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Objective: The primary objective of this study is to describe cancer mortality rates and trends among Japanese elderly aged 65–84 years for the period 1970–2007.

Materials and methods: Age-standardized mortality rates were calculated by the direct method using age-specific mortality rates at 5-year age intervals and weights based on the age distribution of the standard world population. The joinpoint regression model was used to describe changes in trends.

Results: For all cancers combined, the mortality rate at age 65–84 years during 2000–2007 was 1145.13 (per 100 000 population) for men and 461.93 (per 100 000) for women. Mortality rates have declined in the past 10 years in both sexes. These favorable trends were driven largely by decreases in mortality for three leading cancers in the elderly men [lung, stomach and colorectal cancer (CRC)] and for two of the three most common cancers in the elderly women (stomach and CRC), combined with a leveling off of death rate from lung cancer in women.

Conclusion: The population-based data in the current study underscore the importance of cancer research and prevention for the older segment in Japan to reduce the additional cancer burden among the growing number of elderly persons.

Key words: cancer, elderly, epidemiology, mortality, time trends

Introduction

Cancer is a major public health problem that affects disproportionately more elderly than younger individuals. In Japan, >60% of new cancer cases occur among those ≥65 years. Data from regional cancer registries showed that individuals in this age group have a risk 13 times greater than that of individuals aged <65 years (an age-adjusted cancer incidence rate of 1474.56 per 100 000 compared with 117.24 per 100 000 in 2002) [1]. Cancer mortality is also higher in the elderly, with >75% of deaths from cancer occurring in those aged ≥65 years. Result from vital statistics (2007) indicated that the overall age-adjusted mortality rate for the age group ≥65 years (802.36 per 100 000) is 20 times greater than the rate for those aged <65 years (40.25 per 100 000) in Japan [2]. Older individuals therefore bear the brunt of cancer burden.

Furthermore, life expectancy has increased to 80 years for men and 86 years for women in Japan. The proportion of individuals ≥65 years has increased from 7% to >21% during the last four decades. Increasing life expectancy and aging population will inevitably result in a growing number of elderly patients with cancer in Japan. This increasing cancer burden will challenge both healthcare institutions and healthcare professionals. Research focused on the intersection of aging and cancer is necessary not only in biological areas but also in epidemiological regions.

On the other hand, cancer behavior may change with the age of patients: some cancers (acute myeloid leukemia, lymphoma and ovarian cancer) may become more aggressive and others (breast and lung cancer) more indolent. Thus, the pattern of cancer rates and trends is largely different for the elderly compared with young and middle-aged patients. Elderly patients with cancer should therefore be assessed differently than younger patients.

To monitor recent rates and trends in cancer mortality among the elderly population, we analyzed the occurrence of cancer deaths among individuals aged 65–84 years at the population level over the period of 1970–2007, using official death certificates, which record 100% of deaths in Japan.

Materials and methods

The number of deaths by cause, stratified for sex and 5-year age group for cancer for the period 1970–2007, was derived from vital statistics compiled by the Ministry of Health, Labor and Welfare of Japan. Population figures were obtained from census data and inter-census estimates, by calendar year, age and gender. Population censuses of Japan are conducted every 5 years by the Statistics Bureau, Ministry of Internal Affairs and Communications.
For comparison, we also calculated the cancer mortality rate in other developed countries, including Canada (2000–2004), the United States (2000–2005) and England and Wales (2000–2006). Deaths at age 65–69, 70–74, 75–79 and 80–84 years were derived from the World Health Organization (WHO) mortality database. Estimates of the residential population, based on official censuses, were obtained from the same WHO database.

During 1970–2007, three different revisions of the International Classification of Disease (ICD) were used. In Japan, this included ICD-8 from 1970 to 1978, ICD-9 from 1979 to 1994 and ICD-10 from 1995 onward. Since the differences were minor in various revisions, we recorded cancer sites, including all cancers combined (ICD-10: C00–C97), lip, oral cavity and pharynx (ICD10: C00–C14), larynx (ICD-10: C32), esophagus (ICD-10: C15), stomach (ICD-10: C16), colorectal (ICD-10:C18–C21), pancreas (ICD-10: C25), lung (ICD-10:C33–C34), prostate (ICD-10: C61), breast (ICD10: C50), uterus (ICD10:C53–C55), kidney (ICD10: C64–C66, C68), leukemia (ICD10: C91–C95) and lymphomas (ICD-10: C81–C85). Age-standardized mortality rates at age 65–84 years were calculated by the direct method using age-specific mortality rates for 5-year age intervals and weights based on the age distribution of the standard world population.

Joinpoint software 3.3.1 from the Surveillance Research Program of the US National Cancer Institute was used for trend analysis [3, 4]. We allowed up to four joinpoints for each model. Mortality rates and their standard errors were calculated using SAS 9.0. Time trends were assessed by site and sex. Mortality trends for Canada (1970–2004), the United States (1970–2005) and England and Wales (1970–2006) were included for comparison.

### results

Table 1 gives age-adjusted mortality rates for the elderly (aged 65–84 years) for all malignant tumors and the main types of cancer in Japan and other developed countries. Age-adjusted mortality rates in Japan for six successive 5-year calendar periods, i.e. 1970–1974, 1975–1979, 1980–1984, 1985–1989, 1990–1994 and 1995–1999, and also for the 8-year period of 2000–2007 were calculated. For all cancers combined, the mortality rate at age 65–84 years during 2000–2007 was 1145.13 (per 100 000 population) for men and 461.93 (per 100 000) for women. Trends of age-standardized mortality from cancer are shown in Figures 1 and 2 and Table 2. Mortality for all cancers combined has declined for both sexes in recent decade. The average annual percent change in the last 10 years was $-1.7\% (P < 0.05)$ for men and $-1.4\% (P < 0.05)$ for women.

### Table 1. Age-adjusted mortality rate (per 100 000) by sex and diagnostic group at age 65–84 years in Japan and other developed countries

<table>
<thead>
<tr>
<th>Tumor</th>
<th>Japan</th>
<th>Canada</th>
<th>United States</th>
<th>England and Wales</th>
</tr>
</thead>
<tbody>
<tr>
<td>Males</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All malignant tumors</td>
<td>1111.30</td>
<td>1130.84</td>
<td>1172.77</td>
<td>1184.71</td>
</tr>
<tr>
<td>Larynx</td>
<td>14.53</td>
<td>12.42</td>
<td>10.14</td>
<td>8.58</td>
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<tr>
<td>Esophagus</td>
<td>68.57</td>
<td>61.81</td>
<td>57.45</td>
<td>54.00</td>
</tr>
<tr>
<td>Stomach</td>
<td>486.87</td>
<td>423.34</td>
<td>364.64</td>
<td>304.50</td>
</tr>
<tr>
<td>Colorectal</td>
<td>76.61</td>
<td>88.42</td>
<td>98.75</td>
<td>106.33</td>
</tr>
<tr>
<td>Pancreas</td>
<td>41.43</td>
<td>49.07</td>
<td>60.26</td>
<td>69.95</td>
</tr>
<tr>
<td>Lung</td>
<td>157.71</td>
<td>201.06</td>
<td>244.63</td>
<td>273.37</td>
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<tr>
<td>Prostate</td>
<td>22.53</td>
<td>26.61</td>
<td>30.88</td>
<td>36.31</td>
</tr>
<tr>
<td>Kidney</td>
<td>7.47</td>
<td>10.06</td>
<td>13.90</td>
<td>18.93</td>
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<tr>
<td>Leukemia</td>
<td>9.75</td>
<td>13.17</td>
<td>17.02</td>
<td>19.96</td>
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<tr>
<td>Lymphoma</td>
<td>15.70</td>
<td>19.38</td>
<td>22.09</td>
<td>25.09</td>
</tr>
<tr>
<td>Females</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All malignant tumors</td>
<td>596.21</td>
<td>582.75</td>
<td>567.62</td>
<td>539.20</td>
</tr>
<tr>
<td>Lip, oral cavity and pharynx</td>
<td>4.02</td>
<td>4.37</td>
<td>4.29</td>
<td>3.91</td>
</tr>
</tbody>
</table>
malignant neoplasm of lip, oral cavity and pharynx
Death rates from lip, oral cavity and pharynx cancers among the elderly population were 21.92 (per 100 000) for men and 5.40 (per 100 000) for women during 2000–2007. For men, mortality rate peaked in 1996, then leveled off in the after years. Rate was stable for women before 1997, and a significant decline was observed in recent decade (with 1.2% per year).

malignant neoplasm of larynx
Mortality rates from larynx cancer remained low for both sexes during 2000–2007 (5.83 per 100 000 for men and 0.28 per 100 000 for women). The death rates decreased by 3.8% per year for men and 8.9% per year for women during the last 10 years.

malignant neoplasm of esophagus
Death rates from esophagus cancer among the elderly population were 55.84 (per 100 000) for men and 6.07 (per 100 000) for women during 2000–2007. A significant decline was observed in both sexes (by 0.6% per year in men and 1.7% per year in women) in the past decade.

Figure 1. Trends on age-adjusted mortality for cancer among the elderly aged 65–84 years, males, Japan, 1970–2007.
Figure 2. Trends on age-adjusted mortality for cancer among the elderly aged 65–84 years, females, Japan, 1970–2007.
Males

- Female stomach cancer mortality rate was 124.50 (per 100 000) for men and 64.06 (per 100 000) for women.

stomach cancer

Decline trends were observed in 1970–1974 and 1974–1993 for men, and trends have continued to decrease in recent years (by 3.2% per year), after a short leveling-off period from 1993 through 1996. For women, mortality rate has declined since 1970 and further declined in 1980s (with 4.9% per year) and 1990–2007 (with 3.8% per year). Compared with other developed countries, mortality rate from stomach cancer was high in Japan (193.99 per 100 000 for men and 59.87 per 100 000 for women during 2000–2007).

colorectal cancer

Mortality rates increased during the 1970s–1990s and peaked in 1998 in men and 1995 in women. Decline trend was observed in recent 10 years with 1.3% per year for both sexes. From 2000 through 2007, death rates from colorectal cancer (CRC) among the elderly population were 124.50 (per 100 000) for men and 64.06 (per 100 000) for women.

pancreas cancer

Mortality rates peaked at the end of 1980s for men and declined thereafter with 0.2% per year. For women, an increase was observed with 0.4% per year in recent decade.

lung cancer

Rates peaked in 1996 in men and 1999 in women and have leveled off more recently in women after a short period decline. Decline trend was observed for men with 1.7% per year during 1996–2007. Lung cancer is the leading cause of cancer among the elderly men and the second leading cause of cancer among the elderly women in Japan. During 2000–2007, the mortality
rate among the elderly population was 272.41 (per 100 000) in men and 62.45 (per 100 000) in women.

kidney cancer
For women, mortality rates from kidney cancer have continued to increase since 1970. For men, death rate peaked at 1997 and leveled off thereafter. From 1997 through 2007, the annual percent change was 0.4% (P > 0.05) per year in men and 1.3% per year (P < 0.05) in women.

genitourinary organ cancer and breast cancer
Mortality from prostate cancer peaked in 1998 and has declined thereafter (with 0.7% per year). For women’s reproductive cancer, a continuous decline was observed in uterus throughout the whole period. Although the mortality rate from breast cancer is low in Japanese elderly women compared with Western countries, the rate has increased since 1970 by 1.6% per year and has further increased in the past two decades (by 2.4% per year).

malignant neoplasm of lymphoid, hematopoietic and related tissue
For leukemia, the sharpest increase occurred in the 1970s–1980s, and in the past 10 years, rates have remained stable for both sexes. For lymphoma, the mortality rates peaked at 1999 in men and 2000 in women and declined thereafter.

discussion
This study has presented detailed analysis on the trends of cancer mortality in the elderly in Japan. A total of 8 277 541 people died from cancer during 1970–2007, and 4 662 340 deaths from cancer occurred among people aged 65–84 years. Although rates decreased in this age group, the number of cancer deaths by year increased 3.5 times (from 58 473 in 1970 to 201 804 in 2007), with an increasing aging population in Japan. The joinpoint regression method was used in our research to evaluate the trend in cancer deaths. This method has allowed a detailed and accurate description of the pattern of cancer mortality since it identifies the calendar years in which statistically significant changes in trends occurred. According to trend analysis, mortality rates have decreased in the past 10 years in both sexes. These decreases were driven largely by declines in death rates for three leading cancers in the elderly men (lung, stomach and CRC) and for two of the three most common cancers in the elderly women (stomach and CRC), combined with a leveling off of mortality from lung cancer in women. Here, we explore potential explanations of the recent mortality trends in five common cancers.

Lung cancer is the leading cause of cancer mortality in Japan in men and the second in women aged 65–84 years. Smoking has been consistently established as the main etiologic factor for lung cancer and accounts for ~85% to 90% of cases. Changes in the prevalence of smoking may explain the decline in the lung cancer rate in the past decade. Some previous age–birth cohort studies have reported a trough in lung cancer mortality and incidence trend in Japanese men born during the 1930s and explained this characteristic by the prevalence of smoking among this population [5, 6]. Men born during the 1930s had less opportunity to begin smoking in their adolescence because of the limited cigarette supply during the period from the end of World War II to the beginning of Japan’s post-war economic growth, and this is reflected in the ~10% reduction in the rate of excessive smoking in the birth cohort around the 1930s compared with the adjacent birth cohort [7]. This low-risk birth cohort surpassed 65 years old in the past decade and may have contributed in part to the favorable trend in lung cancer mortality among the elderly. Low smoking prevalence rate among 1930s generation has also been identified among Japanese women. Similarly, the leveling off in lung cancer mortality among the elderly women observed in the past decade is partly due to this cohort effect. On the other hand, as the prevalence of women smoking among younger generations is still increasing in Japan, an upward trend in the lung cancer mortality rate among the elderly women may be expected in coming years.

Mortality from stomach cancer among the Japanese elderly is still threefold higher than in Western countries. A dramatic reduction has occurred over the past century in Japan. Changes in environmental risk factors, such as reduced salt use and increased fruit and fresh vegetable consumption associated with improved food storage with the advent of refrigerators are considered to have played important roles in the reduction of gastric cancer incidence and mortality [8]. The contribution of mass screening to the decline in the incidence and mortality rates has been mentioned in other epidemiological researches on stomach cancer in Japan [8, 9]. A mass screening program with photofluorography for stomach cancer has been conducted in Japan since 1960. Over 4 million Japanese received the screening in 2006, covering ~12.1% of the target population according to a report from the Ministry of Health, Labor and Welfare of Japan [10]. In addition to the organized screening program, there have been an increasing number of the opportunistic tests carried out in various settings. Improved diagnosis and treatment of disease may also have played an important role toward these favorable trends.

The trend in mortality from CRC has been decreasing in the past decade. The favorable trend in recent years might reflect a decline in risk factor exposure, such as the wider availability of vegetables and stabilization of meat consumption. According to the report of the National Nutrition Survey conducted by the Ministry Of Health, Labor and Welfare, the average consumption of vegetables in Japanese increased from 230 to 290 (g/day) during 1990–2006 [11]. Improved survival of CRC due to progress in surgical techniques and more widely used adjuvant chemotherapy has contributed in part to the decline of mortality rates. Research has indicated that CRC screening may also have had a favorable impact on mortality by detecting the cancer at an earlier stage [12, 13]. Furthermore, the risk of CRC may be reduced by removing premalignant lesions endoscopically or surgically, as almost all CRCs arise from premalignant polyps. However, the contribution of CRC screening to the recent reduction in mortality from CRC among the elderly seems limited in Japan, as participation rate in CRC screening of eligible population is still relatively low.

Although mortality rates from breast cancer among elderly women in Japan remain relatively low compared with the
United States, Canada and England and Wales, rates have been increasing over the past three decades. Increased mortality among Japanese elderly women implies a real increase in incidence in this population because the survival rate has been increased with improved treatment of breast cancer. Changes in menstrual and reproductive factors such as age at menarche, age at first birth and number of births were speculated to be related to the increasing trends of breast cancer incidence rates in Japan [14]. Other factors, including the changing patterns of childbirth, breast-feeding and adaption to a Western lifestyle also contributed to the observed increase in mortality and incidence rates [15, 16]. Increased detection of early-stage cancer can result in improved breast cancer survival and reduction in mortality rates [17, 18]. Disparity in screening may explain some differences in mortality trends between Japan and Western countries. In the United States, mammography screening became widespread during the 1980s, and the coverage rate among women aged 20 years was estimated to be >70% in 2000; however, mammography screening was not implemented in Japan until 2000 [19]. A report from the Ministry of Health, Labor and Welfare of Japan indicated that 1 631 811 women underwent screening for breast cancer (mammography screening with clinical breast examination) in 2006, accounting for only ~12.9% of the target population [10].

For prostate cancer, the rise in mortality among Japanese elderly up to the 1990s stopped in 1997 and declined thereafter. One explanation for this favorable trend could be the improved treatments. New surgical techniques for localized disease, antiandrogenic therapies and new irradiation protocols could have played an important role in survival improvements [20]. Prostate-specific antigen (PAS) screening seems to contribute little explanation for changes in the incidence and mortality that occurred in the past decade because PAS screening in Japan is still unusually common even as a public health policy, while the effectiveness of PAS screening for mortality remains under debate [21, 22].

Previously research on mortality trends among the elderly was republished in the early 2000s, and data were presented up to 1998 for Japan [23]. In the present report, we have updated trends in cancer mortality rates to 2007. Trends in cancer mortality in Japan are generally comparable to other developed countries, but different patterns among countries have been found in this study; e.g. the rate of breast cancer fell in other developed countries in recent years compared with a significant increase among Japanese women. The reason for these trend disparities in the cancer mortality rate is complicated. Differences in the distribution and changes of risk factors among different countries might explain differences in mortality patterns. As mentioned above, the lag time in the establishment and enforcement of an effective cancer intervention policy in Japan might also contribute to unfavorable trends in some cancer mortality.

There are some limitations of this study. The use of ICD-10, a new classification for coding causes of death since 1995, may impact cancer death rates. The new revision and resulting changes in classification and rules for selecting the underlying cause of death have implications for the analysis of mortality trends by cause of death. Discontinuity in trends will occur for some specific sites [24, 25]. Moreover, the validity of the underlying causes of death may be questioned owing to the presence of more than one chronic disease contributing to death, especially at older ages. The completeness and reliability of recorded data among elderly populations may affect trends in the cancer mortality rate.

Despite these limitations, this report provides an updated cancer mortality trends among the elderly Japanese population using population-based data, which covered 100% deaths from cancer. The trend in cancer incidence is not only due to changes in the underlying rate of disease but also influenced by advancements in survival and early diagnosis. National mortality rates are less influenced by such modifications and provide less biased information in long-term trends. Analysis of trends in national mortality rates over several decades may provide additional insight into the burden and impact of cancer.

conclusions

This report presents updated figures and trends in cancer mortality among the elderly aged 65–84 years in Japan and other developed countries. Despite decrease in cancer death rates among the elderly in recent decade, the number of cancer deaths by year increased rapidly during past four decades with an increasing aging population. The population-based data in the current study underscore the importance of cancer research and prevention for the older segment in Japan to reduce the additional cancer burden among the growing number of elderly persons.

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LY designed and carried out analyses and drafted the paper; DQ prepared data and created the figures and JF and NS edited the paper and commented on the interpretation of the results. All authors have read and approved the final draft of the paper.

references