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Inequalities in Noncommunicable Disease Mortality in the Ten Largest Japanese Cities

Megumi Kano, Miyuki Hotta, and Amit Prasad

ABSTRACT *The burden of noncommunicable diseases and social inequalities in health among urban populations is becoming a common problem around the world. This phenomenon is further compounded by population aging. Japan faces the task of maintaining its high level of population health while dealing with these challenges. This study focused on the ten largest cities in Japan and, using publicly available administrative data, analyzed standardized mortality ratios to examine inequalities in relative mortality levels due to major noncommunicable disease at both city and subcity levels. On average, the ten major cities had excess mortality due to cancer and lower mortality due to heart disease and cerebrovascular disease compared to the country as a whole. Substantial inequalities in relative mortality were observed both between and within cities, especially for heart disease and cerebrovascular disease among men. Inequalities in relative mortality levels within cities appear to be increasing over time even while relative mortality levels are decreasing overall. The widely observed health inequalities signal the need for actions to ensure health equity while addressing the burden of noncommunicable diseases. Increasingly, more countries will have to deal with these challenges of inequity, urbanization, aging, and noncommunicable diseases. Local health governance informed by locally specific data on health determinants and outcomes is essential for developing contextualized interventions to improve health and health equity in major urban areas.*

KEYWORDS *Japan, Urban health, Noncommunicable disease, Mortality, Health equity*

BACKGROUND

Japan has remarkably improved population health and strengthened its health system over the last 50 years.[1] It has provided universal health insurance since 1961 while keeping health expenditures relatively low, even as the population aged rapidly. Japan has led the world in life expectancy for many years with good health maintained through the later years of life; both men and women in Japan have the world's longest healthy life expectancy at age 60 (17.5 and 21.7 years, respectively, in 2002).[2]

Japan is not immune, however, to the many global health challenges of today including population aging, urbanization, health inequity, and the heavy burden of noncommunicable diseases. The country's population has aged considerably in recent years with a diminishing proportion of children and working-age population.

Kano and Prasad are with the Centre for Health Development, World Health Organization, I.H.D. Centre Building 9F, 1-5-1 Wakinohama-Kaigandori, Chuo-ku, Kobe, 651-0073, Japan; Hotta is with the Graduate School of Medicine, Faculty of Medicine, Osaka University, 2-2 Yamadaoka, Suita, Osaka, 565-0871, Japan.

Correspondence: Megumi Kano, Centre for Health Development, World Health Organization, I.H.D. Centre Building 9F, 1-5-1 Wakinohama-Kaigandori, Chuo-ku, Kobe, 651-0073, Japan. (E-mail: Kanom@who.int)

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In 2005, those aged 65 and over accounted for 20.1 % of the total population resulting from a 16.5 % growth in this subgroup in only 5 years.[3] Japan is at the forefront of a global trend of population aging and associated changes in health needs.[4]

Contrary to popular images of youthful cities, the aging trend inevitably affects the urban areas where nearly 70 % of all Japanese people reside today.[5] Japan has some of the world's largest and most population-dense cities where both wealth and poverty concentrate. Concerns about health in urban areas and the health inequities arising from the broader determinants of health have been well documented globally.[6–9] In Japan, there are signs that income inequality is growing despite its reputation as an equitable society.[10] This increase in socioeconomic inequalities may be contributing to growing health inequalities in the country since 1995[11] with some indication that this effect may be pronounced in larger cities.[12] Moreover, there is evidence that the gains in life expectancy in Japan since 1995 were mostly in years of poor self-rated health, suggesting an expansion of morbidity within a lifetime.[13]

These factors—aging, urbanization, and socioeconomic determinants of health—are among the contributing factors to the growing global burden of noncommunicable diseases as recognized in the WHO resolution on Strengthening Noncommunicable Disease Policies to Promote Active Ageing (WHA65.3)[14] adopted during the 65th World Health Assembly as well as in the Political Declaration of the 2011 UN High-Level Meeting of the General Assembly on the Prevention and Control of Noncommunicable Diseases.[15] In Japan, noncommunicable diseases account for 77 % of years of life lost.[16]

While there has been much global attention to Japan's achievements in health development, comparatively less attention has been paid, especially in the English literature, to contemporary health problems the country faces. The issues of inequity, urbanization, aging, and noncommunicable diseases have become important not only for Japan but increasingly so for many developing countries following improvements in life expectancy and the epidemiological transition taking place around the world in the context of globalization. The objective of this study is to describe the mortality levels due to noncommunicable disease in Japan's major cities relative to those at the national level, and how they vary between cities and also within cities. It will demonstrate the feasibility of using routine administrative data to uncover health inequalities which contributes to a nuanced understanding of health in cities, as national indicators often gloss over these differentials.

MATERIALS AND METHODS

Data Source

Given the focus of this study on comparing mortality levels across varying geographic units with different demographic compositions, this study analyzed 5-year cumulative standardized mortality ratios (SMRs) at the city and subcity level in Japan. Data were obtained from vital statistics reported by the Health, Labour and Welfare Ministry of Japan available through the portal site of official statistics, e-Stat (http://www.e-stat.go.jp), maintained by the National Statistics Center. Relevant data were available for 1998–2002 and for 2003–2007. Data for only the ten largest cities were used in this study to control for the wide variations in population size, density, and urbanicity among Japanese towns and cities.

Table 1 shows some population characteristics of the study cities. The population of these cities combined represents 20 % of Japan's total population. Based on the 2005 census, most of the cities had a younger population compared to the national average (proportion of elderly, 65 years and above, was 20.1 %, nationally). However, all of the cities experienced aging between 2000 and 2005 with the proportion of elderly increasing from 15.0 to 17.7 % on average.

Mortality Measure

The relative risk of dying was estimated using the SMR. The SMR for each study area had been calculated using the standard method of dividing the observed deaths in the study population by the expected deaths calculated from indirect adjustment and multiplying it by 100. The formula used to estimate the 5-year cumulative SMR for each area was reported as:

$$\mathbf{SMR} = \frac{o}{e} \times 100 = \frac{m}{\left(\sum M_a p_a\right) \times 5} \times 100 \qquad (1)$$

where o and m represent the total deaths observed in the study area over the 5-year reference period, e is the total deaths expected in the study area over the reference period, M_a represents the 5-year cumulative age-specific mortality rate observed for the national population (i.e., standard population), and p_a represents the age-specific population in the study area at the midpoint of the reference period. A Bayesian statistical method had been used to smooth the SMRs due to the variability of the SMR in wards with small populations.[17]

SMRs were reported separately for men and women by cause of death. This study focused on deaths caused by cancer, heart disease, and cerebrovascular disease, respectively. These three are the leading causes of mortality in Japan, accounting for about 60 % of all deaths.[3] The burden of these diseases generally increases with population aging in the context of the epidemiological transition from communicable to noncommunicable diseases. In Japan, in 2011, the average age-specific (5-year bandwidth) mortality rates for cancer, heart disease, and cerebrovascular disease were

TABLE 1 Population characteristics of the ten largest cities in Japan, 2005

City	Population density (per sq km)	Population	Population 65 years and above (% of total population)	Average annual income per capita in 2007 (million yen)
Tokyo	13,663.2	8,489,653	18.5	4.61
Osaka	11,835.6	2,628,811	20.1	3.31
Kawasaki	9,299.3	1,327,011	14.6	4.08
Yokohama	8,184.3	3,579,628	16.9	4.16
Nagoya	6,785.3	2,215,062	18.4	3.88
Saitama	5,408.6	1,176,314	15.9	3.99
Fukuoka	4,114.1	1,401,279	15.2	3.48
Kobe	2,763.3	1,525,393	20.0	3.73
Kyoto	1,781.4	1,474,811	19.9	3.47
Sapporo	1,677.7	1,880,863	17.3	3.17

Source: Ministry of Internal Affairs and Communications, Japan. 2005 National census and 2007 Municipal tax survey.

8.2, 3.9, and 2.1 per 100,000, respectively, for age groups under 45, and 945.9, 1,030.8, and 606.9 per 100,000, respectively, for age groups between 45 and 99.

Analysis

The analysis involved three levels of cross-sectional comparison: (a) city to country comparison, (b) city to city comparison, and (c) intracity comparison. In addition, the changes between 1998–2002 and 2003–2007 in average level of relative mortality and level of intracity relative mortality differentials were analyzed.

The cross-sectional analysis utilized the most recently available data (i.e., 2003–2007). First, mortality in the ten cities was compared to the national standard by examining the city level, sex-, and cause-specific SMRs. SMRs equal to 100 imply that the observed mortality rate for the city is equal to the age-adjusted mortality rate at the national level; numbers higher than 100 imply an excess mortality; and those below 100 imply below-standard mortality. Deviations from the national reference indicated by the SMR can be interpreted as being due to differences in sex- and age-specific mortality rates between the city and the country as a whole. Secondly, the relative sizes of the SMRs were compared across cities focusing on the observed range of SMRs by sex and cause of mortality. The observed differences in SMRs are not due to differences in age or gender composition of the areas being compared since the SMRs are age-standardized and reported separately by sex. Thirdly, the relative sizes of the SMRs were compared across wards within cities focusing on the gap between the highest and lowest ward-level SMR. While dispersion can be assessed using other measures, such as standard deviations or interquartile ranges, this study focused on the absolute difference between minimal and maximal SMR in line with WHO's focus on the highest attainable level of health. Finally, the trends in average city-level SMR and intracity SMR gap were analyzed by comparing data from the two reference periods by sex and cause of mortality.

RESULTS

Comparing City-Level Mortality to the National Standard

Table 2 shows SMRs by city for deaths due to all causes, cancer, heart disease, and cerebrovascular disease, respectively, disaggregated by sex for the period 2003–2007. Total mortality among the cities was, on average, about equal to the national standard for both men and women. There was excess mortality due to cancer compared to the national standard for both men (mean SMR = 104.0) and women (mean SMR = 107.2). Mortality due to heart disease was somewhat lower than the national standard (mean SMR = 97.3 for men and 97.0 for women), and that due to cerebrovascular disease was even lower (mean SMR = 91.5 for both sexes). For reference, the cause-specific, 5-year cumulative, unadjusted mortality rates per 100,000 population during the same period at the national level were: cancer—316.9 for men, 199.4 for women; heart disease—131.2 for men, 134.8 for women; and cerebrovascular disease—100.6 for men, 104.8 for women.

Comparing between Cities

A wide range was observed in SMRs across the study cities (Table 2). The widest range in SMRs between cities was observed for male heart disease mortality which ranged from a low of 73.7 in Fukuoka to a high of 110.9 in Nagoya with a mean of 97.3 across the ten cities. In terms of the unadjusted mortality rates, it was 74.4/100,000 in Fukuoka, 131.3/100,000 in Nagoya, with a mean of 112.9/100,000

TABLE 2 Five-year cumulative SMR by city, cause of death, and sex, 2003–2007

	All causes		Cancer		Heart disease		Cerebrovascular disease	
City	Male	Female	Male	Female	Male	Female	Male	Female
Osaka	118.7	111.7	121.1	118.6	105.4	103.4	99.3	91.1
Nagoya	102.8	105.4	103.8	106.8	110.9	111.0	95.5	97.3
Kobe	99.7	101.4	108.1	110.9	88.5	91.7	79.5	82.0
Kawasaki	99.1	96.9	103.5	103.2	99.2	92.2	102.3	100.2
Kyoto	98.5	99.0	102.4	107.0	104.3	102.1	92.6	89.7
Tokyo	98.0	101.8	101.3	108.5	99.6	101.2	94.7	98.3
Sapporo	96.8	93.4	104.1	107.2	92.8	93.5	90.4	91.1
Fukuoka	96.6	95.8	103.6	108.1	73.7	77.7	74.7	73.4
Saitama	92.4	99.7	94.8	98.7	108.6	105.3	95.8	100.7
Yokohama	92.4	95.9	97.2	102.8	89.5	91.6	89.9	91.2
Mean	99.5	100.1	104.0	107.2	97.3	97.0	91.5	91.5
Minimum	92.4	93.4	94.8	98.7	73.7	77.7	74.7	73.4
Maximum	118.7	111.7	121.1	118.6	110.9	111.0	102.3	100.7
Range	26.3	18.3	26.3	19.9	37.2	33.3	27.6	27.3

Source: Ministry of Health, Labour and Welfare of Japan, National Statistics Center. 2003–2007 Vital statistics by local public health center and municipality. 2009 update.

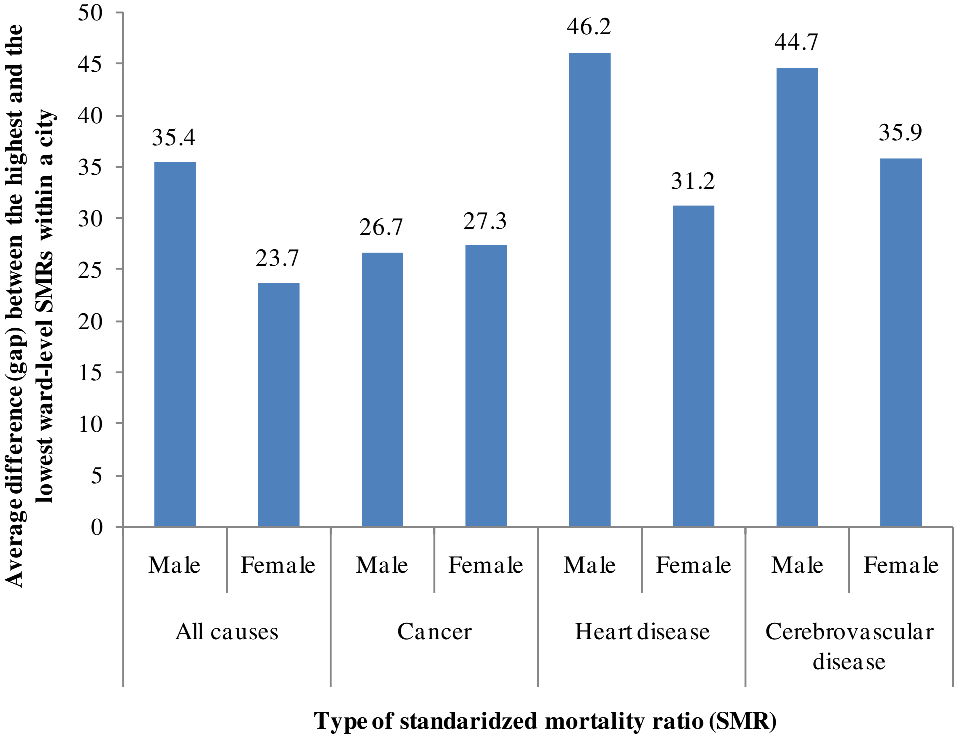
across the cities. On the other hand, the narrowest range was observed for female cancer mortality which ranged from 98.7 in Saitama to 118.6 in Osaka with a mean of 107.2. The corresponding unadjusted mortality rates were 156.1/100,000 in Saitama, 228.7/100,000 in Osaka, and a mean of 188.7/100,000 across the cities.

Comparing within Cities

Intracity health inequalities were examined by analyzing the absolute difference, or gap, between the minimum and maximum ward-level SMR within each city. SMRs varied widely within cities, notwithstanding the statistical measures taken to stabilize these small-area estimates. The largest within-city SMR gap was a 101.3-point gap in male heart disease mortality in Osaka where the ward-level SMR ranged from 79.5 to 180.8. Conversely, the smallest SMR gap, by 13.3 points, was observed in Fukuoka for female heart disease mortality, which ranged from 74.2 to 87.5.

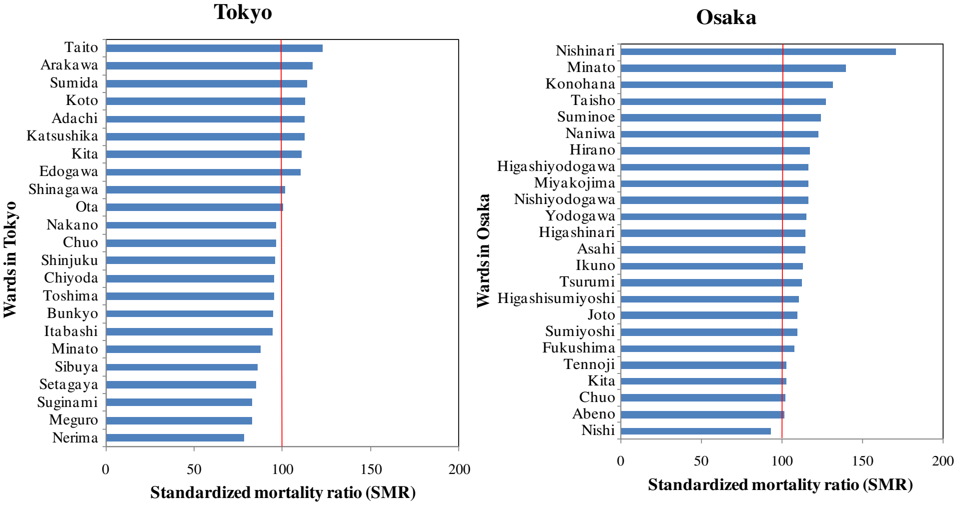
These data on intracity inequalities in relative mortality are summarized in Fig. 1. On average, the intracity SMR gaps were greater among men than among women with the exception of cancer mortality. Furthermore, the intracity mortality inequalities tended to be larger for heart disease and cerebrovascular disease than they were for cancer. The largest SMR gaps were observed for heart disease and cerebrovascular disease mortality among men (Fig. 1). These overall patterns did not change when the intracity disparities were measured in terms of interquartile ranges of the SMRs instead of the gap between the lowest and highest SMRs.

Disaggregated mortality profiles of each city revealed considerable differences within cities. For example, Fig. 2 shows male all-cause mortality profiles of Tokyo and Osaka, the two main urban centers of Japan, for 2003–2007. Over half of the wards in Tokyo had SMRs below 100 while all but one of the wards in Osaka had SMRs above 100. The extent of intracity inequality was also greater in Osaka. Tokyo had a 45-point gap between the lowest ward-level SMR (78.0) and the highest ward-level SMR (122.9) while Osaka had a larger 78-point gap (range was 93.0–171.0).



Source: Ministry of Health, Labour and Welfare of Japan, National Statistics Center. 2003-2007 Vital statistics by local public health center and municipality. 2009 update.

FIGURE 1. Average intracity SMR gap, by cause of death and sex, 2003–2007.



Source: Ministry of Health, Labour and Welfare of Japan, National Statistics Center. 2003-2007 Vital statistics by local public health center and municipality. 2009 update.

FIGURE 2. Comparison of ward-level, male all-cause mortality between Tokyo and Osaka, Japan, 2003–2007.

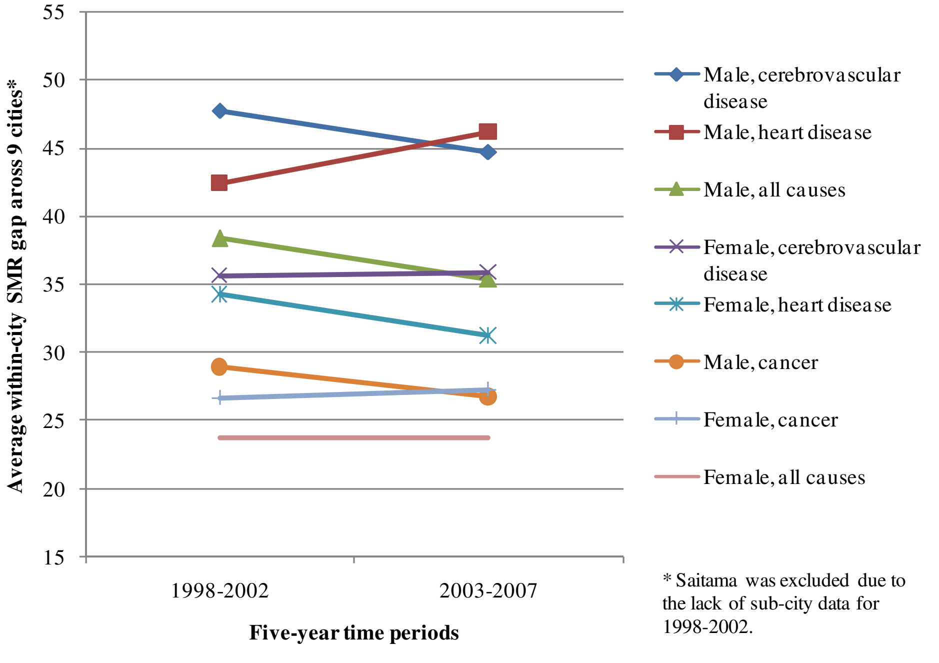
Trend in Mortality Levels and Intracity Inequalities

On average, relative mortality levels among the ten largest cities of Japan decreased from 1998–2002 to 2003–2007 for all causes studied and for both sexes. The greatest reduction was seen in female cerebrovascular disease mortality for which the mean SMR declined from 93.5 to 91.5 over the two periods. However, signs of increase, or deterioration, were observed for some measures of intracity inequalities such as for cancer mortality among women and especially for heart disease mortality among men (Fig. 3).

DISCUSSION

This study examined age- and sex-adjusted, 5-year cumulative standardized mortality rates for cancer, heart disease, and cerebrovascular disease in the ten largest cities in Japan. The main objective was to reveal mortality levels in major urban areas relative to those at the national level and, more importantly, to expose the extent of inequalities in relative mortality between and within the cities to show that even in a country as Japan with a high level of socioeconomic and health development, health disparities remain a challenge.

On average, the cities studied had excess mortality due to cancer and lower mortality due to heart disease and cerebrovascular disease compared to the respective national mortality levels. The existing literature provides some insights into the explanation of these outcomes. The finding on excess cancer mortality is



Source: Ministry of Health, Labour and Welfare of Japan, National Statistics Center. 1998-2002 Vital statistics by local public health center and municipality, 2004 update. & 2003-2007 Vital statistics by local public health center and municipality, 2009 update.

FIGURE 3. Trend in average intracity SMR gap by sex and cause of mortality among the ten largest cities in Japan, 1998–2002 to 2003–2007.

consistent with prior research on rural–urban comparisons which found higher age-, race-, and sex-adjusted cancer incidence and mortality rates in urban populations for most anatomic sites.[18] Yet the epidemiological explanation of this phenomenon is still insufficient. Some studies have found excess cancer mortality associated with higher doses of exposure to carcinogens in the urban environment, such as air pollution[8,19,20] and estrogenic compounds.[21,22] The major behavioral risk factors for cancer are known to be tobacco, alcohol, and diet and physical activity,[23] but there is still a lack of substantial epidemiological evidence that exposure to these risks or the causal effects of these risks are aggravated in urban areas.

The lower mortality due to heart disease and cerebrovascular disease in the cities is contrary to some previous studies conducted outside of Japan which showed cardiovascular disease risk to increase with industrialization and urbanization which, in turn, were associated with unhealthy lifestyles.[24,25] In Japan, a paradox has been observed in which incidence and mortality from coronary heart disease and stroke have remained low despite absolute increases in body mass index and total cholesterol levels since the 1970s. This has been explained as a result of concurrent declines in hypertension and smoking and the historically low serum cholesterol level among middle-aged and elderly people in Japan.[26] Within this context, the substantially lower cerebrovascular disease mortality in urban Japan, also found in other studies,[27] may be due to a combination of protective factors. Urban Japanese diets typically have lower sodium, higher calcium, and higher animal protein than rural Japanese diets,[28] and cities tend to have better access to emergency health services that can help prevent fatal outcomes from stroke.[29]

Similar factors may help explain the lower mortality due to heart disease in urban Japan. However, a recent study revealed that the decline in mortality due to coronary heart disease and stroke since the 1970s was notably smaller in men aged 30–49 in Tokyo and Osaka, and has plateaued.[28] In fact, the incidence of coronary heart disease has increased among middle-aged men in the suburbs of Osaka. These trends may explain why heart disease mortality was only slightly lower in the studied cities compared to the country as a whole, signaling a potential source of future problems.

Among the cities studied, there were considerable variations in relative mortality level that cannot be explained by differences in age or gender composition. The cities varied the greatest in terms of male cerebrovascular disease mortality and the least in terms of female cancer mortality. Considering that the cities, on average, experience excess cancer mortality and low cerebrovascular disease mortality, the results suggest that female cancer mortality is a common problem across the cities while there are pockets of high-risk areas for male cerebrovascular disease mortality.

Substantial relative mortality inequalities were also observed at the subcity level. In Tokyo, one ward in the city center had male all-cause mortality over 20 % in excess of the national level while in another ward, only about 10 km away, it was 20 % less than the national standard. These intracity inequalities tended to be greater among men than among women. In Japan, men appear to be more sensitive to health inequalities due to socioeconomic status.[12,30] A study examining small-area variations in cancer mortality in relation to socioeconomic deprivation in Spanish cities also found greater inequalities among men.[31] Furthermore, in the present study, intracity inequalities were greater for relative mortality due to cerebrovascular disease and heart disease than that due to cancer. These are likely to be influenced by small-area disparities in the risk factors for these diseases as well as in the availability, accessibility, and utilization of emergency healthcare services.[29]

Interventions to improve health equity, thus, require attention to aspects of gender, disease types, and the broader determinants of health.[32] In order to develop policy and program interventions that can effectively address the issues uncovered by the kind of data presented in this study, there needs to be more evidence on the causes of these outcomes which can contribute to theoretical development about causes of health disparities. Moreover, local governments need explanations specific to their city about their risk profiles that lead to certain mortality outcomes and differentials. For example, two cities with comparable relative mortality levels may have differential age- and gender-related risk profiles. In this respect, there is a need to strengthen local data systems so that health outcomes data can be easily linked to data on broader determinants of health and be disaggregated by relevant sociodemographic and geographic groups. This study found that this was not the case with the centralized statistical system at the national level.

The comparison of data from 1998–2002 to 2003–2007 revealed signs of increasing relative mortality inequalities within cities while average relative mortality rates declined. This occurred in the context of growing income inequality in the country.[10] Japan is improving its major mortality indicators, but actions are needed to address health inequalities, particularly those that are systematic, unfair, and modifiable, i.e., health inequities.[33] There is a moral imperative and a practical value in improving health equity. Large health inequalities can be a major detriment to the efficiency and effectiveness of public health and social services. It is especially relevant to local governments in Japan which bear responsibility for providing social, health, and long-term care services for a rapidly aging population with a dwindling resource base. Future research should aim to generate further evidence and develop appropriate metrics to understand the causes of urban health inequity and the effectiveness of policies and interventions to tackle them.[9,34–36]

Limitations of this study include that only two data points representing 10 years of data were available for the trend analysis and that the difference in SMR between the most and least advantaged areas was used to assess intracity health inequality. This restricted the study's ability to capture long-term trends and the gradient in SMR within cities. It will be important to identify long-term trends and the pattern of health outcomes besides the disparity between two extremes, especially when evaluating the impact of interventions.[36] More importantly, cities need specific explanations about why these variations exist in order to develop subgroup differentiated, contextualized policy and program interventions. This requires in-depth analysis of each city relating mortality outcomes to data on sociodemographic characteristics and the broader determinants of health. While this kind of explanatory analysis specific to each city was beyond the scope of this study, it is certainly a required step in order for local authorities to take effective action to address the uncovered health differentials.

CONCLUSIONS

In an increasingly aging and urbanizing world, the need to address noncommunicable diseases and health equity through multisectoral action on the wider determinants of health is a clear global health priority. The recent WHO resolution on Strengthening Noncommunicable Disease Policies to Promote Active Ageing[14] urges member states to develop, implement, monitor and evaluate policies, programs and multisectoral action on noncommunicable disease prevention and health promotion in order to achieve the highest standard of health and wellbeing for older persons. Furthermore, the UN Political Declaration on the Prevention and Control of Noncommunicable Diseases[15] provides a renewed opportunity to adopt the most cost-effective interventions for noncommunicable diseases such as promoting awareness of the dangers of unhealthy diets and physical inactivity; pushing industries to reduce salt and sugar in their food products; enforcing bans on tobacco advertising, promotion and sponsorship; and raising taxes on tobacco and alcohol.[37] These population-based measures have the potential to reduce disease burden and improve health equity, but need to be responsive to local priorities.

Subnational governments, especially those with jurisdiction over major metropolitan areas, are often able to incorporate these types of measures into their local planning and legislation and are capable of being more sensitive to local needs compared to the national government provided they have appropriate context-specific evidence on priority health determinants and their outcomes. These actions at the local government level are crucial to ensure healthy urban development in the face of rapid social, economic, and demographic changes.[38]

As an example, Japan's legal enforcement of tobacco control at the national level is lagging behind other developed countries. As a signatory to the Framework Convention on Tobacco Control, Japan is ostensibly committed to legally enforcing appropriate measures for tobacco control. However, the issue is compounded by the fact that the government is a major shareholder of Japan Tobacco Inc. (JT), which controls over half of the domestic cigarette market. JT-related issues and laws also fall under the jurisdiction of the Finance Ministry and not the Health, Labour and Welfare Ministry. Local governments, however, are beginning to take legislative action to go beyond what the national law currently requires for preventing secondhand smoke exposure.[39]

Political will and commitment from all levels of government and all sectors to allow a shared policy framework for taking action on major health threats is essential. Yet, when it comes to responding sensitively to the shifting needs of dynamic urban populations, subnational governments' leadership and initiative on assessing needs, determining capacities, and developing relevant local interventions are paramount.

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