Cancer Prevalence in Aichi, Japan for 2012: Estimates Based on Incidence and Survival Data from Population-Based Cancer Registries

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Abstract  

Background: Cancer is the leading cause of death among both men and women in Japan. Monitoring cancer prevalence is important because prevalence data play a critical role in the development and implementation of health policy. We estimated cancer prevalence in 2012 based on cancer incidence and 5-year survival rate in Aichi Prefecture using data from a population-based cancer registry, the Aichi Cancer Registry, which covers 7.4 million people.  

Methods: The annual number of incident cases between 2008 and 2012 was used. Survival data of patients diagnosed in 2006–2008 and followed up until the end of 2012 were selected for survival analysis. Cancer prevalence was estimated from incidence and year-specific survival probabilities. Cancer prevalence was stratified by sex, cancer site (25 major cancers), and age group at diagnosis.  

Results: The estimated prevalence for all cancers in 2012 was 68,013 cases among men, 52,490 cases among women, with 120,503 cases for both sexes. Colorectal cancer was the most incident cancer with 6,654 cases, accounting for 16.0% of overall incident cases, followed by stomach cancer with 5,749 cases (13.8%) and lung cancer with 5,593 cases (13.4%). Prostate cancer was the most prevalent among men, accounting for 21.5%, followed by colorectal and stomach cancers. Breast cancer was the most prevalent among women, accounting for 28.6%, followed by colorectal, stomach, and uterine cancers.  

Conclusion: This study provides cancer prevalence data that could serve as useful essential information for local governments in cancer management, to carry out more practical and reasonable countermeasures for cancer.  

Keywords: Population-based cancer registry- cancer prevalence- incidence- survival

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Introduction  

Cancer has been the leading cause of death among both men and women in Japan since the 1980s, with about 865,000 new cases in 2012 and approximately 370,000 cancer-related deaths in 2014 (Hori et al., 2015) (Ministry of Health Labour and Welfare). Early diagnosis by cancer screening and the efficacy of cancer treatment have improved the prognosis of cancer patients. Because the number of cancer patients will almost certainly continue to increase, understanding the health care needs of these patients and the demands on health care is of increasing importance.  

The cancer incidence rate, as well as the cancer survival rate, estimated from population-based cancer registry data, is crucial in the development and evaluation of cancer policies on a population basis. Monitoring cancer prevalence is also important because prevalence data play a critical role in the development and implementation of health policy through identification of health problems and decision-making regarding the distribution of medical resources for cancer diagnosis, treatment, and palliative care (Parkin et al., 2001).  

Until the Cancer Registry Promotion Act was enacted in 2016 (Tanaka and Matsuda, 2015), local government had been responsible for the organization of population-based cancer registries in Japan. Population-based cancer registration was the only way to obtain information on cancer incidence, mortality, and survival on a population basis. Aichi Prefecture is located approximately in the center of Japan, facing the Pacific Ocean. The prefecture spans an area of 5,146 square kilometers and has a population of 7.41 million (Statistics Bureau Ministry of Internal Affairs and Communications). The prefectural capital is Nagoya, and the prefecture includes 53 municipalities, as well as the 16 wards of Nagoya City itself. The Aichi Cancer Registry was established in 1962 as a population-based cancer registry, to provide an accurate picture of cancer in the prefecture. Because the data quality was relatively high, Aichi Cancer Registry

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data has been used since 2006 to estimate cancer incidence rates for the Monitoring of Cancer Incidence in Japan (MCJ) project (Hori et al., 2015) and the Survival 2006–2008 Report (Center for Cancer Control and Information Services, 2016). Registry data are also used for Cancer Incidence in Five Continents, Vols. IX (Curado. M. P., 2007) and X (Forman D, 2014) and the CONCORD study (Allemani et al., 2015).

Assessment of cancer prevalence in each prefecture has not been conducted in Japan, and there are only a small number of existing reports (Tabata et al., 2008). Geographic variation in cancer incidence and mortality in Japan has been reported (Cancer Registry and Statistics. Cancer Information Service), which implies that geographic variation might exist in the cancer prevalence as well. Understanding of the cancer prevalence is critical to local governments, for cancer management and to develop practical countermeasures for cancer (Grande E et al., 2007). Therefore, we estimated the cancer prevalence in 2012 based on the cancer incidence and survival rate in Aichi Prefecture, using data from the Aichi Cancer Registry. Our results can provide a comprehensive overview on cancer prevalence, which may be beneficial for cancer prevention and control in Aichi Prefecture.

Materials and Methods

Data source

**Incidence and survival**

Using data from the Aichi Cancer Registry, we estimated the annual number of incident cases between 2008 and 2012, by age group and sex, for all cancers and 25 primary sites. Age groups were categorized as follows: 0–4, 5–9, 10–14, 15–19, 20–24, 25–29, 30–34, 35–39, 40–44, 45–49, 50–54, 55–59, 60–64, 65–69, 70–74, 75–79, 80–84, and over 85 years old. For Aichi Prefecture, incidence, deaths, histologically verified (HV) cases, cases first notified via death certificate (DCN), and death certificate only (DCO) were available by sex and age group for total cancers and 25 primary sites. The International Classification of Disease, 10th Revision (ICD-10) (World Health Organization, 2010) was used to classify tumors of the following sites: oral cavity and pharynx (ICD-10 code C00-C14), esophagus (C15), stomach (C16), colorectal (colon and rectum) (C18-C20), colon (C18), rectum (C19-C20), liver (C22), gallbladder and biliary tract (C23-C24), pancreas (C25), larynx (C32), lung (C33-C34), skin (C43-C44), breast (C50), bladder (C67), kidney (C64-C66, C68), brain and nervous system (C70-C72), thyroid (C73), lymphoma (C81-C85, C96), multiple myeloma (C90, C96) and leukemia (C91-C95) for both sexes; prostate (C61) for men, and uterus (C53-C55) and ovary (C56) for women.

Survival data of patients diagnosed in 2006–2008 and followed up until the end of 2012 were used for survival analysis. Death certificates were checked against the records of registered cancer patients. Unmatched cases for death certificates 5 years after diagnosis were requested of each city office, to determine patients’ residency and check their survival status on the date of last follow-up. Those cases that could not be followed through either the death certificate or residency records were defined as cases that were lost to follow-up. A total 4.8% of patients diagnosed in 2006–2008 were lost to follow-up. The 5-year overall survival rates by age group and sex for all cancers and 25 primary sites were calculated using the Kaplan–Meier method. Patients who were DCO cases, had secondary cancers, non-malignant tumors, intraepithelial cancers, and who were of unspecified age or aged ≥ 100 years were excluded in the survival analysis.

Prevalence

Cancer prevalence is defined as the number or proportion of the entire population with a past or current diagnosis of cancer at a given point in time (Hans-Olov Adami et al., 2008). We assumed that annual incident cases occurred at mid-year. We considered 5-year prevalence to be the number of patients alive with a cancer diagnosis < 5 years. We considered patients who were alive 5 years after diagnosis to be cured cases because for most cancers, death rates among such patients are similar to those among the general population after 5 years’ time. The 5-year survival rate in 2006–2008 was applied to estimate prevalence under the assumption that the survival rate remained the same until 2012. Prevalent cases were estimated from incidence and year-specific survival probabilities, according to the following formula developed by Pisani (Colonna et al., 2001; Pisani et al., 2002; Tabata et al., 2008):

\[ \text{Estimated number of prevalent cases} = \sum_{u=1}^{v} I(u) \times S(v) \]

where \( P(t) \) corresponds to partial prevalence at \( t \) years, \( I(u) \) the number of incident cases during year \( u \), and \( S(v) \) the age-specific survival rate observed after \( v \) year (s) by the Kaplan–Meier method. We combined the annual number of new cases and the corresponding probability of survival by time-derived estimates of prevalence. For example, 1-year prevalence in 2012 was estimated from the number of new cases in 2012 multiplied by the probability of surviving at least 6 months, and 5-year prevalence summed the number of cancer patients who were alive at 0.5, 1.5, 2.5, 3.5, and 4.5 years. Cancer prevalence was further stratified by sex, cancer site (25 major cancers), and age group at diagnosis. Because the estimated number of prevalent cases was rounded to one decimal place, the number of prevalent cases does not always sum up to the total number when prevalence is shown according to sex in the Tables.

Results

**Incidence, age-standardized incidence rate, mortality, and 5-year relative survival rate, according to primary cancer site**

The incidence for all cancers in 2012 was 24,559 cases among men and 17,131 cases among women (Table 1). Colorectal cancer (colon and rectal cancer) was the most incident cancer with 6,654 cases, accounting for 16.0% of overall incident cases; this was followed by stomach cancer with 5,749 cases (13.8%) and lung cancer with 5,593 cases (13.4%). In 2012 among men, stomach cancer was the most incident cancer with 4,040 cases, accounting for 16.5% of incident cases; this was followed by lung cancer with 3,944 cases (16.1%) and prostate cancer with 3,944 cases.
Table 1. Cancer Incidence, Mortality, 5-Year Survival Rate, and Prevalence in Aichi Prefecture, Japan

| Cancer Site               | Incidence 2012 | Mortality 2012 | 5-Year Survival Rate (%) | Prevalence 2012 |
|---------------------------|----------------|----------------|-------------------------|----------------|
| All sites                 |                |                |                        |                |
| Total                     |                |                |                        |                |
| Male                      |                |                |                        |                |
| Female                    |                |                |                        |                |
| Estimation of prevalence  |                |                |                        |                |

3,863 cases (15.7%). In 2012 among women, breast cancer was the most incident cancer with 3,538 cases, accounting for 20.7% of incident cases; this was followed by colorectal cancer with 2,899 cases (16.9%) and stomach cancer with 1,709 cases (10.0%). The largest number of cancer deaths were owing to lung cancer, followed by stomach and colorectal cancers, accounting for 20.8%, 14.0%, and 13.6% of the total cases, respectively. The 5-year relative survival rate in 2006–2008 was 48.1% overall. Survival rates differed remarkably by cancer site, ranging from 4.7% for pancreatic cancer to 77.0% for prostate cancer, 84.7% for breast cancer, and 87.1% for thyroid cancer.

Estimated prevalence by cancer site and sex

The estimated prevalence for all cancers in 2012 was 68,013 for men and 52,490 for women (Table 1). Estimated prevalence varied by cancer site, ranging from 667 for cancer of the brain and nervous system to 21,735 for colorectal cancer. Colorectal cancer was the most prevalent cancer, accounting for 18.0% of the overall prevalent cases, followed by stomach (13.4%), breast (12.6%), and prostate (12.1%) cancers. Together, these cancers accounted for 56.1% of the cancer prevalence in Aichi Prefecture. Among men, the highest prevalence was for prostate cancer, accounting for 21.5% of total prevalence; this was followed by colorectal (18.5%) and stomach (17.0%) cancers. In women, the highest prevalence was for breast cancer with 15,036 cases, accounting for 28.6% of total prevalence; this was followed by colorectal (17.4%) and stomach (8.8%) cancers.

The analysis, stratified by primary site and age group, is shown in Table 2. Tables 3 (men) and 4 (women) show the results of analysis stratified by major site, age group, and sex. According to age group, 68.0% and 30.0% of total prevalence in men was among those aged ≥ 65 years and ≥ 75 years, respectively. In women, 51.6% and 26.0% of total prevalence was among those aged ≥ 65 years and ≥ 75 years, respectively. These results suggest that there are more prevalent cases with younger age among women than among men. Among the leading 12 incident cancers, the most prevalent cancers among those aged ≥ 65 years were prostate (81.3% of total age prevalence) and liver...
(75.1%) cancers; among those aged < 65 years, the most prevalent cancers were uterine (73.0% of total age prevalence) and breast (64.2%) cancers. When stratified by sex, the most prevalent cancers among those aged ≥ 65 years were prostate (81.4%), bladder (71.7%), and liver (71.5%) cancers in men, and liver (82.8%) and bladder (74.9%) in women. Of the total prevalence, the most prevalent cancers among those aged < 65 years were ovarian (74.6%), uterine (73.0%) and breast (64.4%) cancers in women and malignant lymphoma (45.9%) and kidney (44.5%) cancers in men.

**Discussion**

In this study, we calculated cancer prevalence using estimated incidence and survival data in Aichi Prefecture. In 2012, there were 120,503 prevalent cases diagnosed with cancer in the previous 5 years, representing approximately 1.6% of the total population of Aichi. We found the most prevalent cancers in the prefecture in 2012 to be prostate cancer, colorectal, and stomach cancers in men and breast, colorectal, stomach, and uterine cancer in women.

Our study showed that the ranking of cancer sites for estimated prevalence differed from that for incidence. For example, prostate cancer was the most prevalent cancer but the third most incident cancer in 2012. There were around 3.8 times more prostate cancer prevalent cases than incident cases. Because the overall survival rate of prostate cancer was high (77.0%), the prevalence was also high. However, lung cancer was the fifth most prevalent cancer but had the third highest incidence among both sexes. There were 1.8 times more lung cancer prevalent cases than incident cases, with the lowest prevalence:incidence ratio among the 12 leading incident cancers. Overall 5-year survival rates were low (22%) for lung cancer. Furthermore, our study showed that more common cancers with shorter survival rates may have lower prevalence than less common cancers with longer survival rates. For example, although pancreatic cancer accounted for 4.1% of incidence and leukemia accounted for 1.4% among both sexes, there were fewer prevalent cases of pancreatic cancer (a more common cancer) than for leukemia (a less common cancer). This is because people survive longer after a diagnosis of leukemia than a diagnosis of pancreatic cancer. These findings suggest that cancer prevalence has a different effect on cancer management than does incidence or mortality.

### Table 3. Five-Year Cancer Prevalence According to Primary Site and Age Group Among Men in Aichi Prefecture, Japan

| Primary Site | 20-24 | 25-29 | 30-34 | 35-39 | 40-44 | 45-49 | 50-54 | 55-59 | 60-64 | 65-69 | 70-74 | 75-79 | 80-84 | 85+ | 79.1% | Total | Percentage |
|-------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-----|-------|-------|-----------|
| All sites | 3 | 5 | 3 | 4 | 4 | 5 | 5 | 7 | 6 | 6 | 4 | 3 | 2 | 1 | 2.0% | 120,503 | 100.0% |
| Uterus | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2.0% | 120,503 | 100.0% |
| Breast | 3 | 5 | 3 | 4 | 4 | 5 | 5 | 7 | 6 | 6 | 4 | 3 | 2 | 1 | 2.0% | 120,503 | 100.0% |
| Cervix | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0% | 120,503 | 100.0% |
| Colon | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2.0% | 120,503 | 100.0% |
| Rectum | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2.0% | 120,503 | 100.0% |
| Prostate | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0% | 120,503 | 100.0% |
| Bladder | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0% | 120,503 | 100.0% |
| Kidney | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0% | 120,503 | 100.0% |
| Liver | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0% | 120,503 | 100.0% |
| Lymphoma | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0% | 120,503 | 100.0% |
| Multiple sites | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0% | 120,503 | 100.0% |

### Table 4. Five-Year Cancer Prevalence According to Primary Site and Age Group Among Women in Aichi Prefecture, Japan

| Primary Site | 20-24 | 25-29 | 30-34 | 35-39 | 40-44 | 45-49 | 50-54 | 55-59 | 60-64 | 65-69 | 70-74 | 75-79 | 80-84 | 85+ | 68.1% | Total | Percentage |
|-------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-----|-------|-------|-----------|
| All sites | 3 | 5 | 3 | 4 | 4 | 5 | 5 | 7 | 6 | 6 | 4 | 3 | 2 | 1 | 8.0% | 120,503 | 100.0% |
| Uterus | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0% | 120,503 | 100.0% |
| Breast | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0% | 120,503 | 100.0% |
| Cervix | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0% | 120,503 | 100.0% |
| Colon | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0% | 120,503 | 100.0% |
| Rectum | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0% | 120,503 | 100.0% |
| Prostate | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0% | 120,503 | 100.0% |
| Bladder | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0% | 120,503 | 100.0% |
| Kidney | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0% | 120,503 | 100.0% |
| Liver | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0% | 120,503 | 100.0% |
| Lymphoma | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0% | 120,503 | 100.0% |
| Multiple sites | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0% | 120,503 | 100.0% |
It has been reported that cancer prevalence estimates are higher among men than women in Japan; this is similar to incidence, which is higher among men than women (Ito H et al., 2004) (Matsuda et al., 2014). More older cancer patients (aged ≥ 65 years) were male than female. We found that patients with prostate, bladder, and liver cancers were more likely to be aged ≥ 65 years. A recent study suggested that latent prostate cancer has become more frequent in recent years (Kimura et al., 2015). The 5-year overall survival rate for prostate cancer was high (77.0%) in this study, which contributes to the high number of prevalent cases of prostate cancer among older age groups. Since the 1990s, some municipalities of Aichi Prefecture have used population-based screening for some cancers including prostate cancer. Some cancer cases detected by cancer screening results in overdiagnosis that, in the absence of screening, would not present symptomatically during one’s lifetime. (Marcus et al., 2015). There is concern that prostate-specific antigen (PSA) - based screening for prostate cancer could lead to overdiagnosis (Lin et al., 2008). This evidence increases the incident cases and overestimates the prevalence for prostate cancer. In addition, because cancer screening introduces lead time bias that occurs when a diagnostic approach merely identifies the disease earlier and gives the impression that survival is prolonged (Facciorusso et al., 2016), cancer screening inflates incidence cases and then improves survival rate (Pisani et al., 2002). The screening effect might lead to increase the incident cases and the prevalence estimation for many cancers. We also found more female cancer patients among younger age groups (< 65 years). In particular, 73% of uterine cancer and 64.2% of breast cancer prevalent cases were among women aged < 65 years. The number of breast cancer cases begins to increase after age 30 years, reaches its peak during the 50s, and decreases thereafter (Hori et al., 2015); therefore, it is likely that most breast cancer prevalent cases are among women aged < 65 years. Incidence rates of cervical cancer have increased recently, especially among women aged 20–30 years (Ferlay, 2014); this may contribute to the greater number of young female cancer cases. It has been suggested that there is a likely higher prevalence of malignant cancers among working-age women. One study reported that 34% of Japanese workers living with cancer had lost their jobs or had retired (Noda and Sumi, 2013). Cancer survivors often have difficulty finding work and supporting themselves financially after successful cancer treatment. The second term of the “Basic Plan for Promotion of Cancer Measures” was launched in 2012, which set out to promote improvement of cancer control programs among the working population (Noda and Sumi, 2013) (Government, 2012). Cancer prevalence would be an important measure to determine the present number of working-age people with cancer, for effective implementation of cancer control programs. Nowadays, many cancer patients can live more than 5 years and thus require more information about their long-term prognosis, such as 10-years survival rate (Ito et al., 2014). In addition, pediatric cancer survivor need long term follow-up and survival information because childhood cancer survivors are at risk of developing late treatment-related complications (Signorelli et al., 2017). Therefore, 10-year cancer prevalence would be required to be measured for effective implementation of cancer control programs.

There have been only a few studies on cancer prevalence estimation in Japan (Tabata et al., 2008). Tabata et al. estimated cancer prevalence in the country from 1995 to 2020 for 5-year periods, based on selected population-based cancer registry data. They estimated cancer prevalence in 2010 using incidence data for 1995–2000 and survival data for 1993–1996 (Tabata et al., 2008). Our results are similar to the results of that study, showing that colorectal cancer was the most prevalent cancer in Japan, followed by stomach, prostate, and breast cancers (Tabata et al., 2008).

There are some limitations in our study. A national cancer registry was established in 2016 in Japan (Tanaka and Matsuda, 2015). Until then, prefectural population-based cancer registries were in place throughout the country. These prefectural registries failed to meet international data quality standards for the proportions of DCO and HV cases and incidence-to-mortality ratios. DCN cases between 2008 and 2012 averaged 16.2% in Aichi Prefecture. Therefore, the incident cases in this study might be underestimated. Furthermore, we calculated the survival rate including followed-back cases from DCN. Given the high proportion of incident cases by registered on the basis of death certificates, the survival rate in this study might be underestimated. Second, we used the survival rate from 2006 to 2008 in this analysis. Because early detection and cancer care have been improving steadily in Japan, the actual survival rate (for those diagnosed in 2008–2012) could have been higher than the survival rate used here. In fact, the survival rate used in this study was higher than a previous survival rate using data from 2001 to 2003 in Aichi (Department of Health and Public Welfare Aichi Prefectural Government, 2013). Underestimation of cancer incidence and survival rate could mean that the actual cancer prevalence is greater than that estimated in this study.

Our study showed that cancer prevalence has a different impact than cancer incidence and mortality. Because cancer registration in Japan is expected to improve owing to establishment of a national cancer registry, yielding more accurate incidence and survival data, we will be able to more accurately estimate cancer prevalence in the near future (Tanaka, 2014). We should improve cancer prevalence estimates and regularly monitor cancer prevalence, as cancer prevalence provides crucial information for cancer control and management programs, thereby improving the ability of local governments to meet the needs of the local population.

Conflict of interest
The authors have no conflicts of interest.

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