RESEARCH ARTICLE

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

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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 (MCIJ) 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 (C88, C90) 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):

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

Table 1. Cancer Incidence, Mortality, 5-Year Survival Rate, and Prevalence in Aichi Prefecture, Japan

Primary sites	ICD-10	Incidence (2012)						5-year overall survival rate (2006-08)		Prevalence (2012)					
		Both Sex		Male		Female				Both Sex		Male		Female	
		Number	Percentage (%)	Number	Percentage (%)	Number	Percentage (%)	%	SE	Estimated number	Percentage (%)	Estimated number	Percentage (%)	Estimated number	Percentage (%)
All sites	C00-C96	41,690	100.0	24,559	100	17,131	100	48.1	0.2	120,503	100.0	68,013	100	52490	100
Lip,oral cavity & pharynx	C00-C14	852	2.0	615	2.5	237	1.4	50.4	1.3	2,566	2.1	1,771	2.6	795	1.5
Esophagus	C15	956	2.3	797	3.2	159	0.9	24.9	1.0	1,933	1.6	1,593	2.3	340	0.6
Stomach	C16	5,749	13.8	4,040	16.5	1,709	10.0	45.8	0.5	16,151	13.4	11,531	17.0	4,620	8.8
Colorectal	C18-C20	6,654	16.0	3,755	15.3	2,899	16.9	55.7	0.5	21,735	18.0	12,582	18.5	9,153	17.4
Colon	C18	4,339	10.4	2,299	9.4	2,040	11.9	56.6	0.6	11,760	9.8	7,636	11.2	6,261	11.9
Rectum	C19-C20	2,315	5.6	1,456	5.9	859	5.0	56.6	0.7	7,838	6.5	4,946	7.3	2,892	5.5
Liver	C22	1,949	4.7	1,339	5.5	610	3.6	19.3	0.6	4,248	3.5	2,905	4.3	1,343	2.6
Gallbladder	C23-C24	1,078	2.6	527	2.1	551	3.2	13.1	0.8	1,414	1.2	784	1.2	630	1.2
Pancreas	C25	1,707	4.1	909	3.7	798	4.7	4.7	0.4	1,444	1.2	841	1.2	603	1.1
Larynx	C32	254	0.6	236	1.0	18	0.1	64.5	2.1	899	0.7	838	1.2	61	0.1
Lung	C33-C34	5,593	13.4	3,944	16.1	1,649	9.6	22	4.2	10,197	8.5	6,546	9.6	3,651	7.0
Skin	C43-C44	838	2.0	424	1.7	414	2.4	69.2	1.4	3,039	2.5	1,547	2.3	1,492	2.8
Breast	C50	3,565	8.6	27	0.1	3,538	20.7	84.7	0.4	15,126	12.6	90	0.1	15,036	28.6
Uterus	C53-C55	1,269	3.0	-	-	1,269	7.4	70.9	0.9	4,612	3.8	0	0.0	4,612	8.8
Cervix Uteri	C53	653	1.6	-	-	653	3.8	66.0	1.4	2,172	1.8	0	0.0	2,172	4.1
Corpus Uteri	C54	588	1.4	-	-	588	3.4	77.1	1.2	2,378	2.0	0	0.0	2,378	4.5
Ovary	C56	506	1.2	-	-	506	3.0	51.0	1.6	1,516	1.3	0	0.0	1,516	2.9
Prostate	C61	3,863	9.3	3,863	15.7	-	-	77.0	0.6	14,625	12.1	14,625	21.5	0	0.0
Bladder	C67	1,010	2.4	782	3.2	228	1.3	59.5	1.0	3,580	3.0	2,870	4.2	710	1.4
Kidney	C64-C66,C68	1,106	2.7	776	3.2	330	1.9	56.1	1.1	3,408	2.8	2,475	3.6	933	1.8
Brain & nervous system	C70-C72	249	0.6	142	0.6	107	0.6	31.3	2.0	667	0.6	341	0.5	326	0.6
Thyroid	C73	615	1.5	188	0.8	427	2.5	87.1	1.0	2,547	2.1	654	1.0	1,893	3.6
Malignant lymphoma	C81-C85,C96	1,446	3.5	788	3.2	658	3.8	54.1	1.0	4,274	3.5	2,315	3.4	1,959	3.7
Multiple myeloma	C88,C90	377	0.9	190	0.8	187	1.1	25.4	1.8	735	0.6	386	0.6	348	0.7
Leukemia	C91-C95	598	1.4	361	1.5	237	1.4	27.3	1.1	2,135	1.8	1,221	1.8	914	1.7

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.

Estimated prevalence by cancer site, age group, and sex

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

Table 2. Five-Year Cancer Prevalence According to Primary Site and Age Group Among Both Sexes in Aichi Prefecture, Japan

Primary sites	ICD-10	Age group																			
		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	85-	Total	Percantage (%)
All sites	C00-C96	229	125	106	161	262	577	1,248	2,451	3,742	4,967	6,113	10,350	16,920	19,257	20,188	16,861	10,658	6,288	120,503	100
Lip,oral cavity & pharynx	C00-C14	0	0	3	6	10	20	40	71	76	96	132	260	406	427	422	313	188	96	2,566	2.1
Esophagus	C15	0	0	0	0	0	2	0	4	16	31	64	209	399	460	343	263	94	48	1,933	1.6
Stomach	C16	0	0	0	0	0	17	48	164	226	387	627	1,338	2,434	2,765	3,055	2,526	1,696	869	16,151	13.4
Colorectal	C18-C20	0	0	0	5	4	19	84	223	391	547	975	1,884	3,205	3,697	3,918	3,299	2,133	1,351	21,735	18.0
Colon	C18	0	0	0	5	4	16	50	129	215	283	520	1,014	1,905	2,299	2,557	2,334	1,555	1,012	13,897	11.5
Rectum	C19-C20	0	0	0	0	0	4	35	94	176	265	455	869	1,300	1,398	1,361	965	578	339	7,838	6.5
Liver	C22	9	0	0	0	0	1	12	15	30	61	112	283	536	669	959	902	458	201	4,248	3.5
Gallbladder	C23-C24	0	0	0	0	0	0	0	7	6	20	30	92	155	217	282	249	211	145	1,414	1.2
Pancreas	C25	0	0	0	0	0	2	2	14	25	33	53	122	247	262	252	250	120	62	1,444	1.2
Larynx	C32	0	0	0	0	0	0	0	2	3	21	35	71	159	215	171	126	73	25	899	0.7
Lung	C33-C34	0	0	0	1	1	4	20	57	134	222	426	793	1,618	1,926	1,962	1,604	972	458	10,197	8.5
Skin	C43-C44	0	0	0	2	8	15	27	52	67	65	100	160	256	319	437	468	511	552	3,039	2.5
Breast	C50	0	0	0	0	8	70	254	749	1,359	1,833	1,504	1,815	2,121	1,754	1,382	1,030	692	558	15,126	12.6
Uterus	C53-C55	0	0	0	1	14	78	242	368	418	465	483	674	624	451	353	226	135	81	4,612	3.8
Cervix Uteri	C53	0	0	0	0	12	68	207	290	292	271	162	209	216	160	113	87	43	41	2,172	1.8
Corpus Uteri	C54	0	0	0	0	2	11	34	75	123	195	321	463	406	278	241	128	77	23	2,378	2.0
Ovary	C56	1	0	2	16	19	33	45	63	130	181	195	232	214	152	105	74	36	18	1,516	1.3
Prostate	C61	0	0	0	0	1	0	0	0	5	38	196	661	1,825	3,108	3,739	2,949	1,533	572	14,625	12.1
Bladder	C67	0	0	0	0	0	1	10	21	32	61	111	256	500	552	614	600	493	329	3,580	3.0
Kidney	C64-C66,C68	11	0	0	2	0	6	14	63	151	159	228	319	503	506	509	497	322	117	3,408	2.8
Brain & nervous system	C70-C72	21	17	12	16	7	31	37	56	47	50	42	53	64	55	66	50	30	15	667	0.6
Thyroid	C73	0	1	0	7	41	71	123	161	232	213	231	262	373	305	244	162	92	28	2,547	2.1
Malignant lymphoma	C81-C85,C96	4	9	19	19	42	66	74	100	137	154	287	430	599	631	638	548	324	193	4,274	3.5
Multiple myeloma	C88,C90	0	0	0	0	0	0	1	2	24	23	21	55	118	108	118	132	76	56	735	0.6
Leukemia	C91-C95	91	63	33	48	33	53	71	84	94	96	89	142	189	253	249	217	198	132	2,135	1.8

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

Primary sites		Age group																			
		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	85–	Total	Percentage (%)
All sites	C00–C96	133	69	62	78	120	228	402	706	1,011	1,438	2,487	5,167	9,924	12,556	13,485	10,987	6,403	2,756	68,013	100
Lip,oral cavity & pharynx	C00–C14	0	0	2	3	9	15	24	38	33	58	99	176	322	344	293	203	109	42	1,771	2.6
Esophagus	C15	0	0	0	0	0	1	0	4	13	27	53	166	329	399	285	213	69	36	1,593	2.3
Stomach	C16	0	0	0	0	0	4	28	85	139	233	435	961	1,853	2,101	2,281	1,820	1,141	451	11,531	17.0
Colorectal	C18–C20	0	0	0	3	0	11	51	138	196	305	550	1,163	1,966	2,344	2,413	1,883	1,083	478	12,582	18.5
Colon	C18	0	0	0	3	0	11	31	80	94	159	262	583	1,104	1,386	1,522	1,292	768	344	7,636	11.2
Rectum	C19–C20	0	0	0	0	0	0	20	57	102	146	288	580	862	958	891	591	315	134	4,946	7.3
Liver	C22	7	0	0	0	0	1	7	9	28	51	92	224	410	488	628	590	273	97	2,905	4.3
Gallbladder	C23–C24	0	0	0	0	0	0	0	1	5	7	19	45	93	133	170	139	114	61	784	1.2
Pancreas	C25	0	0	0	0	0	2	1	7	15	23	34	76	150	148	152	152	60	21	841	1.2
Larynx	C32	0	0	0	0	0	0	0	2	3	18	35	67	146	198	165	120	66	20	838	1.2
Lung	C33–C34	0	0	0	1	0	2	5	29	84	118	258	484	1,014	1,306	1,333	1,040	644	229	6,546	9.6
Skin	C43–C44	0	0	0	2	6	9	9	29	36	45	52	93	144	168	252	262	262	178	1,547	2.3
Breast	C50	0	0	0	0	0	0	0	2	0	0	6	6	14	16	22	11	5	9	90	0.1
Uterus	C53–C55	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
Cervix Uteri	C53	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
Corpus Uteri	C54	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
Ovary	C56	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
Prostate	C61	0	0	0	0	1	0	0	0	5	38	196	661	1,825	3,108	3,739	2,949	1,533	572	14,625	21.5
Bladder	C67	0	0	0	0	0	0	9	15	24	53	85	208	418	469	522	486	377	204	2,870	4.2
Kidney	C64–C66,C68	5	0	0	0	0	6	11	46	115	122	176	240	380	397	368	354	205	49	2,475	3.6
Brain & nervous system	C70–C72	11	9	8	10	5	21	26	32	17	24	23	27	41	29	21	24	12	2	341	0.5
Thyroid	C73	0	0	0	3	7	18	27	36	66	58	60	72	94	69	60	57	21	5	654	1.0
Malignant lymphoma	C81–C85,C96	4	6	11	6	19	36	38	53	73	83	148	244	341	368	366	292	151	77	2,315	3.4
Multiple myeloma	C88,C90	0	0	0	0	0	0	1	2	15	13	13	32	72	59	68	67	30	15	386	0.6
Leukemia	C91–C95	49	35	21	27	21	33	38	51	48	52	45	78	100	162	154	146	106	56	1,221	1.8

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

Primary sites		Age group																			
		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	85–	Total	Percentage (%)
All sites	C00–C96	96	56	44	83	142	349	846	1,745	2,731	3,529	3,626	5,183	6,996	6,701	6,703	5,874	4,255	3,532	52,490	100
Lip,oral cavity & pharynx	C00–C14	0	0	1	3	1	6	16	33	43	38	33	84	84	83	129	109	79	54	795	1.5
Esophagus	C15	0	0	0	0	0	1	0	0	4	4	11	43	70	61	58	50	25	12	340	0.6
Stomach	C16	0	0	0	0	0	13	20	79	87	154	192	377	581	664	774	706	555	418	4,620	8.8
Colorectal	C18–C20	0	0	0	2	4	9	33	85	195	243	425	721	1,239	1,353	1,505	1,416	1,050	873	9,153	17.4
Colon	C18	0	0	0	2	4	5	19	49	121	124	259	432	800	913	1,036	1,042	787	668	6,261	11.9
Rectum	C19–C20	0	0	0	0	0	4	14	36	74	118	167	289	439	440	470	374	263	205	2,892	5.5
Liver	C22	3	0	0	0	0	0	5	6	2	11	20	59	126	180	332	312	185	104	1,343	2.6
Gallbladder	C23–C24	0	0	0	0	0	0	0	6	2	13	12	47	62	84	113	110	97	84	630	1.2
Pancreas	C25	0	0	0	0	0	0	1	7	10	10	19	45	97	114	100	98	59	40	603	1.1
Larynx	C32	0	0	0	0	0	0	0	0	0	3	0	4	13	17	6	6	7	6	61	0.1
Lung	C33–C34	0	0	0	0	1	2	15	29	50	104	168	309	604	620	629	564	328	229	3,651	7.0
Skin	C43–C44	0	0	0	0	2	6	18	23	31	21	48	67	112	152	185	206	249	374	1,492	2.8
Breast	C50	0	0	0	0	8	70	254	747	1,359	1,833	1,498	1,809	2,107	1,738	1,360	1,019	688	549	15,036	28.6
Uterus	C53–C55	0	0	0	1	14	78	242	368	418	465	483	674	624	451	353	226	135	81	4,612	8.8
Cervix Uteri	C53	0	0	0	0	12	68	207	290	292	271	162	209	216	160	113	87	43	41	2,172	4.1
Corpus Uteri	C54	0	0	0	0	2	11	34	75	123	195	321	463	406	278	241	128	77	23	2,378	4.5
Ovary	C56	1	0	2	16	19	33	45	63	130	181	195	232	214	152	105	74	36	18	1,516	2.9
Prostate	C61	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
Bladder	C67	0	0	0	0	0	1	1	6	8	8	26	47	81	83	92	114	117	125	710	1.4
Kidney	C64–C66,C68	6	0	0	2	0	0	3	17	36	37	52	79	122	109	141	144	117	68	933	1.8
Brain & nervous system	C70–C72	10	8	4	6	2	10	11	24	30	26	19	26	23	26	45	26	18	12	326	0.6
Thyroid	C73	0	1	0	4	34	53	96	126	166	155	171	190	279	236	184	104	71	23	1,893	3.6
Malignant lymphoma	C81–C85,C96	0	3	8	13	23	30	36	47	64	71	139	186	259	263	272	256	173	116	1,959	3.7
Multiple myeloma	C88,C90	0	0	0	0	0	0	0	0	8	9	9	24	47	49	50	65	46	41	348	0.7
Leukemia	C91–C95	42	28	12	21	13	20	32	33	47	44	44	64	88	92	95	71	92	75	914	1.7

(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.

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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