RESEARCH ARTICLE

Cancer Incidence and Mortality in Osaka, Japan: Future Trends Estimation with an Age-Period-Cohort Model

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Abstract

In previous studies we predicted future trends in cancer incidence for each prefecture in order to plan cancer control. Those predictions, however, did not take into account the characteristics of each prefecture. We therefore used the results of age-period-cohort analysis of incidence and mortality data of Osaka, and estimated the incidence and mortality of cancers at all sites and selected sites. The results reflect the characteristics of Osaka, which has and is expected to have large number of patients with liver cancer. We believe our results to be useful for planning and evaluating cancer control activities in Osaka. It would be worthwhile to base the estimation of cancer incidence and mortality in each prefecture on each population-based cancer registry.

Keywords: Cancer incidence and mortality - estimation - age-period-cohort model - Japan

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Introduction

Estimated future trends in cancer incidence and mortality are important in the planning of cancer control policy and in the evaluation the cancer control activities. In previous studies we predicted the numbers of incident cases of major cancers in all of Japan (Utada et al., 2010a) and in each of Japan's prefectures based on cancer incidence data for all of Japan (Utada et al., 2010b). Although those predicted incidences reflect the population composition and relative degrees of changes in each prefecture, they were estimated without considering characteristics of each prefecture, even though the incidence rates for cancers at certain sites differ between regions (National Cancer Center, 2006). The subjects of the previous estimation were people aged 89 and under, therefore the number of cancers incident in people aged 90 or older was not considered. Japan is rapidly aging, so we believe that the number of cancer incident in people aged 90 or more years old is not negligible.

In this study we estimated the future cancer incidence and cancer mortality reflecting Osaka characteristics for people of all ages in Osaka. Osaka is one of the largest prefectures in Japan, therefore we believe the result of this study would be useful for planning cancer control policy not only for Osaka but also for all of Japan.

Materials and Methods

Data sources and projection methods

We used an age-period-cohort (APC) model to estimate cancer incidence and mortality as in previous studies (Ohno et al., 2004; Utada et al., 2010a: 2010b). An APC model considers three effects on incidence or mortality rate; age, period and cohort effects. Ito et al. (2011) calculated these three effects by using cancer incidence data for the 1968-2003 periods from the Osaka Cancer Registry and cancer mortality data for the 1968-2007 periods from vital statistics. We applied these age, period and cohort effects of cancer incidence and mortality in Osaka (Ito et al., 2011) and predicted these three effects as described below.

The age effects were estimated, in 5-year intervals, for the ages 40-94 for many sites and for the ages 20-94 for the other sites. The age effects for people under 39 or 19 were projected by liner extrapolations, and the 95-99 age effect was considered the same as the 90-94 age effect.
The cohort effects were fixed in the same way as in the Cancer Statistics Report 2004 (CSR2004) (Ohno et al., 2004). That is, the estimated value for the birth cohort that most recently entered the age of cancer onset was used.
The period effects were examined by using the following 11 scenarios in the same way as in the previous study (Utada et al., 2010a). The scenarios are labeled by combinations of abbreviations indicating the order of the fitting function (Constant: C, linear: L, quadratic: Q), the period for fitting examination (only the latest year: I, latest previous 5 years: V, and latest previous 10 years: X) and the year assumed to be stable; that is, the year the slope became zero (2020: 20, 2030: 30).

(CI20) The period effect was fixed for the latest year.

(CV20) The period effect was fixed for the mean value

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for the latest previous 5 years.

(CX20) The period effect was fixed for the mean value for the latest previous 10 years.

(LV20) Linear functions were applied for the period effects of the previous 5 years, and quadratic functions that were tangent to the linear function at the newest year and showed the turning point in 2020 were determined. The period effects after 2020 were stable.

(LX20) Linear functions were applied for the period effects of the previous 10 years, and the rest were calculated the same way as in scenario LV20.

(QV20) Quadratic functions were applied for the period effects of the previous 5 years, and quadratic functions that were tangent to the function at the newest year and showed the turning point in 2020 were determined. The period effects after 2020 were stable.

(QX20) Quadratic functions were applied for the period effects of the previous 10 years, and the rest were calculated the same way as in scenario QV20.

(LV30) Linear functions were applied for the period effects of the previous 5 years, and quadratic functions that were tangent to the function at the newest year and showed the turning point in 2030 were determined.

(LX30) Linear functions were applied for the period effects of the previous 10 years, and the rest were calculated the same way as in scenario LV30.

(QV30) Quadratic functions were applied for the period effects of the previous 5 years, and quadratic functions that were tangent to the function at the newest year and showed the turning point in 2030 were determined.

(QX30) Quadratic functions were applied for the period effects of the previous 10 years and the rest were calculated the same way as in scenario QV30.

Using these age, cohort and 11 scenarios for period effects, we calculated 11 estimated incidence and mortality rates until 2030 by age group for both sexes and for each sex.

The Osaka population data used for estimation was calculated by liner interpolation of 5-year interval values reported by the National Institute of Population and Social Security Research (2009). The estimated number of people aged 90 or over was reported as one group, and we considered 80% of this group to be 90-94 years old and 20% to be 95 or older.

Using this population data and there three effects, we calculated the numbers of incident and mortality cases until 2030 for cancers at all sites and at selected sites.

Selection of the prediction method

We compared 11 estimated incidences and mortalities cases with observed incidence and mortality in order to evaluate the prediction method. For incidence, the sums of squares of the errors of the cancer incidence reported by the Osaka Cancer Registry from 2004 to 2005 were calculated, and the methods showing the smallest differences were selected as the most appropriate prediction methods. For mortality, the sums of squares of the errors of the cancer mortality reported by vital statistics from 2008 to 2009 were calculated, and the most appropriate prediction methods were selected in the same way as for incidence.

Results

Population composition

Regarding the population composition of Osaka in 2000 (observed) and 2030 (estimated), the population is expected to have decreased from 8,789,354 in 2000 to 7,740,941 in 2030, and the proportion of elderly people aged 65 or more is expected to have increased from 15% in 2000 to 31% in 2030.

Incidence

Table 1 shows the prediction methods used in this study. The prediction methods for the corpus uteri, cervix and uterus NOS including CIS, and cervix and uterus NOS were not selected in the way described above. The reported number of incidences in these three sites has increased rapidly since 2004, so very rapidly increasing estimated incidences were selected. This rapid increase is quite

Table 1. Prediction Methods Used in This Study

		Selected prediction method	
	ICD-10 code	Incidence	Mortality
Both Sexes			
All sites*	C00-96, D00-D09	LV20	-
All sites	C00-96	LV30	LX30
Esophagus	C15	LV20	LX30
Stomach	C16	QV20	HX20
Colon	C18	QV30	QX20
Rectum	C19-20	LX20	LX30
Colon & Rectum	C18-20	QV20	QX30
Liver	C22	QX30	LV30
Gallbladder	C23-24	QX30	QX30
Pancreas	C25	QV20	QX30
Lung	C33-34	QV20	LX30
Kidney Renal Pelvis	C64-66, C68	HV20	HX20
Urinary Bladder	C67	QV30	LX30
Malignant Lymphoma	C81-85,96	HX20	HX20
Male			
All sites*	C00-96, D00-D09	QX30	-
All sites	C00-96	LV30	LX30
Esophagus	C15	HI20	LX30
Stomach	C16	QV30	HX20
Colon	C18	LX20	LX30
Rectum	C19-20	LX20	QV30
Colon & Rectum	C18-20	HI20	QV30
Liver	C22	QX30	LX30
Lung	C33-34	QX30	LX30
Prostate	C61	QX30	QV30
Malignant Lymphoma	C81-85,96	QV20	HX20
Female			
All sites*	C00-96, D00-D09	QX30	-
All sites	C00-96	QV20	HV20
Esophagus	C15	HX20	HX20
Stomach	C16	QV30	HX20
Colon	C18	LV30	QX30
Rectum	C19-20	LV30	LX30
Colon & Rectum	C18-20	LV30	QX30
Liver	C22	QX30	QX30
Lung	C33-34	QV20	LX30
Breast*	C50, D05	LX30	-
Breast	C50	LX20	HI20†
Corpus Uteri	C54	QV20→LV30#	LX20
Cervix + Uterus NOS*	C53, C55	QV30→QV20#	-
Cervix + Uterus NOS	C53, C55, D06	QV20→LV30#	QX30
Ovary	C56	HX20	HX20
Malignant Lymphoma	C81-85,96	HX20	HI20†

*Includes CIS, †Estimated period effect was zero, #Selected method by the way discribing in Materials and Methods (left) and finally selected method (right).

Table 2. Time Trends of Age-Standardized Incidence Rates

		2000	2005	2010	2015	2020	2025	2030
Both Sexes:	All sites*	291.0	259.4	242.1	232.3	229.2	229.2	229.2
	All sites	285.0	253.3	234.5	220.9	211.7	206.3	204.6
	Esophagus	8.6	8.4	7.9	7.7	7.6	7.6	7.6
	Stomach	52.5	42.3	37.2	34.5	33.6	33.6	33.6
	Colon	26.4	23.3	21.5	20.2	19.3	18.8	18.6
	Rectum	13.8	12.7	11.8	11.2	11.1	11.1	11.1
	Colon & Rectum	40.2	35.1	31.6	29.7	29.1	29.1	29.1
	Liver	34.0	24.4	18.5	14.9	12.8	11.6	11.3
	Gallbladder	7.8	7.0	6.5	6.2	6.0	5.8	5.8
	Pancreas	10.5	11.2	12.5	13.3	13.6	13.6	13.6
	Lung	40.4	36.9	33.4	31.5	30.9	30.9	30.9
	Kidney Renal Pelvis	5.4	5.3	5.3	5.3	5.3	5.3	5.3
	Urinary Bladder	7.0	5.5	4.5	3.9	3.5	3.2	3.2
	Malignant Lymphoma	7.0	6.6	6.6	6.6	6.6	6.6	6.6
Male:	All sites*	381.2	329.3	294.6	270.2	254.0	244.8	241.8
	All sites	376.5	327.2	295.5	273.0	258.1	249.5	246.7
	Esophagus	15.8	15.5	15.5	15.5	15.5	15.5	15.5
	Stomach	78.6	64.3	57.1	52.1	48.9	47.0	46.4
	Colon	33.0	28.1	26.1	25.0	24.7	24.7	24.7
	Rectum	19.5	17.6	16.3	15.6	15.3	15.3	15.3
	Colon & Rectum	52.5	46.4	46.4	46.4	46.4	46.4	46.4
	Liver	52.9	37.4	27.8	22.1	18.8	17.0	16.5
	Lung	66.4	60.9	55.7	51.9	49.4	48.0	47.5
	Prostate	18.7	21.2	22.7	24.1	25.1	25.7	25.9
	Malignant Lymphoma	9.1	8.1	7.6	7.2	7.1	7.1	7.1
Female:	All sites*	284.4	252.6	228.2	212.2	203.0	198.6	197.4
	All sites	276.5	246.1	227.4	217.2	214.5	215.2	215.7
	Esophagus	3.3	3.1	3.1	3.0	3.0	3.0	3.0
	Stomach	42.0	33.4	28.3	25.0	23.0	22.1	21.8
	Colon	28.5	26.3	24.0	22.6	21.8	21.4	21.4
	Rectum	11.5	10.3	9.3	8.6	8.2	7.9	7.9
	Colon & Rectum	39.8	36.1	32.4	29.9	28.6	27.9	27.8
	Liver	23.7	17.5	13.5	11.2	9.8	9.1	8.9
	Lung	29.1	25.3	21.2	19.1	18.5	18.5	18.6
	Breast*	50.5	52.7	56.4	59.8	62.7	64.5	65.2
	Breast	48.9	50.4	53.1	55.2	56.2	56.5	56.7
	Corpus Uteri	5.0	5.9	6.6	7.2	7.7	8.1	8.2
	Cervix + Uterus NOS*	15.1	17.4	20.6	22.8	23.7	23.7	23.7
	Cervix + Uterus NOS	11.2	11.2	11.5	11.8	12.1	12.2	12.3
	Ovary	8.2	8.1	8.0	8.0	8.0	8.1	8.1
	Malignant Lymphoma	6.8	6.4	6.2	6.1	6.1	6.1	6.1

*Includes CIS.

unlikely to continue, we therefore used other prediction method.

Figure 1 shows the time trends of incident cases for five major cancers and prostate cancer that were calculated using the most appropriate method. For both sexes, the site of most cancer predicted to occur in 2030 is lung, followed in turn by stomach, colon and rectum, and liver. For males lung is expected to be the most common cancer site, followed in turn by stomach, colon and rectum, prostate, and liver. For females breast is expected to be the most common cancer site, followed in turn by colon and rectum, lung, stomach, and liver. The incident cases estimated in this study are closer to the observed data from the Osaka Cancer Registry than those estimated in the previous study. For liver only is the number of incident cases estimated in this study consistently larger than that estimated in the previous study.

Figure 2 shows the time trends of incident cases of age groups (0-64, 65-74, 75-84, 85+). All sites, stomach, lung, liver, and colon and rectum were examined according to sex, and breast and prostate were examined for females and males, respectively. For all sites, the estimated number of incident cases and the proportion of people aged 75 or older (especially 85 or older) are expected to increase. For five major cancers except for breast and prostate cancer, approximately 80% or more of incident cases are elderly people aged 65 or older in 2030. The proportion of people aged 75 or older (especially 85 or older) are expected to increase, especially for prostate and lung.

Table 2 shows the time trends of age-standardized incidence rates (adjusted to the Japanese model population of 1985, per 100,000 population). Those for many sites are expected to continue decreasing, on the other hand, those for female-specific cancers are expected to continue gradually increasing.

Mortality

Figures 3 shows the time trends of mortality cases for

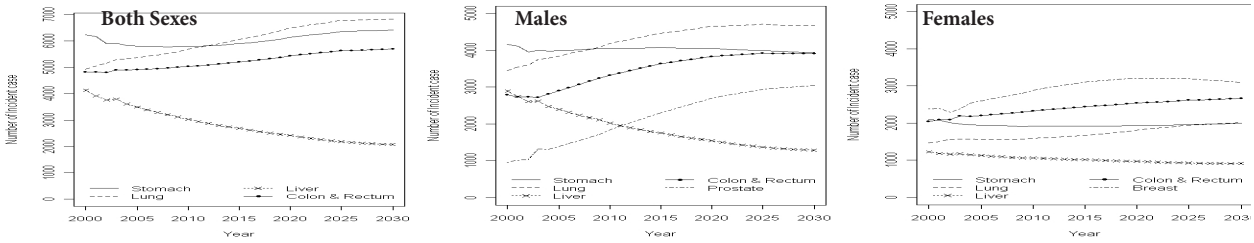

Figure 1. Time Trends of Incident Cases in Both Sexes, Males and Females

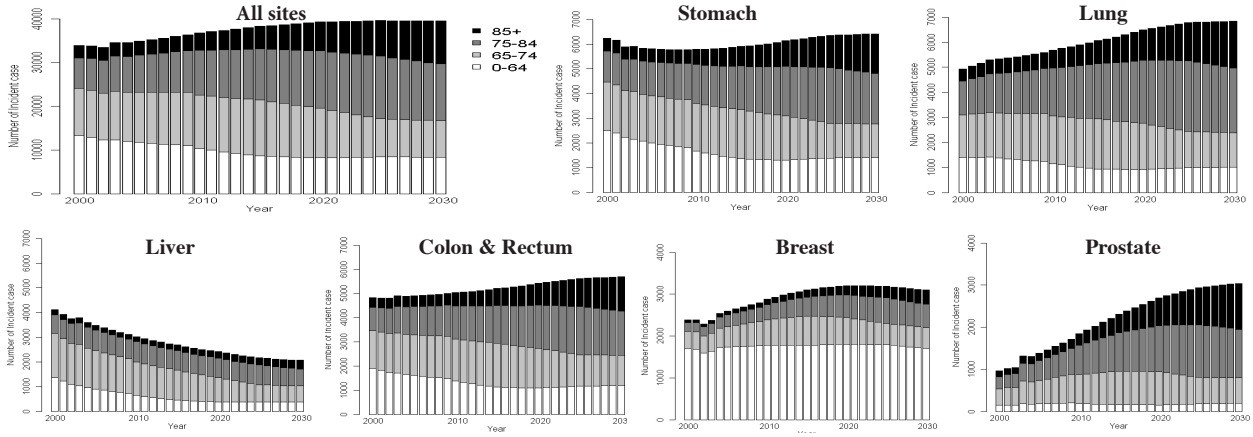

Figure 2. Time Trends of Incident Cases of Age Groups (All sites, five major cancers and prostate cancer).

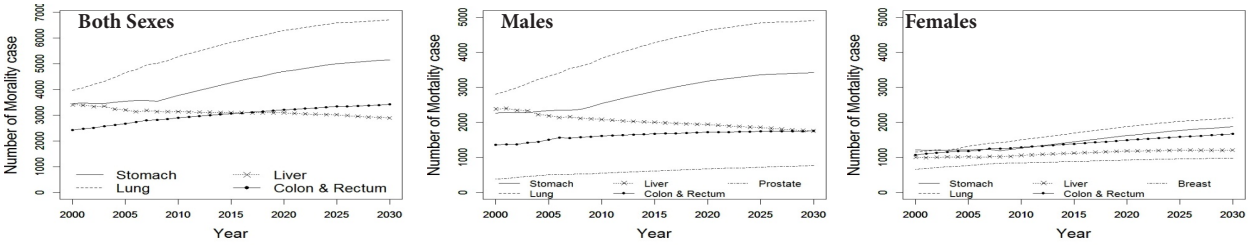

Figure 3. Time Trends of Mortality Cases in Both Sexes, Males and Females

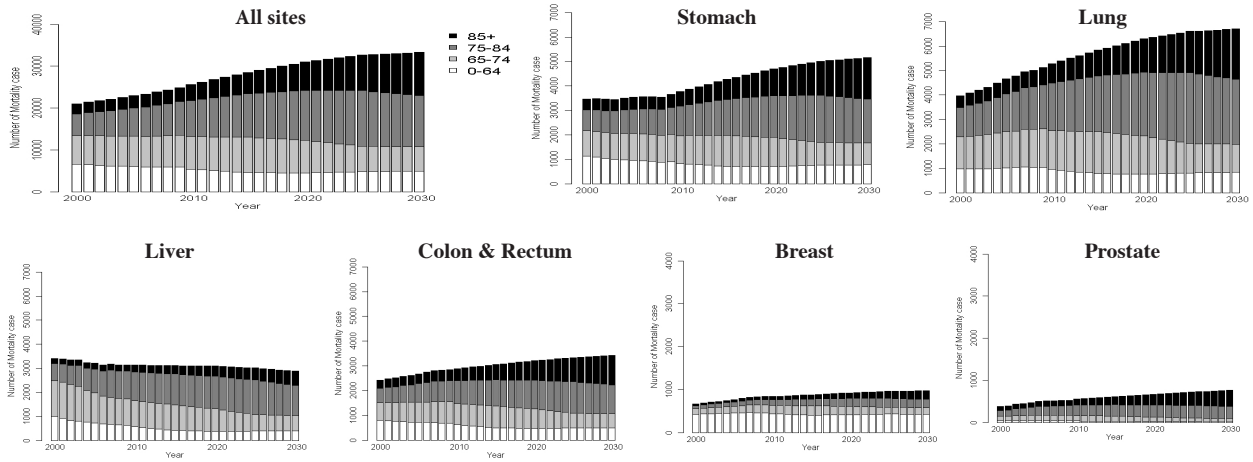

Figure 4. Time Trends of Mortality Cases of Age Groups (All sites, five major cancers and prostate cancer).

five major cancers and prostate cancer that were calculated using the most appropriate method. For both sexes the site of most cancer predicted to occur most in 2030 is lung, followed in turn by stomach, colon and rectum, and liver. For males lung is expected to be the most common cancer site, followed in turn by stomach, colon and rectum, liver, and prostate. For females lung is expected to be the most common cancer site, followed in turn by stomach, colon and rectum, liver, and breast.

Figures 4 shows the time trends of mortality cases of age groups (0-64, 65-74, 75-84, 85+). For all sites, the estimated number of mortality cases and the proportion of people aged 75 or older (especially 85 or older) are expected to increase. For five major cancers except for breast and prostate cancer, 85% or more of mortality cases are elderly people aged 65 or older in 2030. Especially for prostate cancer, 97% are elderly people. The proportion of people aged 75 or older (especially 85 or older) are expected to increase, especially for prostate and lung.

Table 3 shows the time trends of age-standardized mortality rates. For many sites the expected age-standardized mortality rates have decreased, especially

Table 3. Time Trends of Age-Standardized Mortality Rates

		2000	2005	2010	2015	2020	2025	2030
Both Sexes:	All sites	172.0	157.6	149.9	147.1	145.2	144.0	143.7
	Esophagus	6.1	6.0	5.9	5.8	5.7	5.6	5.6
	Stomach	28.3	24.4	22.2	22.2	22.3	22.3	22.3
	Colon	13.1	11.6	10.5	9.6	9.4	9.4	9.4
	Rectum	6.7	6.6	6.3	6.2	6.1	6.0	6.0
	Colon & Rectum	19.7	18.2	16.8	15.7	14.9	14.4	14.3
	Liver	27.9	21.9	18.2	16.0	14.6	13.8	13.6
	Gallbladder	7.0	6.0	5.6	5.2	5.0	4.9	4.8
	Pancreas	9.6	10.0	10.4	10.8	11.0	11.2	11.3
	Lung	32.1	31.1	29.9	28.9	28.1	27.7	27.6
	Kidney Renal Pelvis	2.5	2.7	2.6	2.6	2.6	2.6	2.6
	Urinary Bladder	2.3	2.2	2.1	2.1	2.1	2.1	2.2
	Malignant Lymphoma	4.2	3.9	3.9	3.9	3.9	3.9	3.9
Male:	All sites	245.4	222.6	208.4	201.4	196.7	194.0	193.2
	Esophagus	11.5	11.0	10.7	10.2	9.9	9.7	9.7
	Stomach	43.3	37.1	34.1	34.1	34.1	34.1	34.1
	Colon	16.3	14.2	13.4	12.7	12.3	12.0	11.9
	Rectum	9.7	9.7	8.9	8.2	7.7	7.5	7.4
	Colon & Rectum	25.9	23.9	21.8	19.9	18.7	18.0	17.8
	Liver	44.0	34.2	27.9	24.0	21.6	20.3	19.9
	Lung	54.6	52.4	50.2	48.4	47.2	46.5	46.2
	Prostate	7.6	7.8	6.7	5.9	5.3	5.1	5.0
	Malignant Lymphoma	5.9	5.3	5.3	5.3	5.3	5.3	5.3
Female:	All sites	162.2	146.0	135.8	132.0	130.9	131.1	131.4
	Esophagus	2.4	2.3	2.1	2.1	2.1	2.1	2.1
	Stomach	24.5	20.6	17.8	17.3	17.1	17.1	17.1
	Colon	15.5	13.9	11.9	10.4	9.5	9.1	8.9
	Rectum	5.8	5.4	5.1	4.9	4.8	4.8	4.8
	Colon & Rectum	21.2	19.3	17.2	15.6	14.7	14.3	14.2
	Liver	19.6	15.9	13.1	11.6	10.8	10.4	10.3
	Lung	23.2	21.5	19.6	18.5	17.9	17.8	17.7
	Breast	12.9	13.8	14.1	14.0	14.1	14.2	14.2
	Corpus Uteri	1.5	1.6	1.6	1.6	1.6	1.6	1.6
	Cervix + Uterus NOS	5.7	4.9	4.6	4.8	4.9	5.0	5.1
	Ovary	5.4	5.1	5.0	5.0	5.0	5.0	5.0
	Malignant Lymphoma	4.1	4.0	3.8	3.7	3.6	3.6	3.7

for liver in males.

Discussion

Using the results of APC analysis of cancer incidence and mortality data for Osaka, we have estimated the numbers of cancer incidences and mortalities in Osaka until 2030. For many sites cancer incidence and mortality have increased, while the age-standardized incidence and mortality rates have decreased. In addition, the number of incident and mortality cases and the proportion of people aged 75 or older have increased. These tendencies could be a result of population aging.

Comparing the results of the present study with those of our previous study (Utada et al., 2010b), which was based on incidence data for all Japan, we found liver is the only site for which the numbers of incident cases estimated are larger than those estimated in the previous study. Osaka has large number of patients with viral hepatitis, which often causes liver cancer (Tanaka et al., 1998). We therefore think that Osaka has many patients with liver cancer. The large number of liver cancer cases estimated by this study reflects this situation. In addition, Ito et al. (2011) reported that the cohort effect of incidence and mortality for liver among both male and female in Osaka peaked with the birth cohort in the early 1930's and decreased immediately. As a result, the incidence and mortality of liver has decreased. In addition, Tsukuma et al. (2005) reported that prevalence of hepatitis C virus is high in the generation born around 1935 and is lower in younger generations. This is consist with our results.

We think that the number of incident cases estimated in the present study reflects the characteristics of Osaka, which were not considered in the previous study based on data for the whole of Japan. We recommend that the estimation of the number of incident cases in each prefecture based on the population-based cancer registry. We thus need to pay close attention to the completeness of the population-based cancer registry. As for the Osaka Cancer Registry, the percentage of cases registered by death certificate only (DCO) was improved during recently two decades (Osaka Medical Center for Cancer and Cardiovascular Disease, 2010; Ito et al., 2011), and the completeness of registry is considered to be improved. It is necessary to observe the changes in incidence continuously.

In conclusion, this is the first report in which estimated numbers of incidence and mortality cases for various kinds

of cancer reflect prefecture characteristics. We believe these estimates would be useful in the planning and evaluation of cancer control activities in Osaka.

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