.0	0.6	1.3	1.1	0.7
Total	1.5	1.1	1.3	1.3	1.6	1.4	1.4
Sex-specific age-adjusted and age-and-sex-adjusted ischemic heart disease incidence per year/1000 persons							
Men							
Incidence	2.4 (1.7–3.1)	1.7 (1.1–2.2)	1.5 (1.0–2.0)*	1.7 (1.2–2.1)	1.6 (1.2–2.0)	1.2 (0.8–1.5)†	1.3 (0.9–1.6)†
Percent change		−30.0	−38.0	−31.5	−34.3	−51.0	−46.6
Women							
Incidence	0.9 (0.5–1.2)	0.6 (0.3–0.9)	0.7 (0.4–1.0)	0.3 (0.2–0.5)*	0.6 (0.3–0.8)	0.5 (0.3–0.7)	0.2 (0.1–0.3)‡
Percent change		−28.6	−15.3	−60.3	−34.4	−38.3	−75.6
Total							
Incidence	1.5 (1.2–1.9)	1.1 (0.8–1.4)	1.0 (0.8–1.3)*	1.0 (0.7–1.2)†	1.1 (0.8–1.3)*	0.8 (0.6–1.0)†	0.7 (0.5–0.9)‡
% change		−29.4	−32.2	−38.6	−30.2	−45.7	−53.7

Numbers at risk in 1981–1985, 1986–1990, 1991–1995, 1996–2000, 2001–2005, 2006–2010, and 2011–2015 were the numbers from the census population at 1 October in 1980, 1985, 1990, 1995, 2000, 2005, and 2010, respectively. Ischemic heart disease included myocardial infarction and sudden cardiac death within 24 h. Differences from 1981 to 1985.
*$P < 0.05$.
†$P < 0.01$.
‡$P < 0.001$.

1991–1995, 85 (75–96) in 1996–2000, and 86 (75–98) in 2001–2004 (Fig. 2). The declining trends were more pronounced in women than in men (Table 2).

As shown in Table 3, the total medical expenditures for the National Health Insurance were 6952 yen per capita lower in Kyowa than in the surrounding municipalities in the 1981–1985 period (percentage of difference: −7.6%) and onwards (28 741 yen per capita lower in the 2001–2004 period [−13.2%]). These trends in difference were more prominently observed for heart disease (−4.8 and −42.3%, respectively) and for total cardiovascular diseases (+2.3 and −14.6%, respectively). On the other hand, the medical expenditure for cerebrovascular disease was higher in Kyowa than in the surrounding municipalities in the 1985–1990 and 1991–1995 periods and then became lower thereafter (+1.6% in the 1996–2000 period and −26.2% in the 2001–2004 period). The medical expenditure for hypertensive disease was lower in Kyowa than in the surrounding municipalities in the 1991–1995 period but plateaued thereafter. The medical expenditure for noncardiovascular disease was lower in Kyowa than in the surrounding municipalities, and the difference remained unchanged over time.

DISCUSSION

During the past 35 years in Kyowa, a Japanese rural community where a community-based stroke prevention program was launched, we observed that the incidence of stroke decreased by half, as did that of ischemic heart disease. Secondary outcomes also supported this observation: a similarly larger trend of decrease was observed for mortality from cardiovascular disease in Kyowa than that in the surrounding municipalities. The medical expenditures for cardiovascular disease became lower in Kyowa than in the surrounding municipalities over time.

Along with the stroke prevention program, sodium intake among Kyowa residents decreased mainly in those aged 40–49 years: sodium intake evaluated according to a 24 h dietary record declined from 13.6 g/day in 1982–1986 to 10.5 g/day in 2000–2004 among men, and from 11.6 to 9.9 g/day among women [11], whilst sodium

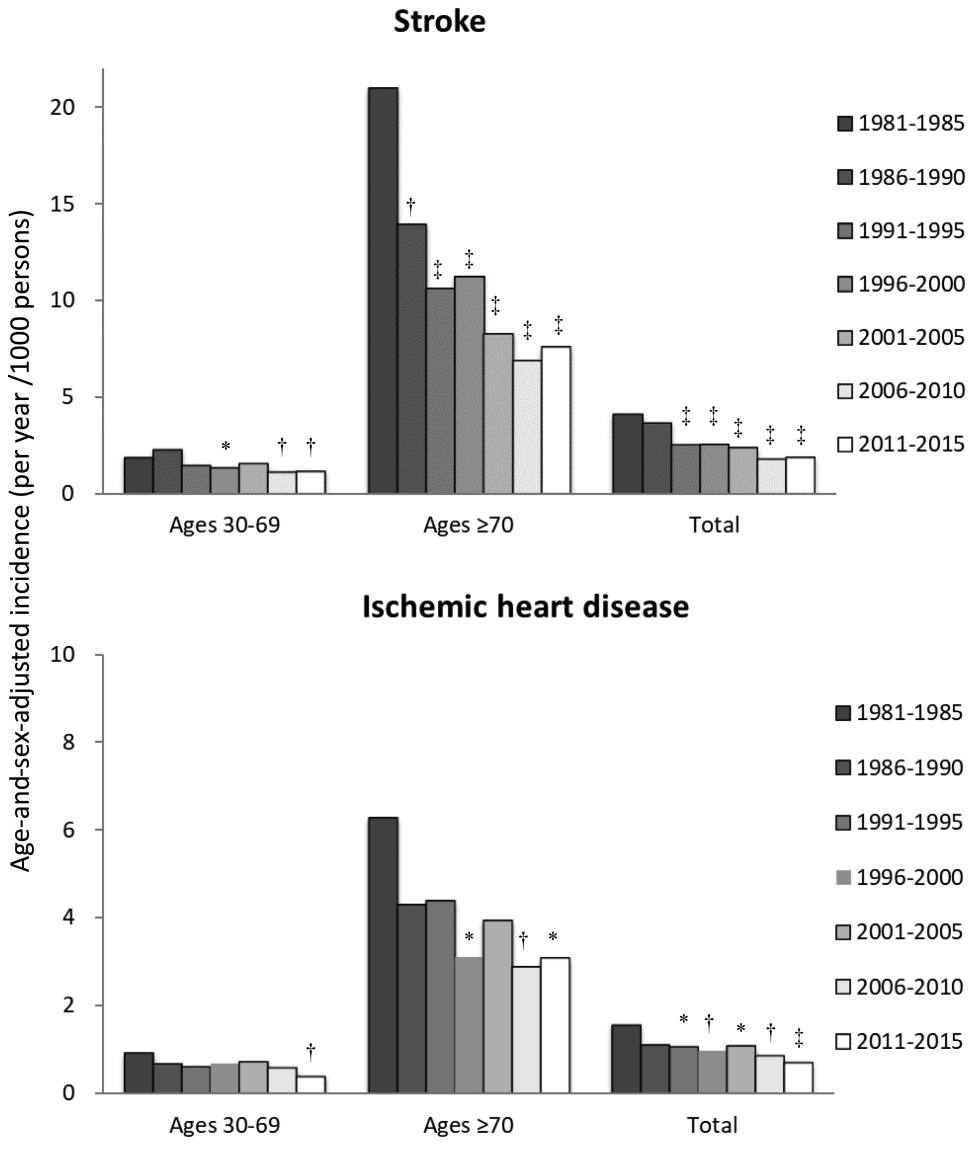

FIGURE 1 Trends in age-and-sex-adjusted incidence (per year/1000 persons) of stroke and coronary heart disease, 1981–2015, Kyowa, men and women. Differences from 1981 to 1985: $^{*}P<0.05$, $^{\dagger}P<0.01$, $^{\ddagger}P<0.001$.

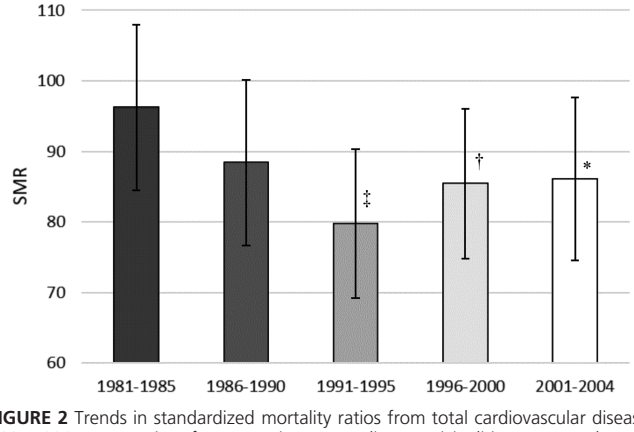

FIGURE 2 Trends in standardized mortality ratios from total cardiovascular disease, 1981–2004, Kyowa in reference to its surrounding municipalities, men, and women. Bars: 95% CIs. Differences between Kyowa and surrounding areas: $^{*}P<0.05$, $^{\dagger}P<0.01$, $^{\ddagger}P<0.001$. CIs, confidence intervals.

intake evaluated according to 24 h sodium excretion showed a similar decline from 13.3 g/day in 1982–1986 to 12.2 g/day in 1990–1994 among men and from 13.3 g/day to 10.9 g/day among women [19]. Moreover, the proportion of intake of miso soup with a salt concentration of less than 1.1%, an adequate salt concentration, increased from 47% in 1985 to 66% in 2004, according to the repeated household surveys [11]. On the basis of the health checkup data for participants aged 40–79 years, we observed declines in mean SBP levels in men (from 140 mmHg in 1981–1986 to 135 mmHg in 1999–2004) and women (from 138 to 131 mmHg), in the prevalence of overweight (BMI of $\geq$25 kg/m^2) in women (from 34 to 31%), and in the proportions of current smokers (from 60 to 47%) in men and heavy drinkers of alcohol consumption of at least 69 g/day (from 8 to 6%) in men, whereas the prevalence of overweight in men increased (from 24 to 34%) [20].

TABLE 2. Trends in mortality (95% confidence interval) from total cardiovascular disease, 1981–2004, Kyowa and surrounding municipalities

Years	1981–1985	1986–1990	1991–1995	1996–2000	2001–2004
Kyowa					
No. of population aged ≥30 years	8854	9737	10 495	11 067	11 366
Men [*n* (%)]	4290 (48.5)	4736 (48.6)	5079 (48.4)	5360 (48.4)	5514 (48.5)
Aged ≥65 years [*n* (%)]	1620 (18.3)	1934 (19.9)	2465 (23.5)	3039 (27.5)	3482 (30.6)
Surrounding					
No. of population aged ≥30 years	51 479	56 716	60,391	62,796	64,511
Men [*n* (%)]	24 915 (48.4)	27 683 (48.8)	29 707 (49.2)	30 809 (49.1)	31 386 (48.7)
Aged ≥65 years [*n* (%)]	9338 (18.1)	10 804 (19.0)	12 893 (21.3)	15 481 (24.7)	17 620 (27.3)
Sex-specific age-adjusted and age-and-sex-adjusted total cardiovascular disease mortality per year/1000 persons					
Men					
Kyowa	6.9 (5.6–8.2)	6.0 (4.9–7.1)	4.1 (3.3–4.8)	3.7 (3.1–4.4)	3.4 (2.7–4.1)
Surrounding	7.6 (7.0–8.1)	6.1 (5.7–6.6)	4.9 (4.5–5.2)	4.2 (3.9–4.5)	3.6 (3.3–3.9)
SMR	91 (75–108)	98 (81–116)	82 (66–98)*	88 (73–104)	89 (72–106)
Women					
Kyowa	5.6 (4.7–6.6)	3.0 (2.4–3.6)	2.7 (2.2–3.2)	2.3 (1.9–2.7)	1.8 (1.4–2.2)
Surrounding	5.6 (5.2–6.0)	3.8 (3.5–4.1)	3.4 (3.2–3.7)	2.6 (2.4–2.8)	2.1 (1.9–2.2)
SMR	100 (84–117)	78 (62–94)†	78 (64–92)†	83 (68–98)*	82 (67–98)*
Total					
Kyowa	6.2 (5.5–7.0)	4.3 (3.7–4.8)	3.3 (2.8–3.7)	2.9 (2.5–3.3)	2.5 (2.1–2.9)
Surrounding	6.5 (6.2–6.8)	4.8 (4.6–5.1)	4.1 (3.9–4.3)	3.3 (3.1–3.4)	2.7 (2.6–2.9)
SMR	96 (84–108)	88 (77–100)	80 (69–90)‡	85 (75–96)†	86 (75–98)*

SMR: standardized mortality ratio of total cardiovascular disease in Kyowa with reference to the surrounding municipalities.
*$P < 0.05$.
†$P < 0.01$.
‡$P < 0.001$.

TABLE 3. Trends in medical expenditures in Kyowa and its surrounding municipalities, 1981–2004

Years	1981–1985	1986–1990	1991–1995	1996–2000	2001–2004
No. of insured persons					
Kyowa	9334	8765	8161	8055	8332
Surrounding	104 866	98 684	88 724	86 257	91 259
Total medical expenditure (yen, per capita)					
Kyowa	91 029	138 554	183 678	212 551	218 101
Surrounding	97 981	141 813	193 880	226 977	246 842
Difference	−6952	−3259	−10 202	−14 426	−28 741
% difference	−7.6%	−2.4%	−5.6%	−6.8%	−13.2%
Medical expenditure for cardiovascular disease (yen, per capita)					
Kyowa	27 590	39 886	51 839	59 462	53 814
Surrounding	26 949	39 046	52 312	61 692	61 697
Difference	642	840	−473	−2230	−7883
% difference	2.3%	2.1%	−0.9%	−3.7%	−14.6%
Medical expenditure for hypertensive disease (yen, per capita)					
Kyowa	13 548	18 289	22 953	28 952	27 496
Surrounding	13 016	18 132	25 215	27 872	26 759
Difference	532	157	−2262	1081	737
% difference	3.9%	0.9%	−9.9%	3.7%	2.7%
Medical expenditure for heart disease (yen, per capita)					
Kyowa	4251	6561	9660	10 783	10 190
Surrounding	4453	7182	9817	14 164	14 501
Difference	−203	−620	−157	−3381	−4311
% difference	−4.8%	−9.5%	−1.6%	−31.4%	−42.3%
Medical expenditure for cerebrovascular disease (yen, per capita)					
Kyowa	8057	14 135	17 445	16 028	12 765
Surrounding	7715	11 911	15 274	15 779	16 108
Difference	342	2223	2171	249	−3343
% difference	4.2%	15.7%	12.4%	1.6%	−26.2%
Medical expenditure for noncardiovascular disease[a] (yen, per capita)					
Kyowa	63 438	98 668	131 839	153 089	164 287
Surrounding	71,032	102 766	141 568	165 285	185 145
Difference	−7594	−4099	−9729	−12,196	−20,858
% difference	−12.0%	−4.2%	−7.4%	−8.0%	−12.7%

Percent difference: difference divided by the expenditure in the surrounding municipalities.
[a]Medical expenditure for noncardiovascular disease was calculated by total medical expenditure minus medical expenditure for cardiovascular disease.

These findings suggest that the salt reduction and other lifestyle changes may have contributed in part to the blood pressure decline in the population as a whole.

A previous study conducted in a rural community of north-eastern Japan, another community of the CIRCS, showed that a municipality providing an intensive community-wide hypertension control program had a 2.6-fold greater decrease in stroke incidence from 1963 to 1987 than did a community with a minimal intervention among men. Among women, however, the stroke incidence declined similarly in both communities [9]. Comparing these two communities, the authors also showed that such an intensive community-wide hypertension control program was cost-saving [10]. Despite the difference in the timing of the studies, the intervention methods (the health education campaign was more intensively provided in Kyowa) and economic evaluation from the previous and present studies, the studies' main findings were generally concordant.

The SMR from total cardiovascular disease in 1991–1995 was 20% lower in Kyowa than in the surrounding areas. The difference narrowed slightly thereafter but remained lower, 15% lower in 1996–2000 and 14% lower in 2001–2004. That slight upward trend in the SMR between 1996–2000 and 2001–2004 was probably because the surrounding municipalities approached Kyowa in terms of declining cardiovascular mortality. Nevertheless, the effect of the preventive measures in Kyowa preceded that in the surrounding areas and continued to be effective overtime.

Total medical expenditure was 13.2% lower in Kyowa than in the surrounding municipalities in the 2001–2004 period, and about one quarter of the difference was explained by cardiovascular disease. We consider that the reduction in the incidence of stroke and ischemic heart disease attenuated the medical expenditure increase for cerebrovascular and heart diseases, which surpassed the extra expenditure for hypertension in the 1996–2000 and 2001–2004 periods, and accordingly, the overall medical expenditure in Kyowa became lower than that in the surrounding municipalities. The higher medical expenditure for hypertensive disease in Kyowa than in the surrounding municipalities may have reflected more active detection and referral to local physicians for seeking medical treatment for hypertension in Kyowa.

We explored the effects of the program on cardiovascular incidence, mortality, and medical expenditure, which is a strength of this study. A previous study found a similar finding for stroke incidence from the 1960s to the 1980s [9], and the present study did show that those findings were still valid after the 1980s, even when mortality from stroke in Japan was approximately 50% lower than in the 1960s [4]. Another feature of this study is the availability of the systematic registry system for cardiovascular disease, which allowed us to investigate the trends in the incidence of stroke and ischemic heart disease. Like the United States, Japan does not have a legally established registry system for stroke and ischemic heart disease; thus, Japan had to rely on the regional registries of a limited number of municipalities [21–24] to estimate the secular trend in cardiovascular disease incidence.

The study's limitations warrant discussion. First, we did not have data on the incidence of stroke in the surrounding municipalities. Instead, as a proxy for the incidence, we compared the mortality from cardiovascular disease in Kyowa and its surrounding municipalities. Second, the mortality and medical expenditure data for each municipality after 2004 were not available because of the municipality merger. The preventive measures launched in Kyowa have been partly continued, and in Chikusei City, they have been expanded after the merger with other municipalities. Last, this study compared Kyowa and its surrounding municipalities but did not randomize the communities. The prevention program was made as a health project of the municipality, and it was not practical to design a randomized comparison in advance. Nevertheless, the incidence of stroke in Kyowa decreased by half, mortality from cardiovascular disease decreased more, and medical expenditures for cardiovascular disease became lower in Kyowa than in the surrounding municipalities, suggesting that the preventive program in Kyowa was effective and cost-saving.

Several issues related to stroke prevention in Asian and African countries have been raised because of the disproportionate burden from stroke for many lower income countries [25]. However, the stroke guidelines in low- and middle-income countries involved insufficient or no description about stroke prevention [26]. Given the limited resources in most of these countries, we would like to emphasize that the preventive measures in Kyowa were implemented by administrative entities on the basis of the expertise of public health nurses, nutritionists, and administrative staff in the municipality with cooperative task forces, such as community organizations, medical associations, public health centers, health services associations, schools, and academic institutes. The keys for effective measures are the establishment of these organizations and the continuation of these measures under the initiative of mayors. We expect the present study, as well as previous studies for heart disease prevention program in Europe [27] and the United States [28], could help to develop preventive measures in low-income and middle-income countries.

In conclusion, our study's findings suggest that a community-based stroke prevention program augmented declines in the incidences of stroke and ischemic heart disease, mortality from cardiovascular disease, and medical expenditures for cardiovascular disease. The findings provide evidence on the effects of noncommunicable disease-preventive measures in low-income and middle-income countries experiencing an epidemic of such diseases [25] along with population aging.

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Conflicts of interest

There are no conflicts of interest.

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