27. Ministry of Health, Labour and Welfare of Japan (2006) *The National Health and Nutrition Survey in Japan, 2006* (in Japanese). Tokyo: Daiichi Shuppan.
28. Tooze JA, Schoeller DA, Subar AF, *et al.* (2007) Total daily energy expenditure among middle-aged men and women: the OPEN study. *Am J Clin Nutr* **86**, 382–387.
29. Snodgrass JJ, Leonard WR, Tarskaia LA, *et al.* (2006) Total energy expenditure in the Yakut (Sakha) of Siberia as measured by the doubly labeled water method. *Am J Clin Nutr* **84**, 798–806.
30. Levine JA, Lanningham-Foster LM, McCrady SK, *et al.* (2005) Interindividual variation in posture allocation: possible role in human obesity. *Science* **307**, 584–586.
31. Schoeller DA, Shay K & Kushner RF (1997) How much physical activity is needed to minimize weight gain in previously obese women? *Am J Clin Nutr* **66**, 551–556.
32. Bigaard J, Frederiksen K, Tjønneland A, *et al.* (2004) Body fat and fat-free mass and all-cause mortality. *Obes Res* **12**, 1042–1049.

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Series

Japan: Universal Health Care at 50 Years 1

What has made the population of Japan healthy?

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People in Japan have the longest life expectancy at birth in the world. Here, we compile the best available evidence about population health in Japan to investigate what has made the Japanese people healthy in the past 50 years. The Japanese population achieved longevity in a fairly short time through a rapid reduction in mortality rates for communicable diseases from the 1950s to the early 1960s, followed by a large reduction in stroke mortality rates. Japan had moderate mortality rates for non-communicable diseases, with the exception of stroke, in the 1950s. The improvement in population health continued after the mid-1960s through the implementation of primary and secondary preventive community public health measures for adult mortality from non-communicable diseases and an increased use of advanced medical technologies through the universal insurance scheme. Reduction in health inequalities with improved average population health was partly attributable to equal educational opportunities and financial access to care. With the achievement of success during the health transition since World War 2, Japan now needs to tackle major health challenges that are emanating from a rapidly ageing population, causes that are not amenable to health technologies, and the effects of increasing social disparities to sustain the improvement in population health.

Introduction

Japan has caught the attention of the rest of the world because of the tremendous success it has achieved in improving the health status of its population in the 20th century. The improving health status of the Japanese population was noted as early as the 1920s when infant mortality rates started to fall.[1] Increased child survival rates were partly possible then through the enhanced education and increasing literacy of mothers—in the early 20th century, with the provision of free compulsory education, almost all girls attended primary schools.[2] However, after World War 2, Japan showed its strength in improving the health of its population. The country was devastated after its defeat. Per person gross domestic product was roughly international $3400 in 1950 (table), which is similar to that in India today (Gakidou E, Institute for Health Metrics and Evaluation, personal communication). The health status of the population was also poor—in 1947, male life expectancy in Japan at birth was only 50 years and female life expectancy was 54 years.[5]

Rapid economic growth started in the late 1950s and life expectancy started to increase at an unprecedented rate. Within a few decades Japan had caught up with and eventually surpassed many other developed nations (figure 1; figure 2). Since 1986, Japan has ranked first in terms of female life expectancy at birth, with the highest ever recorded worldwide life expectancy of 86 years in 2009.[9] The country had also maintained the best healthy life expectancy at birth in 2007 (73 years for men and 78 years for women).[10] With a low rate of total fertility, the proportion of people aged 65 years and older has quadrupled during the past 60 years to 23% in 2010,[4] making the Japanese people the oldest population in the world. Despite the ageing population, Japan's health expenditure is only 8·5% of gross domestic product, which put it in 20th position in terms of expenditure among the countries of the Organisation for Economic Co-operation and Development in 2008.[6]

What has made the population of Japan healthy? How has Japan achieved the longest life expectancy at birth worldwide? Will the Japanese population continue to be

Key messages

- The early establishment of free compulsory primary education and a social insurance system before World War 2 and universal health insurance coverage in 1961 enabled the provision of equal opportunities for health promotion.
- Disparities in health across regions and socioeconomic groups are fairly small in this homogeneous and egalitarian society and have narrowed over time with increased average population health. However, the downward trend in socioeconomic inequality in health has been less obvious since the 1990s, which has coincided with income inequality gradually increasing.
- Japanese life expectancy at birth increased rapidly in the 1950s and early 1960s as a result of decreased mortality rates for communicable diseases in children and young adults, which was largely attributable to the government's strong stewardship in investing in key interventions for public health.
- Stroke mortality reduction was one of the major drivers of the sustained extension of Japanese longevity after the mid-1960s. The control of blood pressure improved through population-based interventions such as salt reduction campaigns and an increased use of cost-effective health technologies such as antihypertensive drugs under universal health insurance coverage.
- Further progress in Japan's longevity primarily depends on prevention of major risk factors for non-communicable diseases such as tobacco smoking and high blood pressure and several cardiovascular risks. Prevention of premature mortality from suicide is also a major challenge for population health.
- A rapidly ageing population as a result of improved survival is challenging Japan's health system in terms of its financing and quality of care. An effective link between medical and long-term care through both top–down and bottom–up approaches is necessary to enhance the welfare of the population throughout the country.

	1950	1960	1970	1980	1990	2000	2005	2010
GDP per person (2005 international $)*	3415	6249	13734	18545	26926	29396	31129	31329
GDP growth rate (%)[3]	NA	12·0†	4·3	2·8	5·6	2·9	1·9	−5·2‡
Total population (×1000)[4]	82199	93189	103710	115915	122251	125720	126393	126536
Population older than 65 years (%)[4]	4·9	5·7	7·0	9·0	11·9	17·2	19·9	22·7
Total fertility rate[4]	3·0	2·0	2·1	1·8	1·5	1·3	1·3	1·4§
Female life expectancy at birth (years)[5]	61·5	70·2	74·7	78·8	81·9	84·6	85·5	86·4
Male life expectancy at birth (years)[5]	58·0	65·3	69·3	73·4	75·9	77·7	78·6	79·6
Total health expenditure (% of GDP)[6]	NA	3·0	4·5	6·4	5·9	7·7	8·2	8·5¶

GDP=gross domestic product. NA=not available. *Gakidou E, Institute for Health Metrics and Evaluation, personal communication. †GDP growth rate in 1961. ‡GDP growth rate for 2009. §Total fertility rate of medium-fertility variant estimate for 2010–15. ¶Total health expenditure for 2008.

Table: **Socioeconomic and demographic characteristics of people in Japan during 1950–2010**

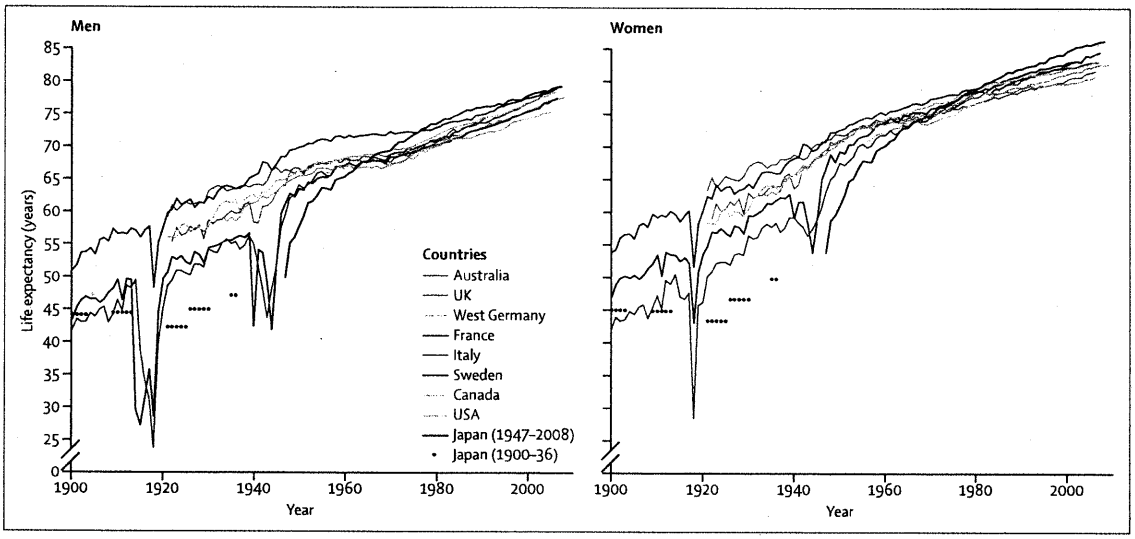

Figure 1: **Trends in life expectancy at birth, 1900–2008**
Data from University of California at Berkeley and Max Planck Institute for Demographic Research[7] and Ministry of Health, Labour and Welfare.[8]

healthy in the future? Understanding what has contributed to making the Japanese population healthy in such a fairly short period is important for global health policy, particularly for countries struggling to improve health. Several aspects of the Japanese lifestyle provide appealing explanations for the first two questions. First, Japanese people give attention to hygiene in all aspects of their daily life. This attitude might partly be attributable to a complex interaction of culture, education, climate (eg, humidity, temperature), environment (eg, having plenty of water and being a rice-eating nation), and the old Shinto tradition of purifying the body and mind before meeting others.[11,12] Second, they are health conscious. In Japan, regular health check-ups are the norm. Mass screening is provided for everyone at school and work or in the community by local government authorities. A systematic check-up of the whole body, referred to as a human dry dock (panel 1), is another type of health screening, which is popular among business people—they stay at clinics or hospitals for several days to undergo thorough physical examinations. Third, Japanese food has a balanced nutritional benefit, and the diet of the Japanese population has improved in tandem with economic development over the five past decades.[15,16]

Healthy lifestyle is, however, only one dimension of Japanese life. Japan is now struggling to deal with several major health challenges, which are partly attributable to the striking changes taking place in the demographic and social structures of its rapidly maturing society. The population is projected to shrink from 128 million in 2005 to 95 million in 2050, while the proportion of people aged 65 years or older is expected to rise to 40%.[17] Since the early 1990s, prolonged political stagnation and economic recession have helped induce a feeling of increasing inequality among this ageing population. Moreover, overweight or obesity is an increasingly serious problem, emanating from a shift towards a western-style diet and sedentary lifestyle. About a third of men aged 30–59 years are overweight or obese,[18] although the prevalence of adult obesity (4%) is well below that in other developed nations.[6]

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This is the first in a Series of six papers about Japan's universal health care at 50 years

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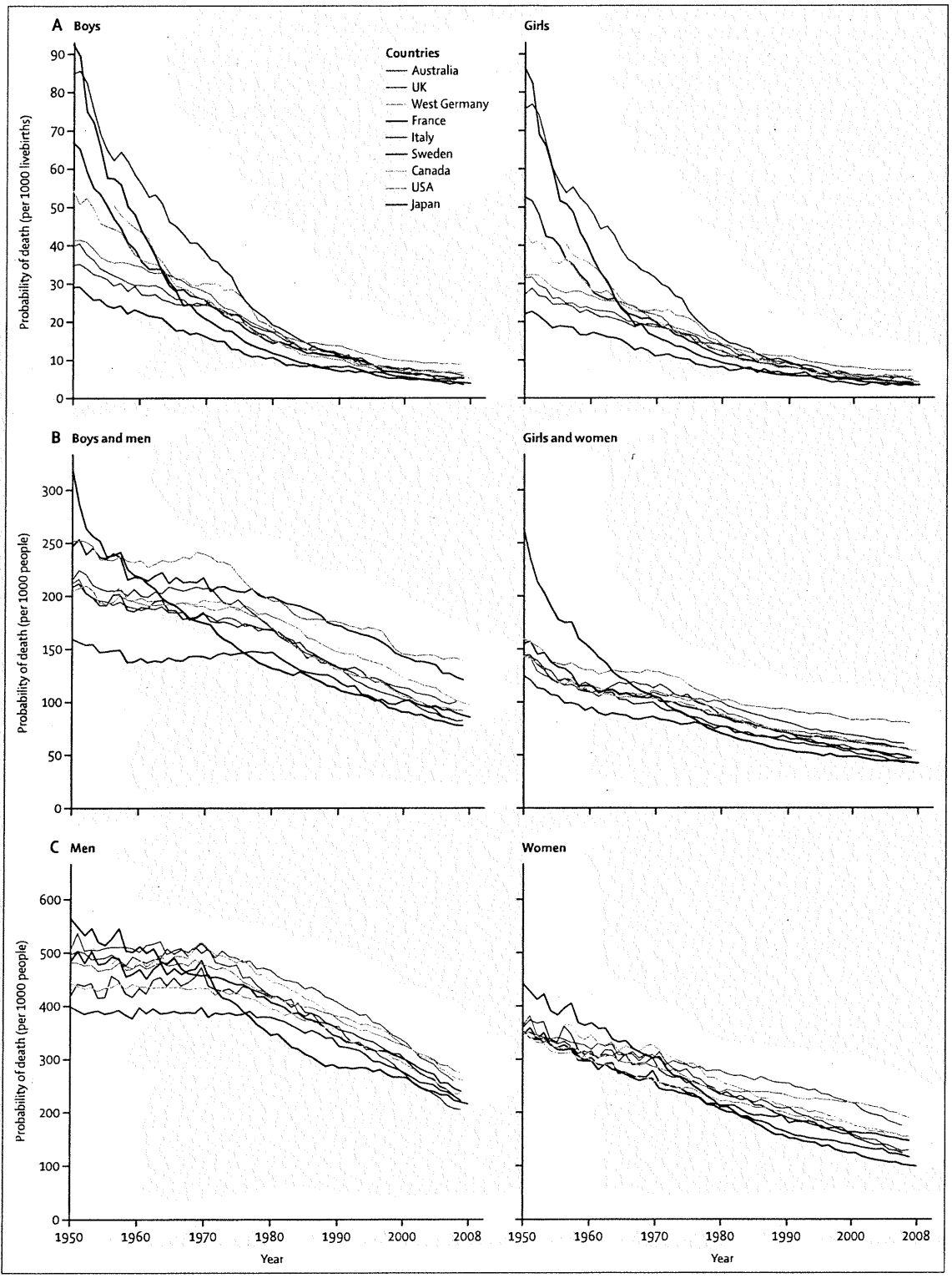

Figure 2: **Trends in the probability of death at age younger than 5 years (A), 15–60 years (B), and 60–75 years (C) in Japan and selected countries during 1950–2008**

Data from University of California at Berkeley and Max Planck Institute for Demographic Research.[7]

Furthermore, the working life of typical salaried workers in Japan seems anything but healthy—often working from early in the morning until late in the evening, 6 days a week. To relieve daily stress, some of them resort to negative health behaviours such as smoking tobacco and getting drunk after work, or even suicide in extreme cases. Death from overwork is also a serious social problem. In the context of these demographic and social challenges, what are the best strategies for Japan to protect the health and wellbeing of its ageing population?

In this first report in the *Lancet* Series, we focus on the improvements in the health of the Japanese population after World War 2. We review and analyse the best available data and evidence for population health in Japan to explore what has made the Japanese people healthy (panel 2). We provide an overview of Japan's population health in terms of the rates and distribution of mortality, and assess possible factors that might account for the longevity of the people in Japan. We also draw attention to the future challenges for Japan in controlling risk factors and social determinants to further enhance the health status of its population. We conclude with the global lessons that can be learned from Japan's experience over the past 50 years.

Mortality rates in infants and young adults

Most of the increase in longevity in Japan in the past 60 years happened during 1950–65. Life expectancy at birth increased by 10·1 years in men and 11·9 years in women during this time, and these increases accounted for almost 40% of the total increase during 1950–2010 (table). Much of the increase in longevity during this early period was indicative of an enormous reduction in mortality rates in children younger than 5 years and young adults. In 1950, the probability of death before the age of 5 years was greater than 80 per 1000 livebirths and was very high compared with the probabilities of death in other developed countries, but fell to about 20 per 1000 livebirths by 1965 (figure 2). The probability of death in individuals aged 15–60 years was also much higher than in other developed countries, but fell and was on a par with probabilities of death in some developed countries by 1965. Consequently, in the 1950s and early 1960s, lower mortality rates in children younger than 5 years accounted for an increase in male life expectancy at birth of 4·1 years and female life expectancy at birth of 4·3 years, whereas reduced mortality rates in adults younger than 60 years accounted for increases in life expectancies of 3·1 years in men and 4·0 years in women (webappendix p 3).

The health of children younger than 5 years improved greatly in 1950–65 through the control of intestinal or respiratory infections and vaccine-preventable diseases that occurred with a drop in the number of neonatal deaths. The age-standardised mortality rate for communicable diseases, other than tuberculosis, decreased by 90% in children younger than 5 years (webappendix p 7); the age-standardised mortality rates for neonatal illnesses fell from 990 per 100 000 boys to 173 per 100 000 and from 772 per 100 000 girls to 133 per 100 000 during 1953–70 (webappendix p 7). Reduction in mortality rates for infectious diseases, other than tuberculosis, in children younger than 5 years accounted for increases of 2·2 years in male life expectancies at birth and 2·4 years in female life expectancies at birth. The reduction in the mortality rate for neonatal illnesses increased life expectancy by 1·0 year in both sexes (webappendix p 3).

The effect of a reduction in the mortality rate for tuberculosis on the extension of life expectancy at birth in young adults was equivalent to the reduction in mortality rate for other infectious diseases in children younger than 5 years. A 95% reduction in the number of deaths from tuberculosis in adults (aged 15–59 years) in 1950–65 (webappendix p 8) contributed to the increase in life expectancy of 2·4 years in men and 2·3 years in women (webappendix p 3).

These reductions in mortality rates in 1950–65 indicated increasing investment in the public health sector during

See Online for webappendix

***Panel 1:* Human dry dock**

The Ningen Dock (or human dry dock) is a comprehensive medical check-up system that is unique to Japan.[13] The Ningen Dock started in 1954 at a hospital in Tokyo. At that time, this service could only be afforded by business and political leaders because it took 6 days of consecutive stay in hospital and cost the equivalent of 3–4 months of a civil servant's starting salary. Advances in automated blood analysers and other testing apparatus reduced the costs, and the 1-day or 1-night stay has become the main type of service. About 3 million people per year are estimated to receive the Ningen Dock at about 1500 medical institutions in the country. A key factor that underpinned the rapid growth in the use of the Ningen Dock was that several companies covered the cost for their employees to ensure their good health.

The Ningen Dock emphasises the importance of a consultation and a post-examination interview. Over 1–2 days, clients undergo a series of medical examinations, such as blood, urine and faecal tests, radiography, and ultrasonography, and a consultation with a doctor about their medical history and lifestyle habits. After the examinations, the doctor explains the results and gives lifestyle advice to the clients.

The Ningen Dock might play a part in the primary prevention of cerebrovascular and cardiovascular diseases through the control of risk factors, such as obesity, hypertension, hyperglycaemia, dyslipidaemia, and hyperuricaemia. It might also be important for secondary prevention through the detection of diseases such as the early stages of cancer. The brain dock with MRI has expanded nationwide since it started in 1988.[14] There has also been a focus on using PET scans to detect the early stages of cancer. However, the cost-effectiveness of the Ningen Dock has been questioned.

Panel 2: **Data sources and methods**

Mortality trends

To assess trends in mortality rates in Japan since 1950, we used life tables and individual cause of death data that were obtained from different sources (Naghavi M, unpublished).[19,20] Life tables were obtained from the human mortality database at the University of California, Berkeley, CA, USA, and the Max Planck Institute for Demographic Research, Rostock, Germany.[7] We also obtained the individual cause-of-death data for 1950–2008 from the Ministry of Health, Labour and Welfare of Japan,[19] and the Institute for Health Metrics and Evaluation at the University of Washington, Seattle, WA, USA (Naghavi M, unpublished).[20] Japan has had a complete vital registration system since 1899. Although the gold standard is cause of death information from vital registration, a potential bias could be attributable to the inclusion of ill-defined codes (eg, cardiac arrest, heart failure, and senility) and unknown causes. With the algorithm developed by Naghavi and colleagues,[21] ill-defined codes and unknown causes on death certificates were redistributed and the consistency across revisions of the International Classification of Diseases and Related Health Problems (ICD) was checked. We assessed the causes that are amenable to medical care, which was originally proposed by Nolte and McKee,[22] extracting the major causes of death from the list (webappendix p 1), because the ICD avoidable causes of death were no longer applicable to our analysis after redistribution of ill-defined and unknown causes.

Health disparities

We assessed the trend in regional disparities in longevity with data for municipal life expectancy at birth at 5-year intervals during 1985–2005.[23] Municipalities are the smallest administrative units for which life expectancy data at birth are available in Japan. Sample sizes were 3307–3354 in 1985–2000 and 1963 in 2005. The substantial drop in the sample size in 2005 was due to the municipal mergers that were undertaken after 2000. We assessed temporal trends in socioeconomic disparities in the age-standardised all-cause mortality rate in the working population (aged 30–59 years), using vital records from 1980 to 2005. We used occupational status as a measure of the socioeconomic status of individuals. We standardised death rates per 100 000 at 5-year intervals using the Japanese population in 1985 as a standard population.[24] We obtained population data according to occupational status from tables reported in the national census that is undertaken every 5 years.[17,24]

demilitarisation and democratisation in the early post-war years in Japan. 32 health laws were enacted during the first decade after the war.[25] The Japanese Government collaborated with the American occupation forces in scaling up public health interventions at the community level.[26] Water supply coverage and key interventions for maternal and child health rapidly improved after the war (webappendix p 10). The effective provision of essential interventions for child survival, such as access to safe drinking water and institutional delivery, was mediated through a high level of maternal education and health facility provision that had already been achieved before the war.[27] Moreover, free treatment for tuberculosis started in 1952,[28] and included systematic screening with chest radiography and the use of streptomycin. The incidence of tuberculosis decreased sharply at a yearly rate of 11% between 1961 and 1977.[29] Additionally, as elaborated in the second report in this *Lancet* Series,[30] health insurance coverage, which was applied to about 70% of the population before World War 2, ensured access to new interventions such as drugs and vaccines for tuberculosis.

Mortality rates for non-communicable diseases

Even after communicable diseases had been successfully tackled, life expectancy of Japanese people continued to increase steadily. Male and female life expectancies at birth, respectively, increased by 5·7 years and 5·9 years during 1965–80, 3·0 years and 4·0 years during 1980–95, and 3·3 years and 2·9 years during 1995–2008 (figure 1). The risks of people dying at the ages of 15–60 years and 60–75 years fell, becoming one of the lowest in the developed world by 1980 (figure 2).

In 1950, mortality rates for cancers and ischaemic heart disease were already quite low in Japan compared with those in other developed countries, whereas the stroke mortality rate was very high. The age-standardised mortality rates for men with cancers and other neoplasms, ischaemic heart disease, and stroke were 163·8 per 100 000, 143·4 per 100 000, and 363·1 per 100 000, respectively, and for women 137·8 per 100 000, 124·8 per 100 000, and 326·5 per 100 000, respectively (webappendix pp 11–13). The low mortality rates for cancers and ischaemic heart disease in the early post-war years is one of the features of the health transition in the Japanese people. Although it is not known why the mortality rates for non-communicable diseases, other than stroke, were already low at this time, the reasons might be a favourable lipid profile and glucose metabolism, a generally low body-mass index, and other lifestyle factors relating to diet and low to moderate alcohol intake.[31] Indeed, the results of the Ni-Hon-San study[32,33] and the Honolulu Heart Program[34] showed that Japanese Americans (first-generation immigrants) were more likely to develop ischaemic heart disease and less likely to develop stroke than were Japanese people living in Japan, drawing attention to the importance of lifestyle rather than genetic background in determining the risk of disease.[32–34] The sustained increase in life expectancy at birth after the mid-1960s was largely attributable to reduced mortality rates for non-communicable diseases (webappendix p 4). From 1965 to 1980, reduced mortality rates in adults with these diseases had a substantial effect on increasing life expectancy. Reduction in the mortality rate for stroke in people aged 60–74 years increased male life expectancy at birth by 1·1 years and female life expectancy at birth by

1·0 years (webappendix p 4). Reduced mortality rate for stroke in women aged 75 years and older also accounted for a substantial increase (0·9 years) in female longevity.

The fall in stroke mortality rates slowed during 1980–95, while ischaemic heart disease mortality rates continued to fall steadily. Although not decreasing so rapidly as that of stroke, the mortality rate for ischaemic heart disease in adults aged 60–74 years nevertheless constantly decreased in this period (webappendix p 9). Consequently, although improved stroke mortality rates continued to be a major determinant of increased life expectancy, the effect of decreased mortality rates for ischaemic heart disease became pronounced during 1980–95, particularly in elderly women (webappendix p 5). Moreover, a reduction in the mortality rate in women aged 75 years and older had the largest effect on the increase in female life expectancy at birth, accounting for a change of more than 2 years (webappendix p 5). The distribution of the effects of change in mortality rate on increased longevity by age and cause of death was similar for both sexes during 1995–2008 (webappendix p 6).

An improved stroke mortality rate coincided with a reduction in average blood pressure that started in the late 1960s.[19,35,36] The numbers of deaths from stroke associated with high blood pressure have decreased over the past three decades.[37] Two factors that might be important in contributing to the falling trend in blood pressure in the population are the increased coverage of antihypertensive drugs in patients with hypertension and improved lifestyles that include reduced dietary salt intake.[38]

A population-wide approach with easy access to primary care as a result of universal health coverage has proved to be especially successful in reducing the incidence and prevalence of stroke.[39] The national government launched a strategy for the prevention and control of hypertension and stroke in 1969 and applied the strategy nationwide in 1982. This strategy included the measurement of blood pressure for screening high-risk populations, provision of national health insurance coverage for the clinical treatment of hypertension, and population-wide health education for reduction of dietary salt intake and improvement of other lifestyle-related factors. On the basis of this strategy, occupational health acts were enacted in 1972 and community health acts in 1982 to mandate the provision of programmes for primary and secondary prevention, including annual health check-ups. More than 70% of Japanese men aged 45–54 years have some form of health check-up at least once a year.[40]

A reduction in dietary salt intake has been very important for the health improvement of the Japanese population. Average salt intake among middle-aged men decreased from 30 g/day in the 1950s to 14 g/day in the 1980s.[41] Some aspects of a westernised Japanese diet, such as the improved preservation of food might have contributed to the reduction in dietary sodium consumption.[16] These results partly support the claim that both a population-based approach and subsequent advances in modern medical technologies with the scale-up of their access have made a substantial contribution to the improved life expectancy of the Japanese population.

Cultural background

Japan's success in terms of the increased life expectancy of its population is unlikely to have resulted solely from the achievement of good access to health care. Instead, other cultural background factors might be involved. Marmot and Smith[42] hypothesised that the way Japanese people relate to each other and groups might partly account for the longevity of the Japanese population.[42] Results of previous studies have lent support to this hypothesis because strong ties in Japanese communities seem to be associated with improved outcomes in mental health, dental health, and physical functioning, while buffering against the adverse effects of income inequality.[43] More than 50 years of peace and political stability might also have contributed indirectly to Japan's success in population health.

Health inequality

The homogeneous and egalitarian nature of Japanese society is shown in terms of strong educational policies, formal and informal regulations that ensure employment security, and universal access to health care. Disparities in life expectancy at birth between prefectures had started to decrease before World War 2 and continued to decline steadily until they were very low in the 1970s.[2] Indirect evidence suggests that people living in prefectures in the northeast of Japan might have shorter life expectancies than do those living in the prefectures in the southwest.[44] This geographical gradient might be attributable to differences in risk profiles such as a higher prevalence of hypertension and diabetes in the northeastern prefectures that are related to lifestyles, health-care resources, and socioeconomic status. Our additional analysis showed that the variability in life expectancy at birth across municipalities remained low from 1985 to 2005—standard deviations of longevity changed by about 1·0 for male life expectancy and 0·8 for female life expectancy, and were small compared with 2·0–2·5 and 1·5–2·0, respectively, for counties in the USA.[45]

Gaps in all-cause mortality rates for men in different occupational groups were reduced from the early 1960s to the late 1980s, except for workers in the service industry and those working in the agriculture, fishery, and forestry industries.[2] An additional analysis we undertook showed that the downward trend in socioeconomic disparities in mortality rates continued in the early 1990s, and the mortality rates for managers and professionals rose in the late 1990s, which coincided with the Asian financial crisis in 1997 (webappendix p 14).

The rapid reduction in mortality rates in Japan might have been partly attributable to the narrowing gap in income during the period of high economic growth in the 1960s and 1970s.[42] By the 1990s, more than 90% of

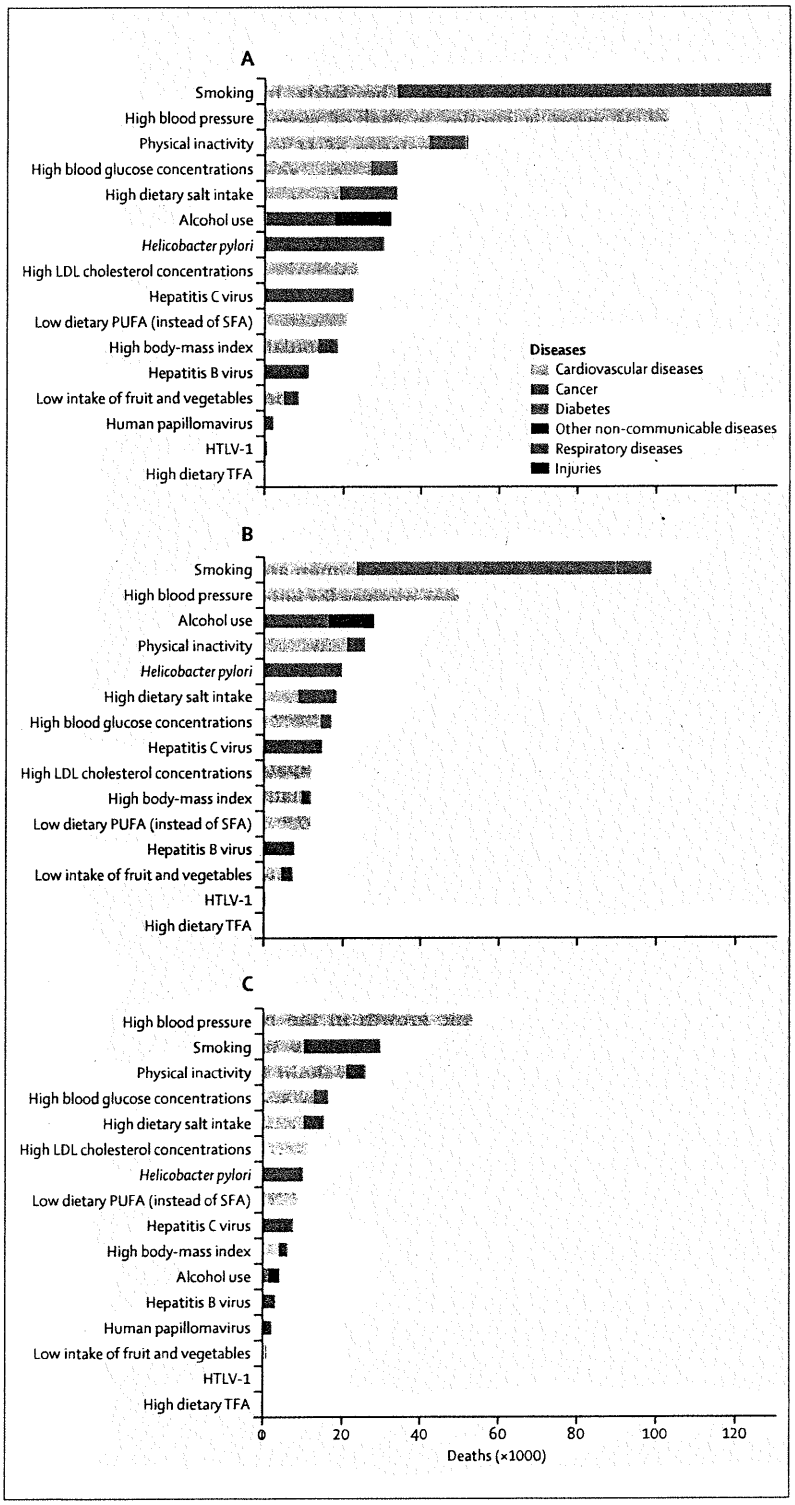

Figure 3: **Deaths from non-communicable diseases and injuries that were attributable to risk factors in Japan in 2007**
(A) Both sexes. (B) Men. (C) Women. Data from Shibuya.[37] PUFA=polyunsaturated fatty acids. SFA=saturated fatty acids. HTLV-1 =human T-lymphotropic virus type 1. TFA=trans fatty acids.

people believed that they were middle class.[46] However, this belief might no longer be applicable. During the past two decades, Japan has had economic recession. Income inequality has increased to match the average for the member countries of the Organisation for Economic Co-operation and Development,[47] which accords with reports suggesting widening health disparities in recent years,[48] despite the decreasing trend and fairly small health disparities until the 1990s.[2]

Challenges for Japanese population health

Increase life expectancy

Cancer, heart disease, and cerebrovascular disease are the three leading causes of death in Japan, accounting for more than 50% of the risk that a person at age zero will die in the course of their lifetime.[5] To strengthen the extension of Japanese life expectancy, mortality from these non-communicable diseases must be prevented. Although the use of advanced medical technology is a promising strategy for improving survival, modifying the profile of the underlying population risk factors is also important to ensure a long-term increase in population health.

A comparative assessment of preventable risk factors in Japan showed that tobacco smoking and high blood pressure were the two distinctive determinants of adult mortality from non-communicable diseases in 2007 (figure 3).[37] Of 834000 deaths from non-communicable diseases and injuries, the exposure to tobacco smoking in terms of smoking impact ratios accounted for 129000 deaths, whereas high blood pressure accounted for 104000 deaths. A similar estimate of the number of avoidable deaths from tobacco use was reported in a pooled cohort study of the current smoking status.[49] The comparative risk assessment also showed that male life expectancy at birth would have been extended by 1·8 years and female life expectancy at birth by 0·6 years if all adults abstained from smoking; and by 0·9 years for both sexes if the systolic blood pressure was reduced to a pressure that resulted in minimum harmful effects in the population.

Tobacco smoking has a striking effect on population health in Japan. Despite its well known harmful effects, smoking is still commonplace—about 50% of young men smoke—and the rate has been gradually increasing among young women.[18] The Health Promotion Law was enacted in 2003 to support the prevention of smoking and passive smoking in public places. Although compliance with this national tobacco control legislation has improved, disparities still exist in the progress of tobacco control policy across local governments,[50] and no mandatory clean air law has been passed nationally. The retail price of the most popular brand of cigarettes was only US$3·3 in 2008, much lower than the average price in high-income countries ($5·0).[51] These circumstances, favouring smokers, show to some extent that tobacco tax was one of the most important sources of revenue for the government in the past.[52] Further, the rate of mortality attributable to

this risk factor has increased in recent decades because of the accumulation of negative health effects in the older population.[37] Without effective policy interventions, the rate of mortality from tobacco smoking will continue to rise in the coming decades. A renewed emphasis on tobacco control, especially through its pricing mechanism, is necessary to discourage the consumption of tobacco products and promote smoking cessation.

Despite the decline in population blood pressure in the past four decades, the management of blood pressure is still not satisfactory in Japan. Blood pressure is effectively controlled with drugs in less than a fifth of the population with hypertension.[37] Additional efforts in the community and clinical practice in terms of early detection, lifestyle modification, and the effective treatment coverage of high blood pressure have the potential to extend life expectancy through a reduction in the mortality rates for cardiovascular diseases. In relation to this, strengthening adherence to standard clinical guideline recommendations[53] in general practice through continued medical education could be the key to increasing the effective coverage of outpatient services and to ensure the compliance of patients, as discussed in the third report in this Series.[54]

A large improvement in population health is still possible through the reduction of several risk factors for non-communicable diseases, such as high concentrations of blood glucose, physical inactivity, alcohol use, overweight and obesity, and high dietary salt intake. The control of several cardiovascular risks could also increase longevity for both sexes by reducing the risk of death.[37] A comprehensive prevention package is needed to lower the combined effects of several risk factors or metabolic syndrome, including the improvement of lifestyles and diet, and to increase the coverage of antihypertensive drugs. This package would be particularly relevant in the current obesity-friendly environment in Japan because, although lifestyle changes generally seem to matter more than do genetic factors, evidence suggests that the Japanese might be genetically more susceptible to being overweight or to developing diabetes mellitus.[55,56] Since 2008, in response to soaring health costs, the government has made it obligatory for people aged 40–74 years to have an annual check-up and a health education intervention that is focused on the prevention of metabolic syndrome,[57] although the effectiveness of health check-ups is not known in Japan.

Japan, similar to other east Asian countries, has many cancer-associated deaths from infectious causes.[58] Infections with hepatitis C virus and *Helicobacter pylori* account for many of the deaths from cancer.[37] In 2007, *H pylori* infection was the cause of 31000 deaths from gastric cancer. Infection with hepatitis C virus was associated with 23000 deaths from liver cancer, with clustering in people aged 70–79 years—ie, individuals born in the 1930s. Chronic infection with hepatitis C virus plays a major part in the cause of hepatic carcinoma in Japan.[59] A decreasing prevalence of infections with hepatitis C virus after the birth cohort of about 1935 suggests that the disease burden of this virus will decrease in the future. The fairly high prevalence of *H pylori* is similar to that of stomach cancer.[58] However, a fall in the prevalence of *H pylori* infection has been noted in people born after 1955,[60] which indicates a future reduction in the burden of gastric carcinoma attributable to this risk factor in Japan.

Prevention of suicide

Suicide prevention is another challenge for population health in Japan. Suicide rates contribute to premature mortality rates and profoundly affect society—by 2006, an estimated 3 million people had lost a loved one to suicide in Japan.[61] The number of suicides has been greater than 30000 every year since 1998, when a sharp rise was recorded from the previous year (figure 4).[62] Roughly 70% of people who commit suicide are men and 50% are unemployed, and 40% of suicides in men are in individuals aged 45–64 years.[63] Major motives for suicide among working age men include psychiatric disorders such as depression, business failure, unemployment, and debts.[64]

The trends in suicide mortality rates might be associated with the increasing economic and social insecurity resulting from a stagnating Japanese economy since the beginning of the 1990s, especially in response to the Asian financial crisis in 1997.[65] The unemployment rate in the working age male population rose from 2·0% in 1991 to 3·4% in 1997 and then up to 5·5% in 2003.[66] Additionally, the work environment has greatly changed because of the easing in employment contract regulations in the late 1990s.[67] The employment pattern has shifted from the permanent employment that underpinned high economic growth in the past. The percentage of non-regular workers among male employees has increased from 9% in 1991 to about 19% in the late 2000s.[66] The government has responded to the suicide epidemic with a comprehensive strategy (ie, the Comprehensive Suicide Prevention Initiative[68]) that follows on from the Basic Act for Suicide Prevention, which was enacted in 2006, although its effect is not yet notable.

Reduction in morbidity and disability

Do Japanese people not only live longer but better in terms of their physical and psychological functioning? Globally, evidence suggests an increasing prevalence of morbidity in accord with the ageing population, while disability has been falling.[69] In Japan, research suggests that trends in disability prevalence differ between the young elderly (65–74 years) and the oldest old (≥85 years). For example, falling disability rates for those aged 65 years and older were recorded during the 1990s in a nationally representative sample of the Japanese elderly

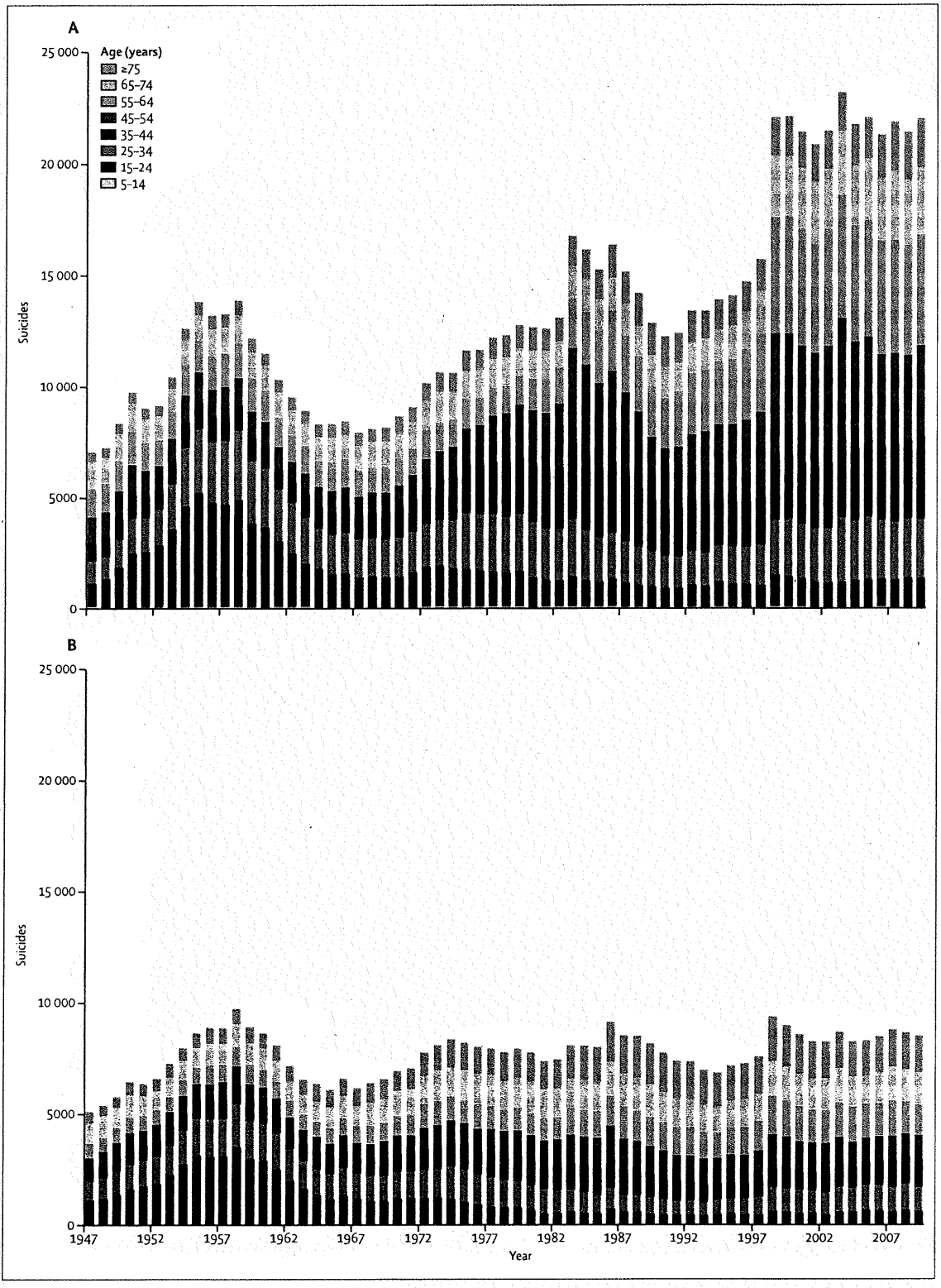

Figure 4: **Deaths from suicide by age in Japan, 1947–2009**
(A) Men. (B) Women. Data from the Ministry of Health, Labour and Welfare.[62]

population,[70] whereas increasing rates were reported for centenarians in other studies.[71,72] National health interview survey data have been used in studies to show that the functional health status of the Japanese people deteriorated during 1995–2004;[73] and morbidity rates decreased from 1984 until 1995, but the trend reversed in the late 1990s until 2004.[74] However, self-reported data were used for a few of the health domains in these studies. The survey questions and response categories are not detailed enough to obtain a reliable measure of the non-fatal health status of the population. Therefore, the national information infrastructure needs to be urgently improved to gather valid, reliable, and comparable data for the rates of disability and morbidity in the Japanese population.

Medical and long-term care

An unprecedented and unexpectedly steep reduction in mortality rates in older age groups[75] is contributing to the rapid increase in remaining life expectancy in Japan. The country has shown the most rapid increase in remaining life expectancy over the past six decades. For Japanese women, life expectancy at age 60 years increased from 16·4 years in 1950 to 28·1 years in 2007 (webappendix p 2), while life expectancy at age 80 years also increased substantially from 5·5 years to 11·4 years (webappendix p 2). The stagnating rate of increase in remaining life expectancy in other developed countries during the past two decades draws attention to Japan's exceptional improvement in life expectancy at older ages.

The nature of health care is also changing in this ageing society. The proportion of deaths resulting from illnesses that are no longer amenable to medical care, and Japanese society's concern about health have been increasing. A close link between medical care and long-term care should be further promoted to enhance population wellbeing and will be elaborated further in the fourth report in this Series.[76]

Global lessons

The experience of post-war Japan suggests that countries with low socioeconomic development can achieve progress in terms of their population health. Japan's national income was low in the beginning of the 1950s, when a tremendous increase in life expectancy at birth started largely as a result of the scale-up of the coverage of essential child survival interventions and provision of free treatment for tuberculosis. The main driving force for improved population health during this period was undoubtedly the strong stewardship of the new Japanese Government in implementing major structural reforms in the health sector and placing priority on investment in key interventions for public health in the early phase of economic growth.

The path towards universal coverage should be encouraged globally. Stroke mortality reduction was a major determinant of the sustained extension of the longevity of the Japanese population after the mid-1960s. The control of blood pressure improved with population-based interventions such as salt reduction campaigns and an increased availability of anti-hypertensive drugs through universal health insurance coverage. A reduction in mortality rates can be brought about by the interplay of improvements in both medical care and other societal factors (eg, income, education, nutrition, and sanitation). In turn, this reduction can vary by individual, place, and disease type.[77,78] A recent assessment of worldwide adult mortality rates[79] identified three important factors—socioeconomic development, increased access to health care and the progress in health technologies, and the diseases of affluence. Universal coverage is one of the most important factors and is essential in enhancing access to cost-effective health care at affordable prices that has indirectly contributed to the longevity through reduced cardiovascular-associated mortality rates in Japan. The lessons learned from the challenges and successes of population health in Japan lend support for the implementation of the current global health strategies to develop domestic health financing and risk-pooling mechanisms through health insurance and to scale up cost-effective interventions.[80]

Health disparities across regions and socioeconomic groups are quite small in this egalitarian society and have narrowed over time with increasing average population health. The establishment of free compulsory primary education early in the 20th century, a social insurance system before the war, and universal health insurance coverage in 1961 enabled the provision of equal opportunities for health promotion. These experiences confirm that working on population averages is not enough. Countries that have the least regional or socioeconomic disparity in longevity tend to be those in which the populations enjoy the longest life expectancies in the world.[69] Globalisation and rising economic disparity contribute to health inequalities and are increasingly causes for concern in many countries, and Japan is no exception. The goals of a health system include not only improvement of the averages but also reduction of health inequalities to a minimum.[81] By doing so, countries could accomplish what Japan has achieved.

Japan now has challenges for population health that many other countries will have soon. Further progress in terms of longevity in Japan is dependent on the prevention of major risk factors for non-communicable diseases such as tobacco smoking, high blood pressure, and metabolic syndrome. Prevention of premature mortality from suicide is another major issue requiring a comprehensive societal response that involves, for example, stabilisation of the labour market, and improvement of the promotion and provision of mental health services.[82] The rapidly ageing population as a result of improved survival also challenges financing and quality of care in Japan's health system.[30,54,76] The tsunami and nuclear crisis caused by the

magnitude 9·0 Great East Japan Earthquake on March 11, 2011, might also affect future population health, which will need to be monitored and assessed. How should Japan respond to these challenges? Policy options to tackle the challenges are addressed in the other five reports in this *Lancet* Series on Japan, which we hope will serve as a guide that will help other countries to develop policies that fit their specific circumstances. Indeed, this Series will draw attention to how Japan is unique in overcoming different and changing population health challenges in the past 50 years to achieve population longevity, and how the country's experience can be an important resource for the global health community and could transcend geographical, social, cultural, and political boundaries for understanding and helping enhance population health worldwide.

Contributors

All authors contributed to the study concept, design of the report, data analysis, and interpretation of the results. NI, ES, NK, and KS wrote the first draft. MI, HI, and ME did a systematic review. NI, ES, NK, HI, SI, TS, AS, and KS contributed to drafting and critical revision. All authors contributed to the discussion and have seen and approved the final version of the report.

Conflicts of interest

We declare that we have no conflicts of interest.

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References

1 Ministry of Health, Labour and Welfare. Vital statistics of Japan 2007. Tokyo: Ministry of Health, Labour and Welfare, 2009. (in Japanese).
2 Hasegawa T. Japan: historical and current dimensions of health and health equity. In: Evans T, Whitehead M, Diderichsen F, Bhuiya A, Wirth M, eds. Challenging inequities in health: from ethics to action. New York: Oxford University Press, 2001: 90–103.
3 World Bank. World development indicators. 2010. http://data.worldbank.org/indicator/NY.GDP.MKTP.KD.ZG (accessed Dec 25, 2010).
4 UN Population Division. World population prospects: the 2010 revision population database. http://esa.un.org/unpd/wpp/index.htm (accessed Aug 1, 2011).
5 Ministry of Health, Labour and Welfare. Fact sheet of abridged life tables for Japan 2010. 2011. (in Japanese). http://www.mhlw.go.jp/toukei/saikin/hw/life/life10/index.html (accessed July 28, 2011).
6 OECD. OECD health data 2011: statistics and indicators. Paris: Organization for Economic Co-operation and Development, 2011.
7 University of California at Berkeley, Max Planck Institute for Demographic Research. Human mortality database. http://www.humanmortality.de (accessed Oct 25, 2010).
8 Ministry of Health, Labour and Welfare. The 20th life tables. Tokyo: Health and Welfare Statistics Association, 2007 (in Japanese).
9 WHO. World health statistics 2011. Geneva: World Health Organization, 2011.
10 WHO. World health statistics 2010. Geneva: World Health Organization, 2010.
11 Horiuchi S. Major causes of the rapid longevity extension in postwar Japan. *Jpn J Popul* 2011; **9**: 162–71.
12 Ohnuki-Tierney E. Illness and culture in contemporary Japan: an anthropological view. New York: Cambridge University Press, 1984.
13 Yamakado M. Taking stock of the Ningen Dock. *Highlighting Japan* 2010; **4**: 10–11.
14 Japan Brain Dock Society. Guidelines for the brain dock 2008. Sapporo: Kyobunsha, 2008 (in Japanese).
15 Ohno Y. Health development in Japan: determinants, implications and perspectives. *World Health Stat Q* 1985; **38**: 176–92.
16 Tominaga S, Kuroishi T. An ecological study on diet/nutrition and cancer in Japan. *Int J Cancer* 1997; **71** (suppl 10): 2–6.
17 Statistics Bureau, Ministry of Internal Affairs and Communications. Population of Japan: final report of the 2005 population census. Tokyo: Japan Statistical Association, 2010. (in Japanese).
18 Ministry of Health, Labour and Welfare. The national health and nutrition survey in Japan, 2007. Tokyo: Ministry of Health, Labour and Welfare, 2010 (in Japanese).
19 Ministry of Health, Labour and Welfare. Vital statistics of Japan 1950–2008. Tokyo: Ministry of Health, Labour and Welfare, 1952–2010 (in Japanese).
20 Institute for Health Metrics and Evaluation. Institute for Health Metrics and Evaluation database. Seattle, WA: Institute for Health Metrics and Evaluation, University of Washington, 2010.
21 Naghavi M, Makela S, Foreman K, O'Brien J, Pourmalek F, Lozano R. Algorithms for enhancing public health utility of national causes-of-death data. *Popul Health Metri* 2010; **8**: 9.
22 Nolte E, McKee M. Does health care save lives? Avoidable mortality revisited. London: Nuffield Trust; 2004.
23 Ministry of Health, Labour and Welfare. Municipal life table 1985–2005. Tokyo: Health and Welfare Statistics Association, 1989–2009 (in Japanese).
24 Statistics Bureau, Ministry of Internal Affairs and Communications. Population of Japan 1980–2000. Tokyo: Japan Statistical Association, 1985–2005 (in Japanese).
25 Sugiura Y, Ju YS, Yasuoka J, Jimba M. Rapid increase in Japanese life expectancy after World War II. *Biosci Trends* 2010; **4**: 9–16.
26 Reich MR, Ikegami N, Shibuya K, Takemi K. 50 years of pursuing a healthy society in Japan. *Lancet* 2011; published online Sept 1. DOI:10.1016/S0140-6736(11)60274-2.
27 Johansson SR, Mosk C. Exposure, resistance and life expectancy: disease and death during the economic development of Japan, 1900–1960. *Popul Stud (Camb)* 1987; **41**: 207–35.
28 Iwasaki T. The tuberculosis situation at the beginning of this century. *Bull Int Union Tuberc* 1974; **49**: 30–51.
29 Mori T. Recent trends in tuberculosis, Japan. *Emerg Infect Dis* 2000; **6**: 566–68.
30 Ikegami N, Yoo B-K, Hashimoto H, et al. Japanese universal health coverage: evolution, achievements, and challenges. *Lancet* 2011; published online Sept 1. DOI:10.1016/S0140-6736(11)60828-3.
31 Iso H. Changes in coronary heart disease risk among Japanese. *Circulation* 2008; **118**: 2725–29.
32 Robertson TL, Kato H, Gordon T, et al. Epidemiologic studies of coronary heart disease and stroke in Japanese men living in Japan, Hawaii and California. Coronary heart disease risk factors in Japan and Hawaii. *Am J Cardiol* 1977; **39**: 244–49.
33 Takeya Y, Popper J, Shimizu Y, Kato H, Rhoads G, Kagan A. Epidemiologic studies of coronary heart disease and stroke in Japanese men living in Japan, Hawaii and California: incidence of stroke in Japan and Hawaii. *Stroke* 1984; **15**: 15–23.
34 Yano K, Reed DM, McGee DL. Ten-year incidence of coronary heart disease in the Honolulu Heart Program. Relationship to biologic and lifestyle characteristics. *Am J Epidemiol* 1984; **119**: 653–66.
35 Ueshima H, Tatara K, Asakura S, Okamoto M. Declining trends in blood pressure level and the prevalence of hypertension, and changes in related factors in Japan, 1956–1980. *J Chronic Dis* 1987; **40**: 137–47.
36 Okayama A, Ueshima H, Marmot MG, Nakamura M, Kita Y, Yamakawa M. Changes in Total Serum Cholesterol and Other Risk Factors for Cardiovascular Disease in Japan, 1980–1989. *Int J Epidemiol* 1993; **22**: 1038–47.

37 Shibuya K. Comprehensive assessment of risk factor interventions and prevention of disease burden in Japan. In: Shibuya K, ed. Comprehensive assessment of the health system in Japan. Report to the Ministry of Health, Labour and Welfare for 2010 grant-in-aid for scientific research (H22-seisaku-shitei-033), 2011: 5–13. (in Japanese)

38 Ikeda N, Gakidou E, Hasegawa T, Murray CJ. Understanding the decline of mean systolic blood pressure in Japan: an analysis of pooled data from the National Nutrition Survey, 1986–2002. *Bull World Health Organ* 2008; **86**: 978–88.

39 Iso H, Shimamoto T, Naito Y, et al. Effects of a long-term hypertension control program on stroke incidence and prevalence in a rural community in northeastern Japan. *Stroke* 1998; **29**: 1510–18.

40 Ministry of Health, Labour and Welfare. 2007 comprehensive survey of living conditions of the people on health and welfare. Tokyo: Health and Welfare Statistics Association, 2009 (in Japanese).

41 Shimamoto T, Komachi Y, Inada H, et al. Trends for coronary heart disease and stroke and their risk factors in Japan. *Circulation* 1989; **79**: 503–15.

42 Marmot MG, Smith GD. Why are the Japanese living longer? *BMJ* 1989; **299**: 1547–51.

43 Hamano T, Fujisawa Y, Ishida Y, Subramanian SV, Kawachi I, Shiwaku K. Social capital and mental health in Japan: a multilevel analysis. *PLoS One* 2010; **5**: e13214.

44 Nakaya T, Dorling D. Geographical inequalities of mortality by income in two developed island countries: a cross-national comparison of Britain and Japan. *Soc Sci Med* 2005; **60**: 2865–75.

45 Ezzati M, Friedman AB, Kulkarni SC, Murray CJL. The reversal of fortunes: trends in county mortality and cross-county mortality disparities in the United States. *PLoS Med* 2008; **5**: e66.

46 Cabinet Office, Government of Japan. Public Opinion Survey Concerning People's Lifestyles 2010. Tokyo: Cabinet Office, Government of Japan, 2011 (in Japanese).

47 OECD. Rights and translation unit. Growing unequal?: income distribution and poverty in OECD countries. Paris: Organization for Economic Co-operation and Development, 2008.

48 Kagamimori S, Gaina A, Nasermoaddeli A. Socioeconomic status and health in the Japanese population. *Soc Sci Med* 2009; **68**: 2152–60.

49 Murakami Y, Miura K, Okamura T, Ueshima H. Population attributable numbers and fractions of deaths due to smoking: a pooled analysis of 180,000 Japanese. *Prev Med* 2011; **52**: 60–65.

50 Shinmura H, Wakabayashi C, Kunisawa N, et al. A nationwide survey for implementation of Health Japan 21 anti-smoking countermeasures in municipalities throughout Japan. *Nippon Koshu Eisei Zasshi* 2008; **55**: 170–76 (in Japanese).

51 WHO. WHO report on the global tobacco epidemic, 2009: implementing smoke-free environments. Geneva: World Health Organization, 2009.

52 Honjo K, Kawachi I. Effects of market liberalisation on smoking in Japan. *Tob Control* 2000; **9**: 193–200.

53 Ogihara T, Kikuchi K, Matsuoka H, et al. The Japanese Society of Hypertension Guidelines for the Management of Hypertension (JSH 2009). *Hypertens Res* 2009; **32**: 3–107.

54 Hashimoto H, Ikegami N, Shibuya K, et al. Cost containment and quality of care in Japan: is there a trade-off? *Lancet* 2011; published online Sept 1. DOI:10.1016/S0140-6736(11)60987-2.

55 Sakane N, Yoshida T, Umekawa T, Kondo M, Sakai Y, Takahashi T. Beta 3-adrenergic-receptor polymorphism: a genetic marker for visceral fat obesity and the insulin resistance syndrome. *Diabetologia* 1997; **40**: 200–04.

56 Yoshida T, Sakane N, Umekawa T, Sakai M, Takahashi T, Kondo M. Mutation of beta 3-adrenergic-receptor gene and response to treatment of obesity. *Lancet* 1995; **346**: 1433–34.

57 Ministry of Health, Labour and Welfare. Standard health examination and guidance program. Tokyo: Ministry of Health, Labour and Welfare, 2007 (in Japanese).

58 Parkin DM. The global health burden of infection-associated cancers in the year 2002. *Int J Cancer* 2006; **118**: 3030–44.

59 Tsukuma H, Tanaka H, Ajiki W, Oshima A. Liver cancer and its prevention. *Asian Pac J Cancer Prev* 2005; **6**: 244–50.

60 Kato M, Asaka M, Shimizu Y, et al. Relationship between *Helicobacter pylori* infection and the prevalence, site and histological type of gastric cancer. *Aliment Pharmacol Ther* 2004; **20** (suppl 1): 85–89.

61 Chen J, Choi Y, Mori K, Sawada Y, Sugano S. Those who are left behind: an estimate of the number of family members of suicide victims in Japan. *Soc Indic Res* 2009; **94**: 535–44.

62 Ministry of Health, Labour and Welfare. Vital statistics of Japan 1947–2009. Tokyo: Ministry of Health, Labour and Welfare, 1949–2011 (in Japanese).

63 Cabinet Office, Government of Japan. White paper on suicide 2010. Tokyo: Cabinet Office, Government of Japan, 2010 (in Japanese).

64 National Police Agency of Japan. Information on suicide in 2010. 2011. (in Japanese). http://www.npa.go.jp/safetylife/seianki/H22jisatsunogaiyou.pdf (accessed April 9, 2011).

65 Chang SS, Gunnell D, Sterne JAC, Lu TH, Cheng ATA. Was the economic crisis 1997–1998 responsible for rising suicide rates in East/Southeast Asia? A time-trend analysis for Japan, Hong Kong, South Korea, Taiwan, Singapore and Thailand. *Soc Sci Med* 2009; **68**: 1322–31.

66 Statistics Bureau, Ministry of Internal Affairs and Communications. Labor Force Survey. Tokyo: Ministry of Internal Affairs and Communications, 2010 (in Japanese).

67 Ministry of Health, Labour and Welfare. Act for securing the proper operation of worker dispatching undertakings and improved working conditions for dispatched workers. 2009 (in Japanese). http://law.e-gov.go.jp/htmldata/S60/S60HO088.html (accessed July 21, 2011).

68 Cabinet Office, Government of Japan. Basic act on suicide prevention. 2006 (in Japanese). http://law.e-gov.go.jp/announce/H18HO085.html (accessed July 21, 2011).

69 Christensen K, Doblhammer G, Rau R, Vaupel JW. Ageing populations: the challenges ahead. *Lancet* 2009; **374**: 1196–208.

70 Schoeni RF, Liang J, Bennett J, Sugisawa H, Fukaya T, Kobayashi E. Trends in old-age functioning and disability in Japan, 1993–2002. *Popul Stud* 2006; **60**: 39–53.

71 Gondo Y. Current research on centenarians in Japan. *Ronen Shakai Kagaku* 2007; **28**: 504–12 (in Japanese).

72 Suzuki M, Akisaka M, Ashitomi I, Higa K, Nozaki H. Chronological study concerning ADL among Okinawan centenarians. *Nippon Ronen Igakkai Zasshi* 1995; **32**: 416–23 (in Japanese).

73 Hashimoto S, Kawado M, Seko R, et al. Trends in disability-free life expectancy in Japan, 1995–2004. *J Epidemiol* 2010; **20**: 308–12.

74 Yong V, Saito Y. Trends in healthy life expectancy in Japan: 1986–2004. *Demogr Res* 2009; **20**: 467–94.

75 Olshansky SJ, Carnes BA, Desesquelles A. Demography. Prospects for human longevity. *Science* 2001; **291**: 1491–92.

76 Tamiya N, Noguchi H, Nishi A, et al. Population ageing and wellbeing: lessons from Japan's long-term care insurance policy. *Lancet* 2011; published online Sept 1. DOI:10.1016/S0140-6736(11)61176-8.

77 Oeppen J, Vaupel JW. Demography. Broken limits to life expectancy. *Science* 2002; **296**: 1029–31.

78 Riley JC. Rising life expectancy: a global history. Cambridge, UK: Cambridge University Press, 2001.

79 Rajaratnam JK, Marcus JR, Levin-Rector A, et al. Worldwide mortality in men and women aged 15–59 years from 1970 to 2010: a systematic analysis. *Lancet* 2010; **375**: 1704–20.

80 WHO. The world health report-health systems financing: the path to universal coverage. Geneva: World Health Organization, 2010.

81 WHO. The world health report 2002: reducing risks, promoting healthy life. Geneva: World Health Organization, 2002.

82 Kaga M, Takeshima T, Matsumoto T. Suicide and its prevention in Japan. *Leg Med (Tokyo)* 2009; **11**: S18–21.

3 Human Rights Watch. Bahrain: systematic attacks on medical providers. July 18, 2011. http://www.hrw.org/news/2011/07/18/bahrain-systematic-attacks-medical-providers (accessed Aug 31, 2011).

4 Cunningham F. Detained Bahraini medics: brutal crackdown against pro-democracy movement. April 22, 2011. http://www.globalresearch.ca/index.php?context=va&aid=24449 (accessed Aug 31, 2011).

5 Hayes RW. Bahrain doctors in prison for daring to speak out. June 25, 2011. http://news.bbc.co.uk/2/hi/programmes/from_our_own_correspondent/9521963.stm (accessed Aug 31, 2011).

6 O'Brien E. The Island of Dilmun. *J Ir Coll Physicians Surg* 1989; **18**: 6–7.

7 McCormack D. Medics held in Bahrain. May 10, 2011. http://www.irishtimes.com/newspaper/letters/2011/0506/1224296280504.html (accessed Aug 31, 2011).

8 O'Brien E. Treatment of medics in Bahrain. June 23, 2011. http://www.irishtimes.com/search/index.html?rm=listresults&filter=datedesc&keywords=o%27brien+bahrain&x=12&y=13 (accessed Aug 31, 2011).

9 O'Brien E. Hippocratic oath. *Irish Examiner*. Aug 31, 2011. http://www.irishexaminer.com/ireland/kfgbcwidgboj/rss2 (accessed Aug 31, 2011).

10 Devi S. Health professionals under threat in Bahrain. *Lancet* 2011; **377**: 1733–34.

The value of the National Health and Nutrition Survey in Japan

There is profound global interest in the Japanese diet as a possible partial explanation for the Japanese people's favourable health status and longevity. The diet differs substantially from that found in western countries and is often deemed a good guide for people who design healthy diets around the world. But is Japan's diet really contributing to better health for its people? Does reliance on a traditional Japanese diet correlate with improved health outcomes and longevity? Are there robust data to back up this common assumption?

The Japanese Government has done an annual nationwide nutrition survey, the National Health and Nutrition Survey, without fail since 1948.[1] Although slight changes have been made to the survey method over the years, it continues to use 1-day or 3-day semiweighed diet records. Since 2004, about 9000 people have participated in this survey every year.

Japan had a marked westernisation of diets between 1960 and 1975, characterised by an increase in average fat intake from 20 to 55 g per person daily.

During this time, age-standardised mortality rates from stroke and stomach cancer—the two main chronic diseases in Japan at the time—started to decrease.[2,3] Some reports show a very high salt consumption—up to 27 g per person daily—in the 1950s among farmers in some regions.[4] The national nutrition survey shows that the average intake had decreased to 14·5 g per person daily by 1972. Thus, westernisation of the Japanese diet helped decrease health risks during this time. Despite this occurrence, western populations still find Japanese dietary habits attractive mainly because of their lower fat intake. However, data show that from 1975 to 2009, average fat intake increased gradually from 21% to 26% of total energy intake while the age-standardised coronary heart disease mortality rate decreased during the same period.[5] But since no data exist for intake of saturated fat and other fatty acids, an accurate explanation of the effect of dietary change on change in mortality is impossible.

Japan, like many other countries, has had a striking increase in the number of people suspected to have diabetes since the mid to late 1990s. But this increase comes at a time when energy intake has steadily decreased from 1970 until the latest year for which data are available, 2009 (from 2210 to 1861 kcal per person daily). Carbohydrate intake (which includes alcohol) has decreased during the same period. Therefore, interpretation of the increase in the number of people with suspected diabetes as being the result of excess caloric or carbohydrate intake is not possible. Instead, low dietary fibre intake and high dietary glycaemic index could be causes of the increase in diabetes, in view of the preference of Japanese people for highly refined rice and bread as their main staples. But no data are available for these variables, and dietary fibre has only been included in the report since 2001.

In addition to these problems of potentially valuable data being excluded from the survey, the data from the survey are, for the most part, only accessible to researchers with governmental tasks. Moreover, accessible data are not the original raw data but the results of calculations, such as compilation of food items. Another problem is that the quality of the data is not assured because of a lack of comprehensive reports on the survey design and data quality control. The survey method is poorly described in the governmental reports, although some efforts have been made to improve the methods, and no statements exist about quality control. For example, standard portion sizes would usually be used when respondents do not weigh the food they eat, but the standardisation methods are not officially reported. As a result, for example, whether the observed decreasing trend in energy intake was

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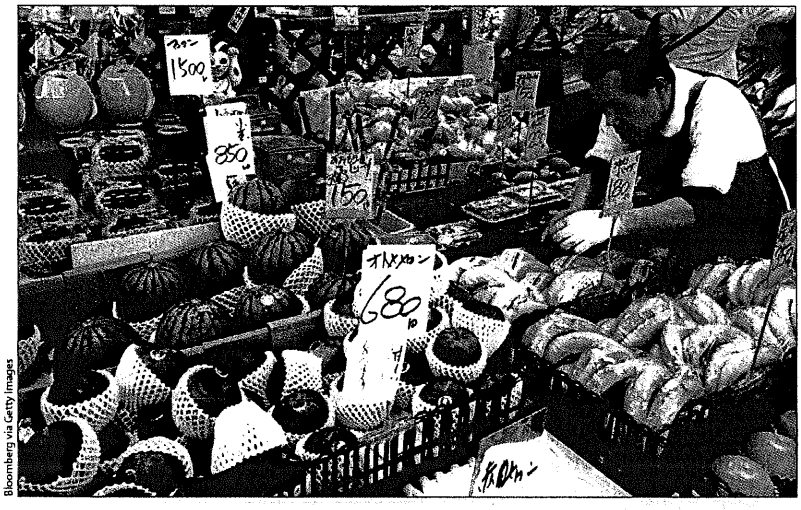

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a real event cannot be determined from the reports, because the decrease could be a biased value caused by a change in the method of data collection, a change in the behaviours of respondents, such as underreporting, or a change in the age distribution of respondents.

The survey has historically been household-based, but this method has been changed to a combination of weighing foods within households and approximating the proportion of foods shared by family members. The individual intake is estimated from this method. Even though the validity of estimated food intake heavily affects the results, it is poorly assessed without any consideration of the range of ability of respondents and of various types of foods shared.[6] More importantly, response rates, inclusion and exclusion criteria of respondents for analyses, body sizes of the analysed participants, or their health status are not reported. With regard to nutrients, neither intake of major fatty acids, nor of major types of carbohydrates (including sucrose and fructose) are reported. Even ethanol (alcohol) and water intakes are ignored. As a consequence, the survey has been of very limited use in building evidence in the discipline of nutrition and health. As long as the survey continues to be done and reported in the current manner, it will not fulfil its potential as a valuable resource for health. This would be a serious loss for Japan and, as a consequence, the world too.

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I declare that I have no conflicts of interest.

1 Katanoda K, Matsumura Y. National Nutrition Survey in Japan: its methodological transition and current findings. *J Nutr Sci Vitaminol (Tokyo)* 2002; **48:** 423–32.
2 Liu L, Ikeda K, Yamori Y. Changes in stroke mortality rates for 1950 to 1997: a great slowdown of decline trend in Japan. *Stroke* 2001; **32:** 1745–49.
3 Tanaka M, Ma E, Tanaka H, Ioka A, Nakahara T, Takahashi H. Trends of stomach cancer mortality in eastern Asia in 1950–2004: comparative study of Japan, Hong Kong and Singapore using age, period and cohort analysis. *Int J Cancer* 2011; published online March 21. DOI: 10.1002/ijc.26080.
4 Sasaki N. The relationship of salt intake to hypertension in the Japanese. *Geriatrics* 1964; **19:** 735–44.
5 Ueshima H. Explanation for the Japanese paradox: prevention of increase in coronary heart disease and reduction in stroke. *J Atheroscler Thromb* 2007; **14:** 278–86.
6 Iwaoka F, Yoshiike N, Date C, Shimada T, Tanaka H. A validation study on a method to estimate nutrient intake by family members through a household-based food-weighing survey. *J Nutr Sci Vitaminol (Tokyo)* 2001; **47:** 222–27.

Education for health professionals in Japan—time to change

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Of Japan's 80 medical schools, only three—Jichi Medical University, National Defense Medical College, and University of Occupational and Environmental Health—explicitly target physician training for rural practice, self-defence forces, and occupational medicine, respectively. The remaining 77 medical schools (42 national, eight prefectural or municipal, and 27 private) follow the traditional style of education to train health professionals. Under this system, tertiary academic centres, in which university hospitals are mostly at the top of the hierarchy, maintain power with little concern for development of secondary and primary health units in community-based programmes. Interprofessional[1] and transprofessional education[2] (which includes non-professional health workers), are still relatively new disciplines.

Japan is known for its good health outcomes, which might indicate support from a strong primary health-care system; however, this is not the case. Most of the country's primary-care physicians are not primary-care physicians according to the standard definition.[3] Furthermore, scarcity of gatekeepers—ie, primary-care physicians who are not well trained as generalists allow patients to self-refer to secondary-care or tertiary-care hospitals even when their ailments could be treated just as well, if not

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Interest in health screening as a predictor of long-term overall mortality: Multilevel analysis of a Japanese national cohort study

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ABSTRACT

Background. In Japan, screening programmes have been widely implemented as a public health practice. We investigated the effect of the area-level interest in health screening on mortality using data from a large cohort in Japan.

Methods. A baseline survey was conducted between 1988 and 1990 among 110,792 residents of 45 areas, aged 40–79 years. Area-level interest in health screening was defined as the proportion of people with high and moderate interest in health screening in an area. Multilevel Poisson regression was employed in a two-level structure of individuals nested within the areas. During 15 years of follow-up (1,035,617 person-years), 13,184 deaths were observed.

Results. The reduction in mortality rate was (a) 2% in both men ($p=0.009$) and women ($p=0.038$) for each percent increase in area-level interest in screening, and (b) 10% in men ($p=0.001$) and 9% in women ($p=0.001$) for individual attendance to screening in the year before follow-up. There was no interaction between area-level interest in screening, individual-level attendance at screening and overall mortality.

Conclusion. Area-level and individual interest for health screening appear to be independent predictor of 15-year mortality in this national Japanese study. The present findings may support public health practices to promote knowledge and participation in screening programmes.

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Introduction

In Japan, health screening programmes have been widely implemented as a public health practice, and regular opportunities to attend health screenings are available (Health and Welfare Statistics Association, 2008; Hisamichi, 1996; Statistics and Information Department, Minister's Secretariat, & Ministory of Health and Welfare, 2006; Yoshimura, 1996). For example, employers are legally required to provide employees with annual health examinations, and municipalities are mandated by various legislative acts to provide residents with general health screening, including cancer screening programmes. In general, residents have the opportunity to undergo annual health screening, which includes blood sample examination, chest radiography, electrocardiography, and stomach photofluorography.

Previous investigations of the effectiveness of health screening programmes are limited to benefits to actual participants. Intervention at the individual level, however, is not always affordable as a health promotion strategy, in terms of practicality, service delivery, and cost. In Japan, although municipal offices and regional health centres have promoted participation in health screening programmes and made considerable efforts to raise public awareness of them, participation rates in health screening still vary from approximately 20–90% between areas throughout Japan (Health and Welfare Statistics Association, 2008; Statistics and Information Department, Minister's Secretariat, & Ministry of Health and Welfare, 2006). However, no direct evidence that health promotion activities which encourage people to attend health screening improve health outcomes has yet been obtained. With regard to health promotion in the Japanese context, people's interest in health screening might be a proxy of a community's overall health consciousness, as well as of health promotion activities led by the municipal office and regional health centres. Recently, there is growing interest in the role of place or context on the health of the population. Contextual effect refers to the health effects of variables related to the broader political, cultural, or institutional context, such as infrastructural resources, social and public support programmes, which are imposed on individuals (Berkman & Kawachi, 2000; Kawachi, Subramanian, & Almeida-Filho, 2002; Kawachi & Berkman, 2003; Kawachi, Subramanian, & Kim, 2008). If a contextual effect of interest in health screening on health can be demonstrated, this effect would serve to strongly encourage health promotion activities aimed at increasing in public interest in health screening.

One method of clarifying the contextual effect is multilevel analysis, which uses data which is nested by area (Goldstein, 2003; Kreft & Leeuw, 1998; Twisk, 2006). The Japan Collaborative Cohort Study for the Evaluation of Cancer Risk (JACC Study) has developed a unique dataset which aggregated area-based cohorts from 45 areas throughout Japan (Ohno & Tamakoshi, 2001; Tamakoshi, 2007; Tamakoshi et al., 2005; Watanabe et al., 2005). The purpose of the present study was to examine the contextual effect of the area-level of interest in health screening on mortality using data from a large prospective cohort in Japan.

Methods

The JACC Study was sponsored by the Ministry of Education, Science, Sports and Culture of Japan and has been described in detail elsewhere (Ohno & Tamakoshi, 2001; Tamakoshi, 2007; Tamakoshi et al., 2005; Watanabe et al., 2005). Briefly, a baseline survey was conducted in 45 areas of Japan from 1988 until 1990 among 110,792 residents (46,465 men and 64,327 women) aged from 40 to 79 years at recruitment: 3 towns in the Hokkaido district, 5 towns in the Tohoku district, 5 towns in the Kanto district, 1 city, 3 towns and 2 villages in the Chubu district, 8 towns and 2 villages in the Kinki

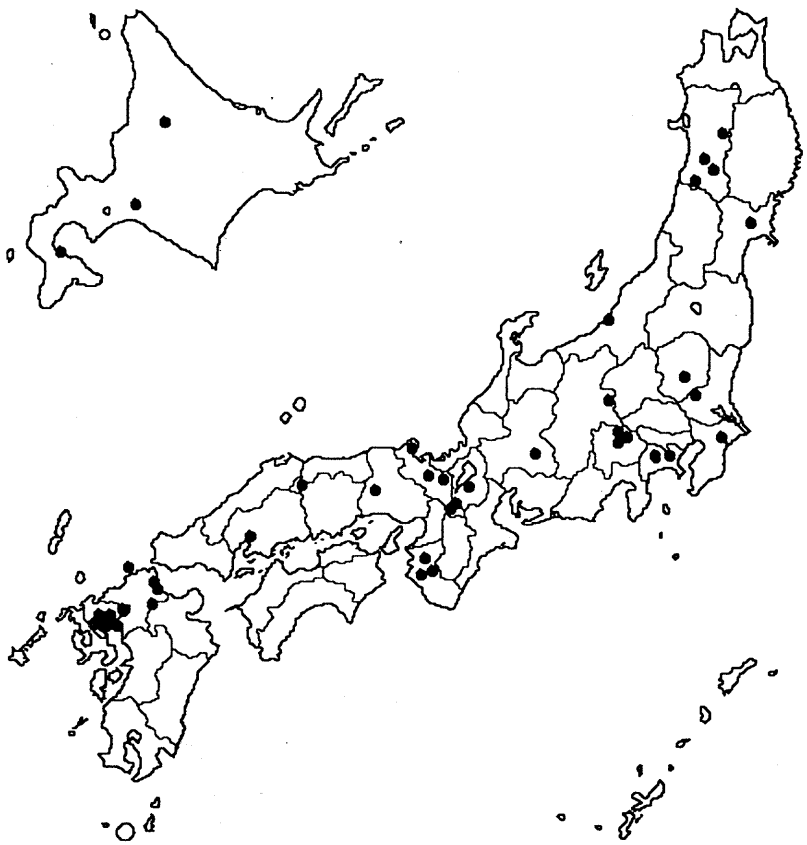

Fig. 1. Locations of the study areas in Japan.

district, 1 city and 1 town in the Chugoku district, and 4 cities, 9 towns and 1 village in the Kyushu district (Fig. 1). Response rates were obtainable from 17 areas, and showed an average response rate of 83% (Tamakoshi et al., 2005), but exact response rate in other areas were unobtainable.

The vital status of each participant was followed until the end of 2006 using data held at regional research centres, with permission from the Ministry of Public Management, Home Affairs, Post and Telecommunications of Japan to review the population registration entries. Informed consent procedures were approved by the Ethics Committee of Nagoya University, Japan.

Data retrieval for analysis

Of 45 areas, 16 areas used a slightly different questionnaire without questions on interest in health screening. Therefore, analysis was restricted to subjects from the 29 of 45 areas from which information about interest level of screening was available (30,061 men and 42,727 women). The number of subjects in each area varied from 239 to 21,986. During 15 years of follow-up (1,035,617 person-years), 13,184 deaths were observed. Mortality rates were 0.018 per year in men and 0.009 per year in women.

Exposure data

We used the participant's responses to the question, "What is your interest level in health screening? - high, moderate, low, or none". Area-level interest in health screening was calculated as the number of persons with high and moderate interest in health screening divided by the total number of subjects in that area.

The self-administered questionnaire also inquired about other baseline characteristics potentially related to mortality, including attendance in the past year in health screening; smoking status (never, former or current smoker); alcohol intake (non-habitual drinker, former habitual drinker; or habitual drinker); history of cerebrovascular disease, hypertension, myocardial infarction, cancer, or diabetes; attendance at any health screening programme in the past year; and hours of walking per day (<0.5, 0.5, 0.6–0.9, and ≥1.0 h per day).

Statistical analysis

Mortality rate ratios (MRR) per one percentage point increase in area-level interest in screening were estimated using a two-level structure of individuals nested within the 29 areas estimated by multilevel Poisson regression models (Stata Corporation, 2009a; Twisk, 2006). A two-level random-intercept and fixed slopes models were applied. These procedures take into account independence violation among individuals in the same cluster. One consequence of failing to recognize hierarchical structures, such as the ordinary least squares, is that standard errors of regression coefficients will be underestimated, leading to an overstatement of statistical significance. Standard errors for the coefficients of higher-level predictor variables will be the most affected by ignoring grouping (Goldstein, 2003; Kreft & Leeuw, 1998; Twisk, 2006). The Wald test was used to test the significance of regression coefficients. Although it is not theoretically correct to perform the Wald test on variance parameters, it provides an approximate indication for significance of random variance. The variance can be considered as significant when the variance is more than 2 times higher than its own standard error (Twisk, 2006).

To examine the contextual effects of community-level interest in health screening on individual health, adjustment of compositional individual factors is required. First, area-level interest in health screening was included in the model (univariate model). Multivariate models further added individual-level attendance in health screening in the past year, and other individual factors potentially related with health were added, including past medical history, smoking status, drinking behavior, and hours of walking per day. We also adjusted for type of recruitment (population-based versus health examinees and/or volunteers). Finally, a cross-level interaction term between attendance at screening at the individual level and interest in screening at the area level was added to analyse whether the observed relationship between area-level interest in screening and mortality is modified by actual participation of screening. All calculations were performed using STATA release 11 (Stata Corporation, 2009b).

Table 1
Basic characteristics of study subjects and areas, 1988–2003, Japan.

Variable	Men	Women
	$n=30061$	$n=42727$
No. of death	7617	5567
Person-year	421918	613699
Individual variables		
Mean age (SD)	57.5 (10.3)	57.9 (10.1)
Interest in health screening		
High	25.5	26.4
Moderate	55.2	57.8
Low	17.0	14.5
No	2.4	1.3
Attendance in past year in health screening (%)	65.2	62.8
Past medical history (%)		
Cerebrovascular disease	2.0	1.0
Hypertension	19.3	20.5
Myocardial infarction	2.8	2.8
Diabetes	6.3	3.9
Cancer	1.0	1.8
Smoking status (%)		
Current smoker	50.3	4.6
Former smoker	25.2	1.4
Never smoker	19.6	80.1
Missing	4.9	13.3
Alcohol intake (%)		
Habitual drinker	72.3	22.4
Former habitual drinker	6.0	1.7
Non-habitual drinker	17.3	67.9
Missing	4.4	8.0
Walking hours per day (%)		
≥1.0	47.2	48.5
0.6–0.9	19.9	20.7
0.5	18.6	17.4
<0.5	10.8	8.8
Missing	3.5	4.6
Area-level variable ($n=29$)		
Average of area-level interest for screening (%)		
Mean (SD)	81.8 (8.1)	
Range	66.7–95.0	

*Showing both men and women.

Results

Table 1 shows the basic characteristics of study subjects and areas. The average area-level interest in health screening varied between 66.7% and 95.0%.

Table 2 shows the results of the multilevel Poisson regression models for mortality in men. In the univariate model, area-level interest in health screening was significant when random variation among areas was taken into account (MRR = 0.98, 95% confidence interval: 0.97–1.00, $p=0.018$). After adjustment for compositional individual factors, area-level interest in health screening was still highly significant in multivariate model. In the multivariate models, MRR of area-level interest for screening was 0.98 (95% confidence interval: 0.97–1.00, $p=0.009$). Individual attendance at health screening in the past year also showed a significant decrease in MRR (MRR = 0.84, 95% CI: 0.79–0.89, $p<0.001$).

Table 3 shows the results of the multilevel Poisson regression models for mortality in women. The results were similar to those in men. In the multivariate models, MRR of area-level interest in screening was 0.98 (95% confidence interval: 0.97–1.00, $p=0.038$).

For both men and women, there was no cross-level interaction between area-level interest in screening, individual-level attendance at screening and overall mortality ($p=0.458$ in men and $p=0.22$ in women). Further, deviances in models with the cross-level interaction term did not significantly improve from those in models without it (−2loglikelihoods are 38430 for men and 33706 for women in models with the cross-level interaction term). Therefore, we regarded that

Table 2
Mortality rate ratios (MRR) in men, 1988–2003, Japan.

	Univariate				Multivariate			
	MRR	95% CI		p	MRR	95% CI		p
Area-level interest in screening (per 1 percentage point)	0.98	0.97	1.00	0.018	0.98	0.97	1.00	0.009
Age (per 1 year)	1.10	1.10	1.10	<0.001	1.10	1.10	1.10	<0.001
Interest in health screening								
High and moderate	0.91	0.85	0.96	0.001	0.84	0.79	0.89	<0.001
Low	Reference				Reference			
No	1.35	1.18	1.54	<0.001	1.11	0.97	1.27	0.138
Attendance in past year in health screening	0.90	0.86	0.95	<0.001	0.91	0.86	0.95	<0.001
Past history of stroke	2.79	2.49	3.12	<0.001	1.38	1.23	1.55	<0.001
Past history of hypertension	1.87	1.77	1.96	<0.001	1.29	1.22	1.36	<0.001
Past history of ischemic heart disease	2.15	1.93	2.40	<0.001	1.27	1.14	1.42	<0.001
Past history of diabetes	1.61	1.48	1.74	<0.001	1.26	1.16	1.37	<0.001
Past history of cancer	2.54	2.16	2.98	<0.001	1.52	1.29	1.79	<0.001
Smoking status								
Never smoker	Reference				Reference			
Current smoker	1.41	1.32	1.51	<0.001	1.64	1.53	1.76	<0.001
Former smoker	1.48	1.38	1.60	<0.001	1.20	1.11	1.29	<0.001
Missing	2.03	1.83	2.25	<0.001	1.38	1.24	1.54	<0.001
Alcohol intake								
Non-habitual drinker	Reference				Reference			
Habitual drinker	0.79	0.75	0.84	<0.001	0.97	0.91	1.03	0.355
Former habitual drinker	1.93	1.77	2.11	<0.001	1.45	1.33	1.58	<0.001
Missing	1.37	1.23	1.52	<0.001	1.15	1.04	1.28	0.008
Walking hours per day								
<0.5	Reference				Reference			
≥1.0	0.87	0.80	0.94	<0.001	0.79	0.73	0.85	<0.001
0.6–0.9	0.96	0.88	1.05	0.364	0.85	0.78	0.92	<0.001
0.5	0.97	0.89	1.05	0.459	0.90	0.82	0.98	0.014
Missing	1.31	1.16	1.49	<0.001	0.88	0.78	1.00	0.045
Type of recruit								
Health examinees or volunteers	Reference				Reference			
Population based	1.48	1.14	1.93	0.004	1.03	0.84	1.26	0.772
Regional random variance (SE)	0.11*	(0.45)			0.026	(0.052)		
-2Loglikelihood	45097*				38343			

*Regional random variance and −2loglikelihood of the univariate model were derived from the univariate model of are-level interest in screening.

the model without the interaction term is the final model. There was no random area variance both in men and women.

Discussion

The present study examined the presence of contextual effects of area-level interest in health screening on mortality in Japan. The reduction in mortality rate was (a) 2% in both men and women for each percent increase in area-level interest in screening, and (b) 10% in men and 9% in women for individual attendance to screening in the year before follow-up.

Although the effect size of area-level interest in health screening was small, namely a 2% decrease in MRR per one percentage point increase in area-level interest, it should be emphasized that this was an area-level factor. Every resident of an area with a high area-level interest in screening obtains this benefit, whether he or she attends health screening or not. A 10 percentage point increase in area-level interest, which is 0.98 to the 10th power, is theoretically equivalent to everyone attending health screening, since MRRs of individual attendance in health screening were 0.91 for men and 0.89 for women. Achieving a 10 percentage point increase in area-level interest in health screening seems a far more promising approach than to assume that everybody attends health screening. The present findings add encouraging evidence in support of the public health strategy practiced in Japan, although the observed effects may be limited to Japan.

The hypothetical term "area-level interest in screening" represents not just the average of aggregated individual characteristics, nor is it a proxy of individual characteristics. Rather, it may be a proxy of characteristics of an area that cannot be captured by individual-level measurements. We postulated two main meanings of area-level interest in health screening. First, it may be a proxy of the level of health promotion activities in the area. In Japan, regional health care centres and municipalities have made substantial efforts to raise public awareness of health screening and participation through media, direct mail, home visiting by public health nurses, and announcements at residents' meetings. In addition, the participation rate of health screening is often referred to when the performance of the health promotion activities of a municipal office is evaluated (Fujimura, Morita, & Nakamoto, 2003; Health and Welfare Statistics Association, 2008; Statistics and Information Department, Minister's Secretariat, & Ministry of Health and Welfare, 2006). Second, it may be a proxy of the health consciousness of an area. The health consciousness of a community does have a different effect from that of an individual because that of the community can affect others whereas that of the individual affects mainly him- or herself.

The mechanisms by which area-level of interest in health screening affects health are not clear, but if it is in fact a proxy of the level of health promotion activities and health consciousness of the community, several hypothetical explanations might be considered. First, an increase in interest in health screening in an area can be considered to have a positive effect on health by increasing access to health-related information and health services. People who live in an area with a high health consciousness are more likely to obtain health information and services on both formal and informal occasions, notwithstanding whether the person is interested in health screening or not. Second, areas with high health consciousness may provide a healthier environment, such as in restaurants, workplaces, and public spaces. If so, this would benefit all residents, including those who are not health conscious. Third, people who live in an area with higher health consciousness are perhaps more likely to develop healthier behaviors and place value on health from a long life-term perspective.

Table 3
Mortality rate ratios (MRR) in women, 1988–2003, Japan.

	Univariate				Multivariate			
	MRR	95% CI		p	MRR	95% CI		p
Area-level interest in screening (per 1 percentage point)	0.97	0.95	0.99	0.001	0.98	0.97	1.00	0.038
Age (per 1 year)	1.12	1.11	1.12	<0.001	1.11	1.11	1.12	<0.001
Interest in health screening								
High and moderate	0.79	0.74	0.85	<0.001	0.87	0.81	0.94	<0.001
Low	Reference				Reference			
No	1.85	1.57	2.17	<0.001	1.10	0.93	1.30	0.251
Attendance in past year in health screening	0.90	0.85	0.96	0.001	0.89	0.84	0.95	<0.001
Past history of stroke	3.81	3.26	4.45	<0.001	1.82	1.56	2.14	<0.001
Past history of hypertension	1.95	1.84	2.06	<0.001	1.21	1.14	1.28	<0.001
Past history of ischemic heart disease	2.18	1.91	2.50	<0.001	1.25	1.10	1.44	0.001
Past history of diabetes	2.49	2.26	2.75	<0.001	1.59	1.44	1.76	<0.001
Past history of cancer	2.16	1.85	2.51	<0.001	1.64	1.41	1.91	<0.001
Smoking status								
Never smoker	Reference				Reference			
Current smoker	1.36	1.21	1.52	<0.001	1.48	1.32	1.67	<0.001
Former smoker	1.80	1.49	2.17	<0.001	1.29	1.07	1.56	0.009
Missing	1.27	1.17	1.38	<0.001	0.99	0.90	1.09	0.841
Alcohol intake								
Non-habitual drinker	Reference				Reference			
Habitual drinker	0.69	0.65	0.75	<0.001	0.92	0.85	0.99	0.025
Former habitual drinker	1.51	1.28	1.79	<0.001	1.26	1.06	1.50	0.008
Missing	1.30	1.19	1.42	<0.001	1.16	1.05	1.28	0.005
Walking hours per day								
<0.5	Reference				Reference			
≥1.0	0.70	0.64	0.76	<0.001	0.71	0.65	0.78	<0.001
0.6–0.9	0.81	0.73	0.89	<0.001	0.78	0.71	0.87	<0.001
0.5	0.85	0.77	0.94	0.002	0.79	0.72	0.88	<0.001
Missing	0.87	0.76	1.00	0.057	0.69	0.60	0.79	<0.001
Type of recruit								
Health examinees or volunteers	Reference				Reference			
Population based	1.86	1.40	2.48	<0.001	1.07	0.86	1.33	0.517
Regional random variance (SE)	0.14*	(0.50)			0.030	(0.062)		
−2Loglikelihood	39638*				33706			

*Regional random variance and −2loglikelihood of the univariate model were derived from the univariate model of are-level interest in screening.

Several limitations of the present study warrant mention. First, although we adjusted for selected individual factors that might potentially be associated with mortality, residual confounding would be present at both the individual and area levels. Socioeconomic characteristics of an area and of individuals are associated with participation in screening and health (Fukuda, Nakamura, & Takano, 2004, 2005a, b), but these relationships were difficult to interpret in the present study. A previous multilevel analysis using a nationally representative sample of Japanese reported that living in a metropolitan area and per capita income were associated with a reduced likelihood of cancer screening, while having a higher individual income were associated with a higher likelihood of cancer screening (Fukuda, Nakamura, & Takano, 2005b). The impact of residual confounding of socioeconomic factors at both the area and individual level on the present results is uncertain. Second, we did not ascertain the type of screening programmes, with regard to either individual attendance or area-level interest in screening. Although the effects of screening might differ between types at the individual level, it may be reasonable to measure area-level interest in screening programmes in general terms rather than with regard to each type of screening, such as stomach cancer screening, breast cancer screening and others. Third, although the model included attendance at health screening, this was baseline data. Thus, we assume that the model adjusted for the individual's attitude and health consciousness rather than for the opportunity to detect diseases.

In conclusion, this study showed that area-level and individual interest for health screening appear to be independent predictor of 15-year mortality in this national Japanese study. This effect benefited all people who lived in these areas, whether they participated in health screening or not. The present findings may support public health practices to promote knowledge of and participation in health screening programmes.

Conflict of interest statement
The authors declare that there are no conflicts of interest.

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References

Berkman, L.F., Kawachi, I.O., 2000. Social epidemiology. Oxford University Press, Oxford.
Fujimura, T., Morita, H., Nakamoto, M., 2003. Evaluation of health services for the aged by using "an evaluation manual for health services". Bull. Sch. Nurs. Yamaguchi Prefectural Univ. 7, 33–42.
Fukuda, Y., Nakamura, K., Takano, T., 2004. Wide range of socioeconomic factors associated with mortality among cities in Japan. Health Promot. Int. 19 (2), 177–187.
Fukuda, Y., Nakamura, K., Takano, T., 2005a. Accumulation of health risk behaviours is associated with lower socioeconomic status and women's urban residence: a multilevel analysis in Japan. BMC Public Health 5, 53.
Fukuda, Y., Nakamura, K., Takano, T., 2005b. Reduced likelihood of cancer screening among women in urban areas and with low socio-economic status: a multilevel analysis in Japan. Public Health 119 (10), 875–884.
Goldstein, H., 2003. Multilevel statistical models. Arnold, London.
Health and Welfare Statistics Association, 2008. National trends in health. J. Health Welfare Statistics 55 (9), 476–477.
Hisamichi, S., 1996. Community screening programs of cancer and cardiovascular diseases in Japan. J. Epidemiol. 6 (3 Suppl), S159–163.
Kawachi, I.O., Berkman, L.F., 2003. Neighborhoods and health. Oxford University Press, Oxford.
Kawachi, I., Subramanian, S.V., Almeida-Filho, N., 2002. A glossary for health inequalities. J. Epidemiol. Community Health 56 (9), 647–652.
Kawachi, I.O., Subramanian, S.V., Kim, D., 2008. Social capital and health. Springer, London. New York.