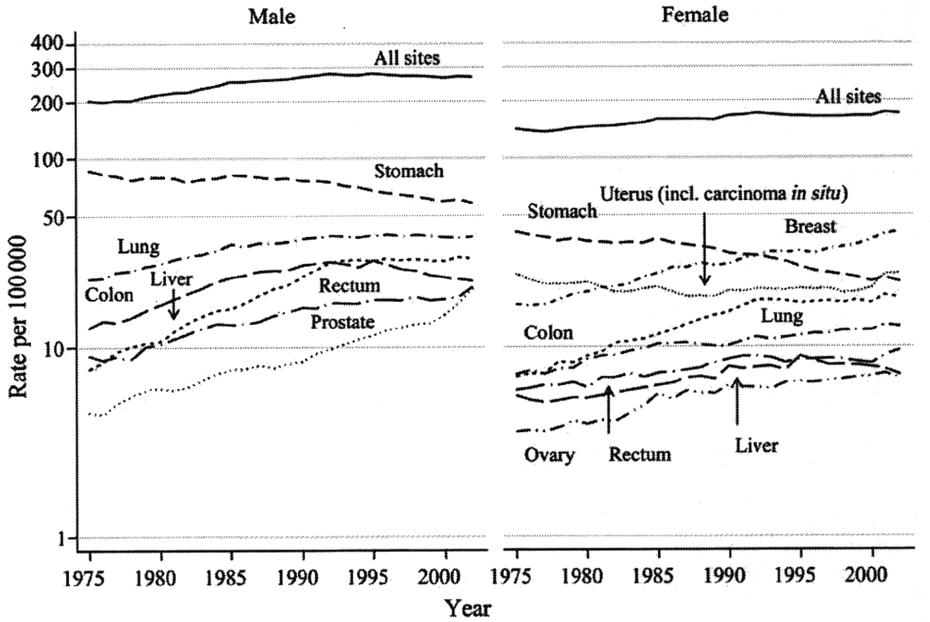

Figure 1. Trends of age-standardized cancer incidence rates for five major sites and male- and female-specific sites (standard population: world population).

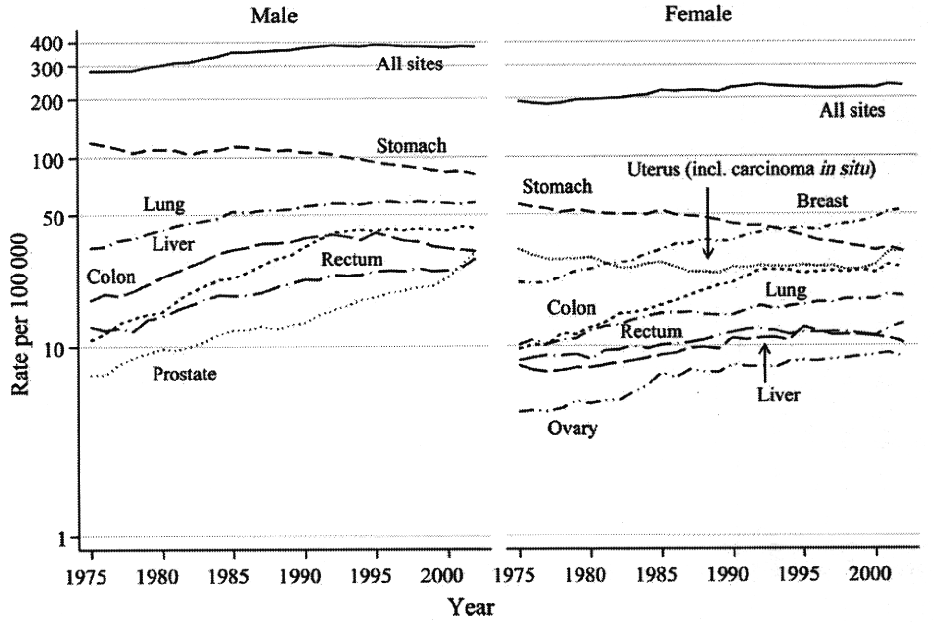

Figure 2. Trends of age-standardized cancer incidence rates for five major sites and male- and female-specific sites (standard population: 1985 Japanese model population).

Regional differences in population-based cancer survival between six prefectures in Japan: Application of relative survival models with funnel plots

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We used new methods to examine differences in population-based cancer survival between six prefectures in Japan, after adjustment for age and stage at diagnosis. We applied regression models for relative survival to data from population-based cancer registries covering each prefecture for patients diagnosed with stomach, lung, or breast cancer during 1993–1996. Funnel plots were used to display the excess hazard ratio (EHR) for each prefecture, defined as the excess hazard of death from each cancer within 5 years of diagnosis relative to the mean excess hazard (in excess of national background mortality by age and sex) in all six prefectures combined. The contribution of age and stage to the EHR in each prefecture was assessed from differences in deviance-based R^2 between the various models. No significant differences were seen between prefectures in 5-year survival from breast cancer. For cancers of the stomach and lung, EHR in Osaka prefecture were above the upper 95% control limits. For stomach cancer, the age- and stage-adjusted EHR in Osaka were 1.29 for men and 1.43 for women, compared with Fukui and Yamagata. Differences in the stage at diagnosis of stomach cancer appeared to explain most of this excess hazard (61.3% for men, 56.8% for women), whereas differences in age at diagnosis explained very little (0.8%, 1.3%). This approach offers the potential to quantify the impact of differences in stage at diagnosis on time trends and regional differences in cancer survival. It underlines the utility of population-based cancer registries for improving cancer control. (*Cancer Sci* 2009; 100: 1306–1311)

The Japanese Government launched the Fundamental Planning of Cancer Control Promotion based on the Fundamental Bill on Cancer Control in June 2007. One of the mainstays of this new strategy was to 'narrow the inequalities of cancer medical services'. Monitoring cancer survival among the prefectures of Japan is important, both to evaluate progress toward this goal and as a contribution to the next Cancer Control Plan or regional cancer control planning. Wide regional differences in cancer survival in Japan have been reported, but the findings were only adjusted by age at diagnosis.[1]

Multivariable models of relative survival have increasingly been used to quantify the impact of various prognostic factors (e.g. country, hospital, calendar period, age).[2–4] Funnel plots, mostly used in meta-analyses, have been used more recently as additional tools for such comparisons.[5–7] In the present study, we combined multivariable relative survival models with the funnel plot approach,[8] to investigate differences in population-based cancer survival between six prefectures in Japan. The role of age and stage at diagnosis was evaluated for cancers of the stomach, lung, and breast (women).

Materials and Methods

Patients. The collaborative study of cancer survival[9] collated data from 11 prefectural cancer registries on some 373 000 cancer patients diagnosed between 1993 and 1996. The national cancer survival figures were estimated on 279 469 records from the seven registries (Yamagata, Miyagi, Niigata, Osaka, Fukui, Tottori, and Nagasaki) that met the quality requirements (death certificate only cases less than 25%; death certificate notification less than 30%; vital status unknown for less than 5% of patients).[9]

These data formed the basis of the analyses reported here, but the data from the Tottori registry (4% of the total) were excluded because tumor stage was missing. Overall, 84 350 cases diagnosed with a first, primary, invasive malignant tumor of the stomach (ICD-10[10] code C16), lung (C33-C34), or breast (C50; only women) between 1993 and 1996 and followed up for at least 5 years were considered as eligible for survival analysis. Of these, we excluded 11 874 patients (14.1% of those eligible) for whom the tumor stage at diagnosis was unknown, and 72 476 patients (85.9%) were included in the survival analyses.

Methods. We first applied relative survival models to examine differences in cancer survival between the six prefectures. The adjusted excess hazard of death for each prefecture was then compared with the grand mean using the funnel plot approach.

In a second step, focussing on the prefecture with the lowest survival, we assessed the influence of age and stage at diagnosis on survival using the R^2 measure to estimate the proportion of variation explained by each variable.

Regional differences in survival up to 5 years since diagnosis: the funnel plots. The excess hazard ratios (EHR) of death from each cancer within 5 years of diagnosis were estimated for each prefecture with a Poisson regression model for relative survival,[11] adjusting first for age, then for age and stage combined. The expected (background) mortality, which is removed from the observed overall mortality, was obtained from complete (single-year-of-age) national life tables.[12] The contrasts used in the model were modified such that the excess hazard of each prefecture was compared to the overall mean hazard of death in excess of the national background mortality. This 'grand mean' across the six prefectures represents the 'target' in the funnel plots,[7,8] that is, the excess hazard of death against which the hazard among cancer patients in each prefecture was compared. Both 95 and 99.8% control limits were estimated according to the 'precision', represented by the inverse variance of the grand mean, and displayed on the x-axis of the funnel plots. An excess hazard outside the 95 (dotted lines) or 99.8% (dashed lines) control limits means that the excess hazard of death from that cancer in that prefecture was considerably higher (if above the limits) or lower (if below) than the risk of death from that cancer in all the prefectures combined.

Evaluation of the role played by prognostic factors on the lowest survival. We then focused on the prefecture with the lowest

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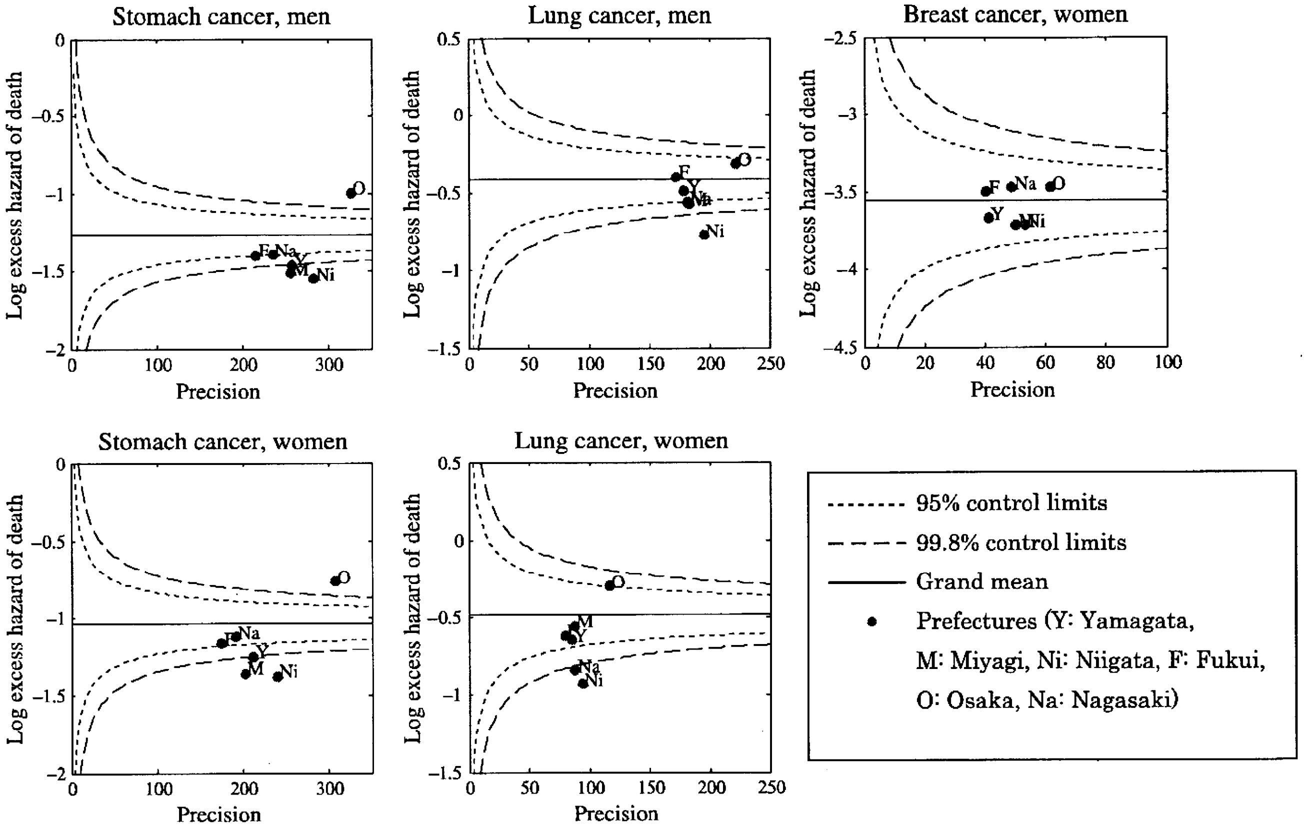

Fig. 1. Funnel plots of the age-adjusted log excess hazard of death within 5 years of diagnosis, by prefecture: cancers of the stomach, lung, and breast. Precision (x-axis) is the inverse of the variance of the age-adjusted log excess hazard of death. The target ('grand mean') is the average of the log excess hazard of death across the six prefectures

survival for each cancer and evaluated the role of age and tumor stage at diagnosis using R^2 measures for the Poisson regression model, based on deviance residuals.[13] We used four models to quantify the effect of adjusting the excess hazard for age and stage. Model 1 comprised the follow-up time (0-, 0.25-, 0.5-, 1-, 2-, and 3–5 years since diagnosis) and the region. In model 2, age at diagnosis was added to model 1, whereas model 3 consisted of model 1 plus stage at diagnosis. Model 4 included both age and stage. The effect of age adjustment was defined as the difference in R^2 between model 4 (adjusted for both age and stage) and model 3 (adjusted for stage). The effect of adjusting the excess hazard for stage was represented by the difference in R^2 between model 4 (age and stage) and model 2 (age).

Results

Stomach cancer. Five-year relative survival was lower in Osaka than in the other five prefectures for both sexes (data not shown). After adjustment for age at diagnosis, the excess hazard of death in Osaka was above the upper 99.8% control limit (Fig. 1). Additional adjustment for stage at diagnosis reduced the excess hazard in Osaka slightly, but it was still above the upper 95% control limit for both sexes (Fig. 2). Some realignment of the prefectural excess hazards was also observed. The data from Miyagi and Niigata showed a significantly low excess hazard of death from stomach cancer. In Miyagi, this persisted after adjustment for both age and stage (Figs 1, 2).

We examined further the role of age and stage on the lower survival in Osaka. Cancer patients in Osaka tended to be diagnosed at a younger age and, for stomach cancer, at a more advanced stage (Table 1). We further restricted the analysis to those cancer registries that conducted active follow up of cancer patients, namely Osaka, Yamagata, and Fukui.

In this restricted analysis, the excess hazard of death for both sexes in Osaka was still significantly higher than in the comparison group of Yamagata and Fukui combined (Table 2: model 1). The EHR barely changed after adjustment for age (model 2). The EHR fell after accounting for stage (models 3 and 4), but it was still significantly high. We estimated that differences in age at diagnosis explained as little as 0.8% in men and 1.3% in women of the difference in cancer survival between Osaka and Yamagata and Fukui combined (Table 3). By contrast, differences in tumor stage appeared to explain 61.3 and 56.8% of the survival differences in men and women respectively (Table 3). This mainly reflects a higher proportion of patients with advanced stage (Table 1), particularly for regional disease (data not shown).

Lung cancer. Age-adjusted excess hazards were lower than the 99.8% control limit in both sexes in Niigata and among women in Nagasaki (Fig. 1). These populations had a higher proportion of localized tumors (Table 1) and, after additional adjustment for tumor stage, the excess hazards of death were all within the 95% control limits except for men in Miyagi prefecture (Fig. 2).

Breast cancer. No outlier was found among the six prefectures for 5-year relative survival or the excess hazard of death from breast cancer within 5 years of diagnosis (Figs 1, 2).

Discussion

Analysis of population-based cancer data showed wide differences in 5-year relative survival from stomach cancer between the six prefectures, after adjustment for age and stage. Patients in Osaka

Table 1. Characteristics of cancer patients diagnosed between 1993 and 1996 in six prefectures in Japan: selected cancers

		Prefecture												Total	
		Yamagata		Fukui		Osaka		Niigata		Miyagi		Nagasaki			
Resident population (1995)		1 256 958		826 996		8 797 268		2 488 364		2 328 739		1 544 934		17 243 259	
Stomach															
Men	Incidence (per milion)†	111.8		104.3		74.2		113.5		97.7		82.3		87.1	
	Mortality (per milion)‡	48.5		37.5		47.5		49.3		42.8		37.5		42.1	
	Age (years)	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
	15–44	157	4.5	87	4.7	466	4.5	263	4.6	177	5.2	125	5.5	1275	4.7
	45–54	389	11.2	208	11.1	1582	15.4	658	11.5	437	12.9	233	10.2	3507	13.0
	55–64	908	26.0	484	25.9	3212	31.3	1637	28.6	992	29.2	636	27.9	7869	29.1
	65–74	1308	37.5	649	34.7	3170	30.9	2082	36.4	1215	35.8	813	35.6	9237	34.2
	75–99	724	20.8	441	23.6	1830	17.8	1082	18.9	577	17.0	474	20.8	5128	19.0
	Stage														
	Localized	2007	57.6	1040	55.6	4830	47.1	3391	59.3	1914	56.3	1193	52.3	14 375	53.2
	Regional	941	27.0	499	26.7	3442	33.5	1619	28.3	919	27.0	716	31.4	8136	30.1
	Distant	538	15.4	330	17.7	1988	19.4	712	12.4	565	16.6	372	16.3	4505	16.7
	Total	3486	100.0	1869	100.0	10260	100.0	5722	100.0	3398	100.0	2281	100.0	27 016	100.0
Women	Incidence (per milion)†	48.5		44.0		28.2		40.8		35.2		34.4		33.7	
	Mortality (per milion)‡	22.0		17.8		17.9		17.5		14.9		14.4		16.4	
	Age (years)	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
	15–44	110	5.9	84	7.9	438	8.7	215	7.5	170	10.4	107	9.1	1124	8.3
	45–54	138	7.4	109	10.3	876	17.4	309	10.8	210	12.8	134	11.4	1776	13.0
	55–64	354	19.1	208	19.6	1118	22.3	610	21.4	330	20.1	243	20.7	2863	21.0
	65–74	690	37.2	312	29.4	1371	27.3	951	33.3	545	33.3	362	30.8	4231	31.1
	75–99	565	30.4	348	32.8	1221	24.3	772	27.0	384	23.4	330	28.1	3620	26.6
	Stage														
	Localized	1018	54.8	526	49.6	2198	43.8	1668	58.4	841	51.3	590	50.2	6841	50.2
	Regional	526	28.3	351	33.1	1761	35.1	841	29.4	495	30.2	371	31.5	4345	31.9
	Distant	313	16.9	184	17.3	1065	21.2	348	12.2	303	18.5	215	18.3	2428	17.8
	Total	1857	100.0	1061	100.0	5024	100.0	2857	100.0	1639	100.0	1176	100.0	13 614	100.0
Lung															
Men	Incidence (per milion)†	51.8		56.8		65.0		63.4		60.3		68.8		55.9	
	Mortality (per milion)‡	45.7		50.8		57.9		47.8		50.8		55.3		47.3	
	Age (years)	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
	15–44	22	1.8	21	2.2	179	2.7	41	1.7	35	2.7	36	2.8	334	2.4
	45–54	63	5.1	50	5.3	696	10.4	180	7.3	101	7.8	92	7.2	1182	8.5
	55–64	263	21.3	184	19.5	1636	24.4	509	20.5	275	21.4	256	19.9	3123	22.4
	65–74	517	41.8	386	40.9	2514	37.5	1077	43.5	587	45.6	565	44.0	5646	40.5
	75–99	372	30.1	303	32.1	1680	25.1	671	27.1	290	22.5	335	26.1	3651	26.2
	Stage														
	Localized	236	19.1	240	25.4	1209	18.0	808	32.6	245	19.0	320	24.9	3058	21.9
	Regional	444	35.9	372	39.4	2826	42.1	986	39.8	485	37.7	507	39.5	5620	40.3
	Distant	557	45.0	332	35.2	2670	39.8	684	27.6	558	43.3	457	35.6	5258	37.7
	Total	1237	100.0	944	100.0	6705	100.0	2478	100.0	1288	100.0	1284	100.0	13 936	100.0
Women	Incidence (per milion)†	15.6		14.9		19.0		17.4		16.0		19.2		16.8	
	Mortality (per milion)‡	12.0		9.4		17.1		10.5		10.8		14.1		12.6	
	Age (years)	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
	15–44	17	3.7	13	3.8	101	3.9	24	2.9	19	4.4	23	4.4	197	3.8
	45–54	44	9.6	26	7.6	309	12.1	77	9.3	48	11.0	43	8.3	547	10.6
	55–64	97	21.1	61	17.9	526	20.5	177	21.3	104	23.9	117	22.5	1082	21.0
	65–74	156	33.9	119	35.0	814	31.8	310	37.3	156	35.8	195	37.4	1750	34.0
	75–99	146	31.7	121	35.6	813	31.7	242	29.2	109	25.0	143	27.4	1574	30.6
	Stage														
	Localized	133	28.9	110	32.4	514	20.1	344	41.4	109	25.0	178	34.2	1388	27.0
	Regional	112	24.3	114	33.5	1003	39.1	250	30.1	131	30.0	160	30.7	1770	34.4
	Distant	215	46.7	116	34.1	1046	40.8	236	28.4	196	45.0	183	35.1	1992	38.7
	Total	460	100.0	340	100.0	2563	100.0	830	100.0	436	100.0	521	100.0	5150	100.0

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Table 1. *Continued*

		Yamagata		Fukui		Osaka		Niigata		Miyagi		Nagasaki		Total	
		Prefecture													
		Yamagata		Fukui		Osaka		Niigata		Miyagi		Nagasaki			
Breast															
Women	Incidence (per milion)†	43.5		40.3		41.6		38.8		53.5		43.1		43.6	
	Mortality (per milion)‡	9.2		9.6		12.0		8.3		9.8		9.7		10.4	
	Age (years)	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
	15–44	189	19.9	152	20.2	1174	19.7	511	23.9	371	21.5	272	22.1	2669	20.9
	45–54	247	25.9	232	30.9	2121	35.6	647	30.2	536	31.0	352	28.6	4135	32.4
	55–64	201	21.1	156	20.7	1330	22.3	424	19.8	389	22.5	240	19.5	2740	21.5
	65–74	210	22.1	135	18.0	840	14.1	389	18.2	305	17.7	254	20.6	2133	16.7
	75–99	105	11.0	77	10.2	489	8.2	171	8.0	127	7.3	114	9.3	1083	8.5
	Stage														
	Localized	563	59.1	439	58.4	3275	55.0	1215	56.7	930	53.8	641	52.0	7063	55.4
	Regional	320	33.6	263	35.0	2324	39.0	827	38.6	686	39.7	521	42.3	4941	38.7
	Distant	69	7.2	50	6.6	355	6.0	100	4.7	112	6.5	70	5.7	756	5.9
	Total	952	100.0	752	100.0	5954	100.0	2142	100.0	1728	100.0	1232	100.0	12 760	100.0

†The age-adjusted incidence rates per 100 000 (Standard Population: Japanese 1985 model population) in 1998 (the estimation of the incidence in each prefecture was based on the collaborative study of cancer incidence in Japan[21] and the total incidence was estimated using data from the 12 population-based cancer registries in Japan[22]).
‡Age-adjusted mortality rate per 100 000 (Std. Pop.: 1985 Japanese model population) in 1998 (data from vital statistics of Japan[23]).

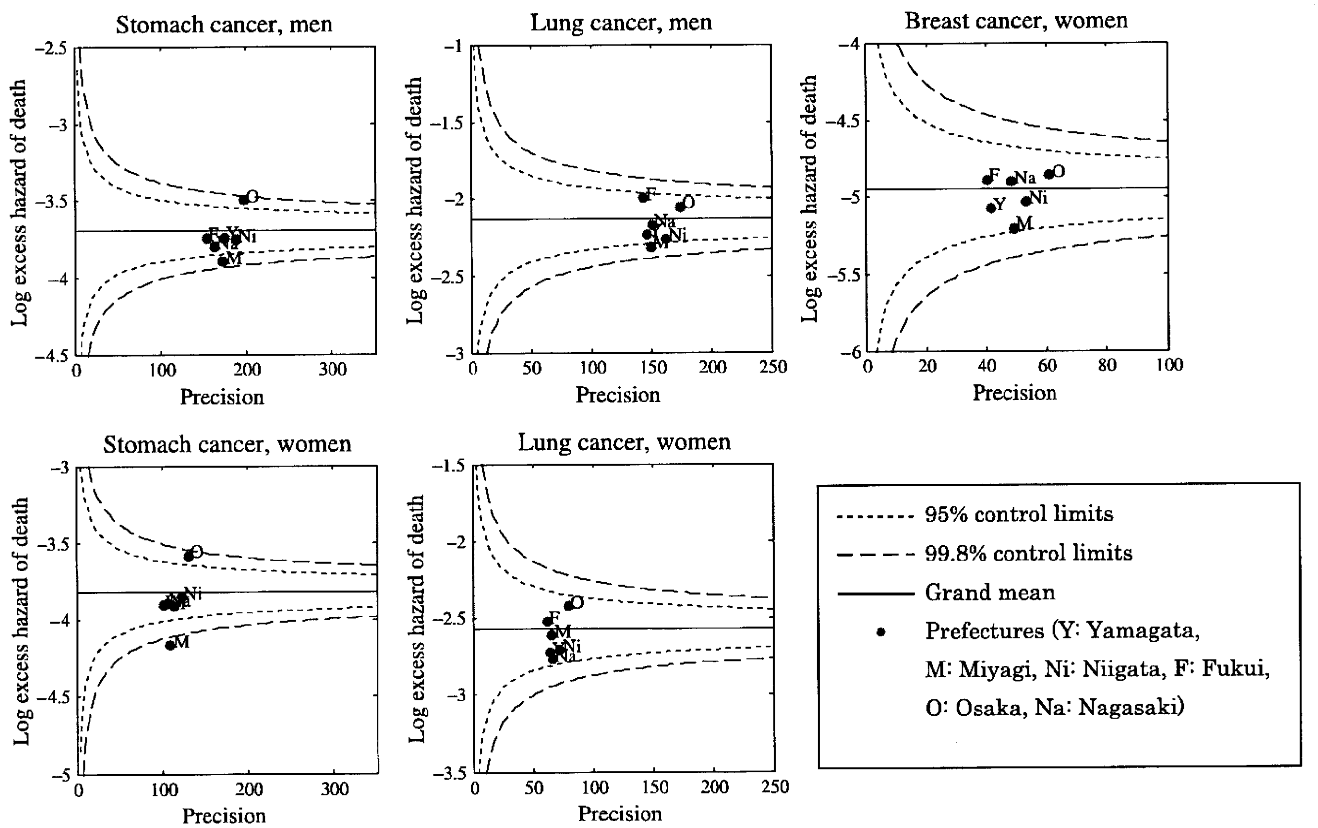

Fig. 2. Funnel plots of the age- and stage-adjusted log excess hazard of death within 5 years of diagnosis, by prefecture: cancers of the stomach, lung, and breast. Precision (*x*-axis) is the inverse of the variance of the age- and stage-adjusted log excess hazard of death. The target ('grand mean') is the average of the log excess hazard of death across the six prefectures

prefecture had higher than average excess mortality attributable to stomach cancer, whereas lower excess mortality was seen in Miyagi prefecture. Additional analyses restricted to three prefectures showed that more advanced stage at stomach cancer diagnosis accounted for approximately 60% of the excess hazard of death in Osaka.

Many cancer screening programmes (stomach, lung, breast, cervix, colorectal, even prostate cancer) have been implemented

Table 2. Stomach cancer: excess hazard ratio (EHR) of death within five years since diagnosis in Osaka relative to Yamagata and Fukui combined: patients diagnosed 1993–1996

	No. patients	Model 1 Follow-up time and region		Model 2 Model 1 + age at diagnosis		Model 3 Model 1 + stage at diagnosis		Model 4 Model 1 + age and stage	
		EHR	95% CI	EHR	95% CI	EHR	95% CI	EHR	95% CI
Men									
Region									
Yamagata + Fukui		5355		1.00		1.00		1.00	
Osaka	10 260	1.53	1.44–1.62	1.59	1.50–1.68	1.26	1.19–1.33	1.29	1.22–1.36
Age group									
15–59	4858			1.00				1.00	
60–69	5508			1.29	1.21–1.37			1.16	1.09–1.24
70–99	5249			1.77	1.66–1.88			1.42	1.33–1.52
Stage									
Localized	7877					1.00		1.00	
Regional	4882					12.43	11.07–13.95	11.54	11.07–13.95
Distant	2856					47.02	41.78–52.90	42.77	41.78–52.90
Women									
Region									
Yamagata + Fukui	2918	1.00		1.00		1.00		1.00	
Osaka	5024	1.55	1.44–1.68	1.65	1.53–1.78	1.34	1.25–1.45	1.43	1.32–1.54
Age group									
15–59	2522			1.00				1.00	
60–69	2057			1.09	0.99–1.20			1.12	1.02–1.24
70–99	3363			1.70	1.57–1.85			1.52	1.40–1.65
Stage									
Localized	3742					1.00		1.00	
Regional	2638					12.90	10.96–15.17	11.69	10.03–13.63
Distant	1562					49.43	41.85–58.38	44.19	37.75–51.73

CI, confidence interval.

Table 3. Summary of the excess hazard of death for stomach cancer patients in Osaka compared with Fukui + Yamagata

Model	Variables included in model	Men		Women	
		EHR	R^2	EHR	R^2
1	Follow up, region	1.53	0.344	1.55	0.380
2	+ Age	1.59	0.364	1.65	0.403
3	+ Stage	1.26	0.970	1.34	0.958
4	+ Age and stage	1.29	0.978	1.43	0.971

The effect of age (difference in R^2 between model 4 and model 3: see text) was 0.8 and 1.3% in men and women respectively. The effect of stage (difference in R^2 between model 4 and model 2) was 61.3 and 56.8% in men and women respectively. EHR, excess hazard ratio.

in Japan with public resources, but they have often not been well organized, with deficient management, poor definition of the target population, low participation (e.g. stomach cancer screening uptake 43.2% in Yamagata, 28.8% in Fukui, 17.9% in Osaka),[14] and poor quality control. Although such issues have not yet been fully documented, the uptake or quality of screening may have been worse in Osaka, by far the most populous prefecture examined here (Table 1).

The proportion of records excluded from analysis because of missing data on stage varied widely by prefecture. The inclusion of cases with missing stage in unadjusted analyses did not, however, eliminate regional differences in stomach cancer survival. Stage distribution is an indication of early detection of cancer, but it does not explain the lower overall survival in Osaka: stage-specific survival was also lower. Patients with regional disease and, to a lesser degree, those with localized cancer, had much lower survival in Osaka prefecture than in Yamagata and Fukui.

Regional disparities in health care management could play a major role in the remaining differences in stomach cancer survival. First, differential cancer screening coverage between Osaka and Yamagata-Fukui was likely to produce lead-time bias and/or length bias and might explain some of the differences in survival. Second, only 25% of cancer patients in Osaka were treated in the designated cancer care hospitals, whereas this proportion reached 70–80% in Fukui and Yamagata.[15] Third, lower 5-year survival has been reported for cancer patients treated in low-volume hospitals:[16–19] in Osaka, a higher proportion of cases was treated in such hospitals.

Significant differences between prefectures in the age-adjusted EHR for lung cancer disappeared after adjustment for stage. We infer that the differences in lung cancer survival arose mainly from differences in stage at diagnosis. In particular, cancer patients in Niigata and Nagasaki were on average diagnosed at an earlier stage than those in other prefectures. The high proportion of localized cases in Niigata could be explained by the high participation in screening. In Miyagi, the survival of localized cases was much higher than in other prefectures (data not shown), which could be due to lead-time bias and/or length bias among screen-detected cases. Niigata and Miyagi are two of the prefectures that have promoted cancer screening the most.

By contrast, no large disparities in survival were observed for breast cancer while all six prefectures achieved high survival on an international scale.[5] Such observations show that regional differences in survival are not inevitable and that the overall organization of health care (from early diagnosis and screening through to treatment) can reach a uniformly high standard. It also demonstrates that the differences in survival observed

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for the other cancers were not simply the result of a complex data artefact.

This is to our knowledge the first report of differences in population-based cancer survival in Japan using multivariable relative survival models, whereas crude survival (e.g. estimated with Cox proportional hazard models) does not account for the differences in background mortality. We did not control for background mortality by prefecture because it was shown to vary very little.[20]

The contrast used here for the funnel plots enabled us to examine the distribution of the excess hazard of death from each cancer in each prefecture in relation to an overall mean excess hazard, after adjustment for age and stage at diagnosis. This approach also enabled us to take into account the differences in precision of the estimates arising from the wide differences in the population of each prefecture.

This cancer survival study was limited to six prefectures. Population-based cancer registration is present in 35 of the 47 prefectures and one city in Japan, but the quality of registration and follow up is often too poor and the proportion of records with missing information on stage too high for systematic survival analysis. Even in the six prefectures that met the predetermined quality criteria, there were some unresolved data management issues. Furthermore, we limited the additional analysis on three prefectures with similar follow-up procedure in order to make the results more comparable.

Analysis of secular trends in these regional disparities in survival, using more recent data, will enable us to improve these investigations. Comparable approaches could also be applied to examine differences in cancer survival between smaller administrative geographies within a given prefecture, such as second-level medical care districts.

High-quality cancer registries with individual follow-up information are a key requirement for effective cancer control. The infrastructure of cancer registration in Japan has lagged behind that in European countries, Canada, and the USA. Systematic analysis of the data from a network of cancer registries is indispensable for monitoring improvements in cancer survival, for assessing equity in the outcome of cancer care, and for implementing and evaluating cancer control policies.

We showed that the use of the multivariable relative survival model combined with funnel plot approach was useful for assessing the regional disparities in cancer survival. It enabled us to quantify the impact of differential age and stage distributions on these regional inequalities. Our study illustrates the value of population-based cancer registries for improving cancer control.

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Epidemiology Note

Cancer Incidence and Incidence Rates in Japan in 2003: Based on Data from 13 Population-based Cancer Registries in the Monitoring of Cancer Incidence in Japan (MCIJ) Project

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The Japan Cancer Surveillance Research Group is involved in cancer monitoring in Japan (1–3). This group estimated the cancer incidence in 2003 as part of the Monitoring of Cancer Incidence in Japan (MCIJ) project, on the basis of data collected from 13 of 31 population-based cancer registries: Miyagi, Yamagata, Chiba, Kanagawa, Niigata, Fukui, Shiga, Osaka, Tottori, Okayama, Hiroshima, Saga and Nagasaki. If data from all 31 registries were used, this would have led to a large underestimation of national cancer incidence because of under-registration. The methods of registry selection, estimation of incidence and the limitations of these methods have been explained in previous studies (4–6). There were two major methodologic changes in the present study: (i) this was the first time we invited all 31 population-based cancer registries in Japan to participate, and from these we selected the 13 cancer registries with high-quality data in order to estimate the national incidence, and (ii) in consideration of timeliness, we did not apply the moving average which calculates the annual mean incidence rates of a year by using preceding and following years, and we used 2003 data alone for the national estimation. Because of the enlargement of the coverage area, Hiroshima prefecture was newly selected as one of the registries with high-quality data for the national estimation, but the other registries remained since the previous estimations. In 2007, we estimated incidences with and without the moving average based on the same registry data to compare the two methods. In conclusion, the estimated incidence without the moving average was comparatively unstable from year to year, but the gaps of the incidence numbers between the two estimations were subtle. These new methods therefore do not bring about changes in the estimated incidence numbers.

The number of incidences, crude rates, age-standardized rates and completeness of registration in 2003 are shown in Table 1, and the age-specific number of incidences and the rates according to sex and primary site are shown in Tables 2 and 3. The total number of incidences in Japan for 2003 was estimated as 620 011 (C00–C96). The time trends of age-standardized incidence rates for the five major sites and male- and female-specific sites in 1975–2003 are shown in Fig. 1 (standard population: the world population) and in Fig. 2 (standard population: the 1985 Japanese model population). The leading cancer site according to the crude and age-standardized incidence rates was the stomach for men and breast for women, as shown in Figs 1 and 2. The apparent increase in age-standardized incidence rates in 2003 is considered to be caused primarily by the development of hospital-based cancer registry in designated cancer care hospitals. The estimated cancer incidence data in Japan by sex, site, 5-year age group and calendar year during the period 1975–2003 are available as a booklet (7) and as an electronic database on the website (http://ganjoho.ncc.go.jp/professional/statistics/statistics.html).

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Table 1. Incidence, completeness of reporting and accuracy of diagnosis in Japan according to sex and primary site, 2003

Primary sites	ICD-10th	Number of incidence	Crude rate[a]	Age-standardized rate[a]		Completeness of reporting		Accuracy of diagnosis
				World population	Japanese 1985 model population	DCO/I (%)	I/M	MV/I (%)
Male								
All sites (incl. CIS)	C00–C96, D00–D09	372 374	597.7	288.0	409.8	16.5	1.99	74.8
All sites	C00–C96	364 072	584.3	281.4	400.5	16.8	1.95	74.4
Lip, oral cavity and pharynx	C00–C14	7835	12.6	6.7	9.1	11.7	1.94	81.0
Esophagus	C15	13 658	21.9	10.8	15.1	15.5	1.45	78.3
Stomach	C16	73 798	118.4	57.1	81.1	13.8	2.30	82.4
Colon	C18	35 262	56.6	27.0	38.5	11.9	2.74	82.6
Rectum and anus	C19, C20	21 892	35.1	18.0	24.8	11.1	2.68	84.2
Liver	C22	29 126	46.7	22.7	31.9	25.2	1.25	38.4
Gallbladder etc.	C23, C24	8755	14.1	6.1	9.2	27.2	1.20	46.0
Pancreas	C25	12 511	20.1	9.5	13.7	28.7	1.11	37.0
Larynx	C32	3921	6.3	3.1	4.3	7.3	4.24	88.5
Trachea, bronchus and lung	C33, C34	55 928	89.8	39.6	59.5	24.2	1.34	69.8
Skin	C43, C44	3325	5.3	2.6	3.6	7.1	6.08	90.6
Prostate	C61	40 062	64.3	27.3	41.4	9.5	4.76	85.7
Bladder	C67	12 646	20.3	9.3	13.6	11.1	3.40	84.7
Kidney, renal pelvis, ureter etc.	C64–C66, C68	8217	13.2	6.7	9.3	16.0	2.27	74.3
Brain and nervous system	C70–C72	2571	4.1	3.1	3.5	27.5	2.95	65.3
Thyroid	C73	2023	3.2	2.0	2.6	5.9	4.53	90.2
Malignant lymphoma	C81–C85, C96	12 881	20.7	11.6	15.5	17.0	2.65	79.9
Multiple myeloma	C88–C90	2251	3.6	1.6	2.4	30.6	1.20	65.8
All leukaemias	C91–C95	5606	9.0	5.8	7.0	25.3	1.37	82.9
Female								
All sites (incl. CIS)	C00–C96, D00–D09	269 220	412.2	193.9	260.8	17.1	2.20	73.6
All site	C00–C96	255 939	391.9	179.3	242.5	17.9	2.09	72.4

Continued

Table 1. *Continued*

Primary sites	ICD-10th	Number of incidence	Crude rate[a]	Age-standardized rate[a]		Completeness of reporting		Accuracy of diagnosis
				World population	Japanese 1985 model population	DCO/I (%)	I/M	MV/I (%)
Lip, oral cavity and pharynx	C00–C14	3180	4.9	2.2	2.9	15.0	2.01	76.6
Esophagus	C15	2742	4.2	1.7	2.3	20.0	1.66	69.3
Stomach	C16	36 525	55.9	22.1	31.2	17.9	2.10	78.3
Colon	C18	29 859	45.7	17.4	24.7	15.8	2.30	77.1
Rectum and anus	C19, C20	11 902	18.2	7.9	10.9	13.1	2.43	81.5
Liver	C22	13 535	20.7	7.0	10.4	29.3	1.26	32.8
Gallbladder etc.	C23, C24	10 200	15.6	4.7	7.1	32.3	1.18	40.5
Pancreas	C25	10 371	15.9	5.5	7.9	34.0	1.05	30.1
Larynx	C32	448	0.7	0.3	0.4	3.8	7.34	91.4
Trachea, bronchus and lung	C33, C34	22 817	34.9	12.8	18.4	25.1	1.51	66.5
Skin	C43, C44	4497	6.9	2.5	3.4	9.6	8.52	89.2
Breast (incl. CIS)	C50, D05	45 716	70.0	43.4	56.1	5.6	4.66	90.5
Uterus (incl. CIS)	C53–C55, D06	24 240	37.1	25.5	32.3	7.4	4.57	88.9
Uterus (only invasive)	C53–C55	17 285	26.5	16.1	20.8	10.0	3.26	85.7
Cervix uteri	C53	8674	13.3	8.8	11.3	7.1	3.65	89.4
Corpus uteri	C54	7430	11.4	6.5	8.5	5.6	5.41	89.6
Ovary	C56	7946	12.2	7.2	9.2	17.2	1.88	77.0
Bladder	C67	3713	5.7	1.8	2.7	18.8	2.19	74.5
Kidney, renal pelvis, ureter etc.	C64–C66, C68	4689	7.2	3.0	4.1	18.3	2.38	71.7
Brain and nervous system	C70–C72	2034	3.1	1.8	2.1	24.6	3.10	60.2
Thyroid	C73	6046	9.3	5.6	7.2	7.6	6.17	87.4
Malignant lymphoma	C81–C85, C96	8592	13.2	6.1	8.2	16.8	2.36	80.8
Multiple myeloma	C88–C90	2234	3.4	1.2	1.7	34.4	1.23	62.3
All leukaemias	C91–C95	3951	6.0	3.8	4.3	25.2	1.35	81.0

ICD-10th, International Classification of Disease, 10th Revision; DCO/I, proportion of cases with the death certificate only to incident cases; I/M, number of incidence/number of deaths; MV/I, proportion of microscopically verified cases to incident cases; CIS, carcinoma *in situ*.
[a]Per 100 000 population.

Table 2. Age-specific incidence in Japan according to sex and primary site, 2003

Primary sites	ICD-10th	All ages	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+
			Age group (years)																	
Male																				
All sites (incl. CIS)	C00–C96, D00–D09	372 374	401	290	190	416	656	1021	1510	2353	4422	7922	18 940	29 913	44 332	57 691	72 125	63 779	36 791	29 622
All sites	C00–C96	364 072	401	290	190	405	650	1020	1497	2310	4213	7732	18 421	29 054	43 110	56 281	70 601	62 386	36 217	29 294
Lip, oral cavity and pharynx	C00–C14	7835	2	0	2	8	34	39	99	127	117	316	626	924	1180	1342	1220	910	543	346
Esophagus	C15	13 658	0	0	0	0	0	0	0	14	93	317	850	1629	2351	2281	2621	1945	981	576
Stomach	C16	73 798	0	0	0	17	47	70	154	281	878	1741	4439	6714	9286	12 022	14 013	12 042	6472	5622
Colon	C18	35 262	0	3	0	8	18	54	120	204	339	713	1698	2905	4591	5634	7014	5589	3432	2940
Rectum and anus	C19, C20	21 892	0	0	1	8	5	15	83	158	420	709	1582	2564	3380	3828	3652	2925	1445	1117
Liver	C22	29 126	11	2	3	0	19	12	33	82	266	573	1792	2714	4018	5290	6146	4455	2127	1583
Gallbladder etc.	C23, C24	8755	0	0	0	0	0	1	4	23	57	79	294	410	820	1137	1483	1697	1438	1312
Pancreas	C25	12 511	0	0	0	0	14	4	1	41	157	194	727	1081	1666	1880	2247	2119	1365	1015
Larynx	C32	3921	0	0	0	0	19	0	0	6	31	72	229	434	604	713	746	616	304	147
Trachea, bronchus and lung	C33, C34	55 928	0	0	0	1	5	3	68	175	296	820	1944	3549	5091	7296	11 701	11 923	7446	5610
Skin	C43, C44	3325	0	0	3	0	13	42	68	50	46	77	107	148	349	358	572	590	364	538
Prostate	C61	40 062	0	0	0	0	0	0	0	0	9	58	430	1251	3704	6719	9914	9291	4852	3834
Bladder	C67	12 646	7	0	0	10	4	23	32	101	92	229	645	862	1196	1544	2623	2287	1520	1471
Kidney, renal pelvis, ureter etc.	C64–C66, C68	8217	14	5	0	0	26	50	35	70	164	280	648	834	932	1226	1487	1223	760	463
Brain and nervous system	C70–C72	2571	67	111	18	45	85	72	88	84	139	146	230	149	319	313	290	202	105	108
Thyroid	C73	2023	0	3	0	1	34	49	44	126	88	137	245	215	224	188	270	193	117	89
Malignant lymphoma	C81–C85, C96	12 881	12	38	76	96	113	123	175	307	528	680	791	1184	1415	2002	1705	1680	1107	849
Multiple myeloma	C88–C90	2251	0	0	0	0	0	0	4	8	10	33	88	184	240	344	349	450	304	237
All leukaemias	C91–C95	5606	138	94	50	77	73	162	142	81	200	211	319	459	518	795	844	699	390	354
Female																				
All sites (incl. CIS)	C00–C96, D00–D09	269 220	397	219	202	332	821	1909	4996	6722	9210	13 421	19 959	22 867	25 392	28 998	34 319	34 339	29 314	35 803
All site	C00–C96	255 939	397	219	202	315	612	1301	3433	5118	7788	12 156	18 900	21 931	24 287	28 108	33 190	33 601	28 888	35 493

Continued

Table 2. *Continued*

Primary sites	ICD-10th	All ages	Age group (years)																	
			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+
Lip, oral cavity and pharynx	C00–C14	3180	0	0	2	18	42	23	33	56	74	100	219	248	332	370	363	468	385	447
Esophagus	C15	2742	0	0	0	0	0	0	1	14	13	123	140	243	250	378	392	335	323	530
Stomach	C16	36 525	0	0	0	2	17	70	234	418	783	1101	1851	2752	3010	4149	5208	5706	4850	6374
Colon	C18	29 859	0	0	0	2	11	36	121	214	346	634	1480	2021	2853	3709	4420	4681	4120	5211
Rectum and anus	C19, C20	11 902	0	0	0	0	0	12	62	120	239	414	852	1162	1444	1511	1695	1602	1264	1525
Liver	C22	13 535	1	0	11	0	0	12	13	10	36	68	246	575	946	1989	2754	2677	2228	1969
Gallbladder etc.	C23–C24	10 200	0	0	0	4	0	0	6	4	44	108	229	337	609	894	1274	1758	2086	2847
Pancreas	C25	10 371	0	0	0	0	0	6	6	33	69	197	394	551	860	1080	1583	1619	1637	2336
Larynx	C32	448	0	0	2	0	0	0	7	2	0	38	2	37	59	83	47	92	39	40
Trachea, bronchus and lung	C33, C34	22 817	5	0	0	5	0	36	35	126	190	417	955	1525	2005	2774	3558	3831	3272	4083
Skin	C43, C44	4497	10	0	10	7	15	13	24	98	56	90	137	168	250	512	441	561	734	1371
Breast (incl. CIS)	C50, D05	45 716	0	0	0	0	29	222	934	1986	3547	5722	6882	5832	5657	4570	3724	3098	2009	1504
Uterus (incl. CIS)	C53–C55, D06	24 240	0	0	0	8	268	835	2479	2529	2299	2167	2432	2876	2030	1557	1609	1360	899	892
Uterus (only invasive)	C53–C55	17 285	0	0	0	2	77	259	988	1114	1146	1408	1978	2557	1791	1377	1531	1291	879	887
Cervix uteri	C53	8674	0	0	0	2	74	223	791	889	870	832	753	879	701	613	600	552	443	452
Corpus uteri	C54	7430	0	0	0	0	3	29	193	203	245	520	1148	1577	997	661	817	606	248	183
Ovary	C56	7946	0	0	20	40	47	150	182	258	412	683	1183	1183	801	695	761	536	488	507
Bladder	C67	3713	0	0	0	0	0	0	2	14	10	42	78	136	197	403	608	659	684	880
Kidney, renal pelvis, ureter etc.	C64–C66, C68	4689	17	8	8	4	2	3	26	25	111	95	348	345	441	559	693	737	593	674
Brain and nervous system	C70–C72	2034	53	27	27	21	9	28	106	43	46	54	79	156	233	223	217	208	225	279
Thyroid	C73	6046	0	0	11	21	89	133	233	325	339	448	715	716	723	591	704	443	225	330
Malignant lymphoma	C81–C85, C96	8592	19	33	13	45	81	86	117	113	217	282	592	637	808	918	1471	1248	969	943
Multiple myeloma	C88–C90	2234	0	0	0	0	0	0	9	11	33	20	81	84	200	215	375	378	368	460
All leukaemias	C91–C95	3951	114	98	32	68	81	44	108	96	97	147	289	321	319	411	483	476	378	389

Table 3. Age-specific incidence rate per 100 000 population in Japan according to sex and primary site, 2003

Primary sites	ICD-10th	All ages	Age group (years)																	
			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+
Male																				
All sites (incl. CIS)	C00–C96, D00–D09	597.7	13.5	9.5	6.1	11.6	16.3	22.1	30.8	55.2	111.9	199.2	379.7	661.4	1100.6	1643.2	2488.8	3093.1	3541.0	3954.9
All sites	C00–C96	584.3	13.5	9.5	6.1	11.3	16.2	22.0	30.6	54.2	106.6	194.5	369.3	642.4	1070.3	1603.0	2436.2	3025.5	3485.8	3911.1
Lip, oral cavity and pharynx	C00–C14	12.6	0.1	0.0	0.1	0.2	0.8	0.8	2.0	3.0	3.0	7.9	12.6	20.4	29.3	38.2	42.1	44.1	52.3	46.2
Esophagus	C15	21.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	2.4	8.0	17.0	36.0	58.4	65.0	90.4	94.3	94.4	76.9
Stomach	C16	118.4	0.0	0.0	0.0	0.5	1.2	1.5	3.1	6.6	22.2	43.8	89.0	148.4	230.5	342.4	483.5	584.0	622.9	750.6
Colon	C18	56.6	0.0	0.1	0.0	0.2	0.4	1.2	2.5	4.8	8.6	17.9	34.0	64.2	114.0	160.5	242.0	271.0	330.3	392.5
Rectum and anus	C19, C20	35.1	0.0	0.0	0.0	0.2	0.1	0.3	1.7	3.7	10.6	17.8	31.7	56.7	83.9	109.0	126.0	141.9	139.1	149.1
Liver	C22	46.7	0.4	0.1	0.1	0.0	0.5	0.3	0.7	1.9	6.7	14.4	35.9	60.0	99.8	150.7	212.1	216.1	204.7	211.3
Gallbladder etc.	C23, C24	14.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.5	1.4	2.0	5.9	9.1	20.4	32.4	51.2	82.3	138.4	175.2
Pancreas	C25	20.1	0.0	0.0	0.0	0.0	0.3	0.1	0.0	1.0	4.0	4.9	14.6	23.9	41.4	53.5	77.5	102.8	131.4	135.5
Larynx	C32	6.3	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.1	0.8	1.8	4.6	9.6	15.0	20.3	25.7	29.9	29.3	19.6
Trachea, bronchus and lung	C33, C34	89.8	0.0	0.0	0.0	0.0	0.1	0.1	1.4	4.1	7.5	20.6	39.0	78.5	126.4	207.8	403.8	578.2	716.7	749.0
Skin	C43, C44	5.3	0.0	0.0	0.1	0.0	0.3	0.9	1.4	1.2	1.2	1.9	2.1	3.3	8.7	10.2	19.7	28.6	35.0	71.8
Prostate	C61	64.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	1.5	8.6	27.7	92.0	191.4	342.1	450.6	467.0	511.9
Bladder	C67	20.3	0.2	0.0	0.0	0.3	0.1	0.5	0.7	2.4	2.3	5.8	12.9	19.1	29.7	44.0	90.5	110.9	146.3	196.4
Kidney, renal pelvis, ureter etc.	C64–C66, C68	13.2	0.5	0.2	0.0	0.0	0.6	1.1	0.7	1.6	4.1	7.0	13.0	18.4	23.1	34.9	51.3	59.3	73.1	61.8
Brain and nervous system	C70–C72	4.1	2.3	3.6	0.6	1.3	2.1	1.6	1.8	2.0	3.5	3.7	4.6	3.3	7.9	8.9	10.0	9.8	10.1	14.4
Thyroid	C73	3.2	0.0	0.1	0.0	0.0	0.8	1.1	0.9	3.0	2.2	3.4	4.9	4.8	5.6	5.4	9.3	9.4	11.3	11.9
Malignant lymphoma	C81–C85, C96	20.7	0.4	1.2	2.4	2.7	2.8	2.7	3.6	7.2	13.4	17.1	15.9	26.2	35.1	57.0	58.8	81.5	106.5	113.4
Multiple myeloma	C88–C90	3.6	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.3	0.8	1.8	4.1	6.0	9.8	12.0	21.8	29.3	31.6
All leukaemias	C91–C95	9.0	4.6	3.1	1.6	2.1	1.8	3.5	2.9	1.9	5.1	5.3	6.4	10.1	12.9	22.6	29.1	33.9	37.5	47.3
Female																				
All sites (incl. CIS)	C00–C96, D00–D09	412.2	14.1	7.5	6.8	9.7	21.4	42.6	104.0	159.9	235.7	339.5	397.2	492.1	594.0	744.7	991.9	1211.3	1479.0	1904.4
All site	C00–C96	391.9	14.1	7.5	6.8	9.2	16.0	29.1	71.5	121.8	199.3	307.5	376.1	471.9	568.1	721.8	959.2	1185.2	1457.5	1887.9

Continued

Table 3. *Continued*

Primary sites	ICD-10th	All ages	Age group (years)																	
			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+
Lip, oral cavity and pharynx	C00–C14	4.9	0.0	0.0	0.1	0.5	1.1	0.5	0.7	1.3	1.9	2.5	4.4	5.3	7.8	9.5	10.5	16.5	19.4	23.8
Esophagus	C15	4.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.3	3.1	2.8	5.2	5.8	9.7	11.3	11.8	16.3	28.2
Stomach	C16	55.9	0.0	0.0	0.0	0.1	0.4	1.6	4.9	9.9	20.0	27.9	36.8	59.2	70.4	106.5	150.5	201.3	244.7	339.0
Colon	C18	45.7	0.0	0.0	0.0	0.1	0.3	0.8	2.5	5.1	8.9	16.0	29.5	43.5	66.7	95.2	127.7	165.1	207.9	277.2
Rectum and anus	C19, C20	18.2	0.0	0.0	0.0	0.0	0.0	0.3	1.3	2.9	6.1	10.5	17.0	25.0	33.8	38.8	49.0	56.5	63.8	81.1
Liver	C22	20.7	0.0	0.0	0.4	0.0	0.0	0.3	0.3	0.2	0.9	1.7	4.9	12.4	22.1	51.1	79.6	94.4	112.4	104.7
Gallbladder etc.	C23, C24	15.6	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.1	1.1	2.7	4.6	7.3	14.2	23.0	36.8	62.0	105.2	151.4
Pancreas	C25	15.9	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.8	1.8	5.0	7.8	11.9	20.1	27.7	45.8	57.1	82.6	124.3
Larynx	C32	0.7	0.0	0.0	0.1	0.0	0.0	0.0	0.1	0.0	0.0	1.0	0.0	0.8	1.4	2.1	1.4	3.2	2.0	2.1
Trachea, bronchus and lung	C33, C34	34.9	0.2	0.0	0.0	0.1	0.0	0.8	0.7	3.0	4.9	10.5	19.0	32.8	46.9	71.2	102.8	135.1	165.1	217.2
Skin	C43, C44	6.9	0.4	0.0	0.3	0.2	0.4	0.3	0.5	2.3	1.4	2.3	2.7	3.6	5.8	13.1	12.7	19.8	37.0	72.9
Breast (incl. CIS)	C50, D05	70.0	0.0	0.0	0.0	0.0	0.8	5.0	19.4	47.3	90.8	144.8	137.0	125.5	132.3	117.4	107.6	109.3	101.4	80.0
Uterus (incl. CIS)	C53–C55, D06	37.1	0.0	0.0	0.0	0.2	7.0	18.7	51.6	60.2	58.8	54.8	48.4	61.9	47.5	40.0	46.5	48.0	45.4	47.4
Uterus (only invasive)	C53–C55	26.5	0.0	0.0	0.0	0.1	2.0	5.8	20.6	26.5	29.3	35.6	39.4	55.0	41.9	35.4	44.2	45.5	44.3	47.2
Cervix uteri	C53	13.3	0.0	0.0	0.0	0.1	1.9	5.0	16.5	21.2	22.3	21.0	15.0	18.9	16.4	15.7	17.3	19.5	22.4	24.0
Corpus uteri	C54	11.4	0.0	0.0	0.0	0.0	0.1	0.6	4.0	4.8	6.3	13.2	22.8	33.9	23.3	17.0	23.6	21.4	12.5	9.7
Ovary	C56	12.2	0.0	0.0	0.7	1.2	1.2	3.4	3.8	6.1	10.5	17.3	23.5	25.5	18.7	17.8	22.0	18.9	24.6	27.0
Bladder	C67	5.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.3	1.1	1.6	2.9	4.6	10.3	17.6	23.2	34.5	46.8
Kidney, renal pelvis, ureter etc.	C64–C66, C68	7.2	0.6	0.3	0.3	0.1	0.1	0.1	0.5	0.6	2.8	2.4	6.9	7.4	10.3	14.4	20.0	26.0	29.9	35.9
Brain and nervous system	C70–C72	3.1	1.9	0.9	0.9	0.6	0.2	0.6	2.2	1.0	1.2	1.4	1.6	3.4	5.5	5.7	6.3	7.3	11.4	14.8
Thyroid	C73	9.3	0.0	0.0	0.4	0.6	2.3	3.0	4.9	7.7	8.7	11.3	14.2	15.4	16.9	15.2	20.3	15.6	11.4	17.6
Malignant lymphoma	C81–C85, C96	13.2	0.7	1.1	0.4	1.3	2.1	1.9	2.4	2.7	5.6	7.1	11.8	13.7	18.9	23.6	42.5	44.0	48.9	50.2
Multiple myeloma	C88–C90	3.4	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.3	0.8	0.5	1.6	1.8	4.7	5.5	10.8	13.3	18.6	24.5
All leukaemias	C91–C95	6.0	4.0	3.4	1.1	2.0	2.1	1.0	2.2	2.3	2.5	3.7	5.8	6.9	7.5	10.6	14.0	16.8	19.1	20.7

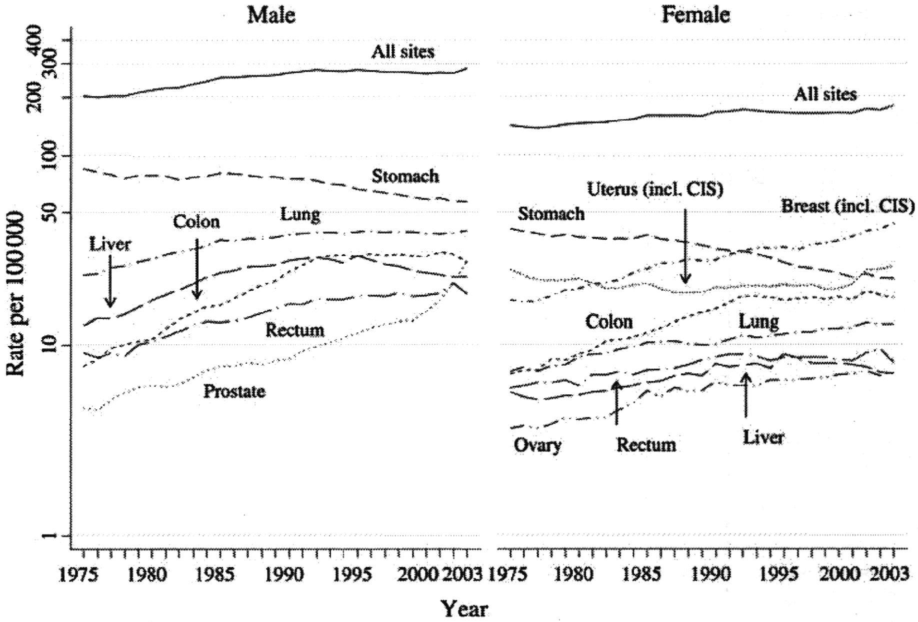

Figure 1. Trends of age-standardized cancer incidence rates for five major sites and specific sites for each sex (standard population: the world population). CIS, carcinoma *in situ*.

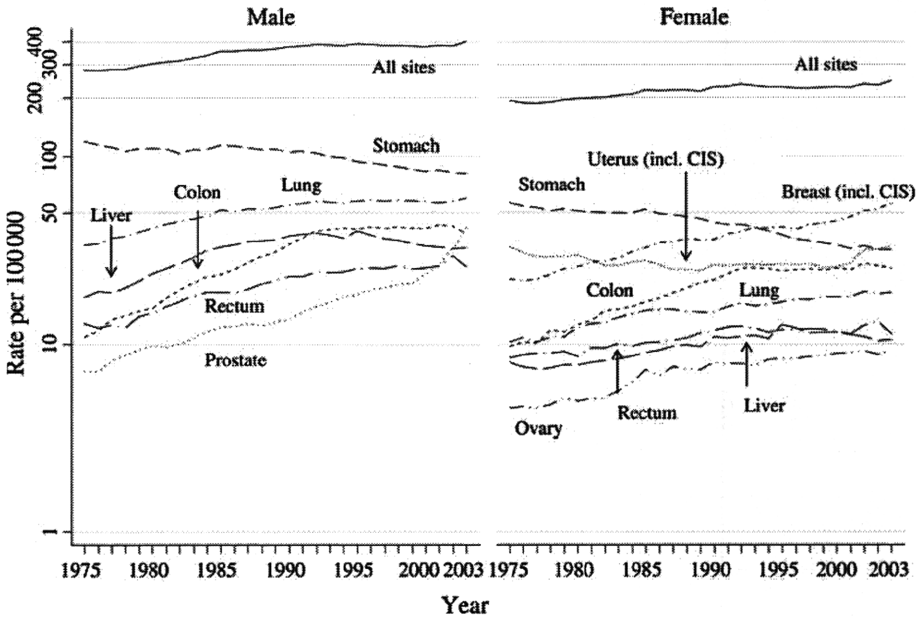

Figure 2. Trends of age-standardized cancer incidence rates for five major sites and specific sites for each sex (standard population: 1985 Japanese model population)

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Conflict of interest statement

None declared.

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Do the Japanese feel more suspicious about cancer registration than the British?

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ABSTRACT

Background: Cancer registration is indispensable, providing useful statistical measures for the appropriate evaluation of cancer control programs and medical treatment or screening. *Methods*: Following the British national survey on attitudes toward cancer registration, we conducted an investigation to correctly evaluate the general opinion of the Japanese population in this regard. We randomly recruited 3000 men and women aged 20–69 years from a research database. *Results*: Only 4% of all respondents had heard about the cancer registry system before the investigation. However, 77% of respondents thought that cancer registration was useful. Forty-three percent of respondents answered, regardless of the strictness of the data protection, that privacy had been violated if the registration occurred without an individual explanation. Compared with the British survey results, Japanese people seemed to be more suspicious about the largely unknown system of cancer registry. Nonetheless, it is noteworthy that Japanese respondents did not show active opposition to cancer registration; they tended to choose "I don't know" instead of "no" to questions asking if they supported the registry system. Multivariate analysis showed that male sex, older age, and living in the southern region were the factors significantly associated with support for cancer registration. *Conclusions*: We can seek society's understanding toward cancer registration by actively utilizing information from cancer registries, by using examples of how data are actually used that have wide appeal, and by educating the public on how the data are treated under the complete privacy policy.

1. Introduction

1.1. Cancer registration in Japan

Registration of cancer cases is indispensable. It provides useful statistical measures for the appropriate evaluation of cancer control programs and medical treatment or screening. The Japanese cancer registration system has been running for more than 50 years, with the first population-based cancer registry having been started in Miyagi prefecture in 1951 [1]. Although cancer registries were in place in 35 of the 47 prefectures as of June 2008 [2], Japan lags behind Europe and the USA in completeness and timeliness of the registry system. In the Cancer Incidence in Five Continents vol. IX, for example, only seven Japanese registries published data [3]. The following reasons for this delay have been postulated: (1) cancer is not a reportable disease in Japan, and therefore the government is not actively engaged in the registration system; (2) hospital medical information systems are still being developed, and treating doctors are excessively burdened with cancer-recording tasks; and (3) medical institutions and the public do not sufficiently understand the cancer registry system. Moreover, collection of cancer incidence data from medical institutions is sometimes considered a violation of privacy, although submission of patient data to the cancer registry is exempt from the Private Information Protection Law [4].

1.2. Results of prior surveys on cancer registries in other countries and in Japan

The British national survey on cancer registration, organized by the research group of Dr. Coleman of the London School of Hygiene and Tropical Medicine, was published in 2006 [5]. The survey examined the public's perception of the use of personal medical data by the national cancer registry. It concluded that the British people were supportive of cancer registration and were generous in supplying personal information used for the public interest, but only if this information was manipulated under strict conditions.

In Japan, the Cancer Control Act was approved in 2006 and the Basic Plan to Promote Cancer Control Program was implemented in 2007, and these policies recognize cancer registration as a central and important component for cancer control. Several surveys on attitude toward cancer registration have since been conducted in Japan. In the "Public opinion survey on cancer controls" organized by the Cabinet Office, 85.6% of the respondents "did not know about

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cancer registration" [6]. One question gave a simple explanation of the cancer registration system in Japan and in foreign countries, and asked how the respondents felt about a nationwide cancer registry. Only half of the respondents (54.6%) thought that such a system was necessary. In the "Public opinion poll on health and the aged society" conducted by the Mainichi Newspaper [7], the questionnaire asked: "A cancer registry system that registers the patient's name, date of birth, and medical information is enshrined in law in Europe and the United States. The data provide information about the extent and patterns of cancer and are used to evaluate treatment. What do you think of the cancer registry system?" Of those who responded, 18% answered, "it is necessary to enshrine the system in law because it is in our interests," and 62% answered, "cases should be registered only when patients give consent". Moreover, 15% answered "cancers should not have to be registered".

These survey results might suggest that Japanese people generally consider cancer registries to be unnecessary, and that this attitude is an obstacle to the development of cancer registration in Japan. However, the response rate of about 50% for these surveys indicates probable recruitment bias in that only people who are interested in cancer or in politics are likely to have answered. In addition since most people are unfamiliar with the topic of cancer registration, they are therefore obliged to answer the questions without sufficient information. The negative presentation of the question, such as "cancer registration is not included in the Cancer Control Act" and the answer choice that "priority should be put on protection of personal information, and cancer should be registered only if patients themselves agree" easily evoke anxiety, and could lead to the results lacking validity.

We therefore need to reinvestigate opinion regarding cancer registration, to resolve the above-mentioned problem and to correctly evaluate the general opinion of the Japanese population. Moreover, a different investigative perspective from that of journalists or administrative officers is needed. The present study aimed to: (1) increase the response rate to avoid recruitment bias, (2) add objective and sufficient explanation about "cancer registration" to the questions, and (3) use a validated, internationally comparable questionnaire in order to assess the Japanese situation objectively.

2. Methods

2.1. Recruitment and questionnaire

For participant recruitment we used the database of Nikkei Research Ltd., in which about 140,000 people are registered as research monitors. These monitors are paid to be engaged in various types of research according to the study objectives. Mindful of the importance of a high response rate, we decided to use this service. We stratified individuals by sex, age, and address according to the proportions of the most recent National Census. Finally 3000 men and women aged from 20 to 69 were recruited at random from the database according to these proportions.

We carefully translated the questionnaire that was used for the British survey so as not to change the intention of the original questions [5], and added two questions which were regarded as important in Japan (Q7 and Q8). Back translation of the Japanese version into English was performed by a professional translator. The research team verified that the two English versions maintained the same meaning for each question. The questionnaire was composed of 17 questions and was mailed to participants in December 2007.

2.2. Statistical methods

A confidence interval of 95% was calculated for each answer. Correlations between the answers and socio-demographic variables were examined by chi-square test. Attitude towards cancer registration and privacy protection were enquired about in Q8, and respondents answered this question by means of a Likert-type scale (1–5). For this discrete variable, an ordered logit model was employed to test for a significant effect of respondents' background factors, while controlling for each variable. The ordered logit model predicts the probability of an event occurring, allowing for more than two ordered response categories in a dependent variable. The model makes the proportional odds assumption for being in a chosen category or higher compared to being in a lower category. In addition we obtained modeled cut-off points between ordered categories allowing us to interpret the respondents' preference for each answer.

Table 1
Background of the respondents.

	n	%
Sex		
Male	1164	47.9
Female	1265	52.1
Total	2429	100.0
Age (years)		
20–29	384	15.9
30–39	495	20.4
40–49	465	19.2
50–59	588	24.3
60–69	490	20.2
Total	2422	100.0
Marital status		
Spouse	1807	74.4
No spouse	621	25.6
Total	2428	100.0
Children		
Yes	1741	76.0
No	649	28.3
Total	2290	100.0
Region		
Hokkaido, Tohoku	305	12.6
Kanto	832	34.3
Chubu	363	15.0
Kinki	415	17.1
Chugoku, Shikoku	238	9.8
Kyushu, Okinawa	274	11.3
Total	2427	100.0
Occupation		
Company employee/executive	900	37.3
Public officer	143	5.9
House husband/ wife	452	18.7
Self-employed	153	6.3
Freelance professional (MD, lawyer, etc.)	45	1.9
Part-time worker	347	14.4
Retired/unemployed	250	10.4
Others	122	5.1
Total	2412	100.0
Educational background		
Junior high school	92	3.8
High school	783	32.3
College	520	21.4
University/graduate school	1031	42.5
Total	2426	100.0
Household income		
≤4 million yen	567	23.8
4–8 million yen	993	41.6
>8 million yen	826	34.6
Total	2386	100.0

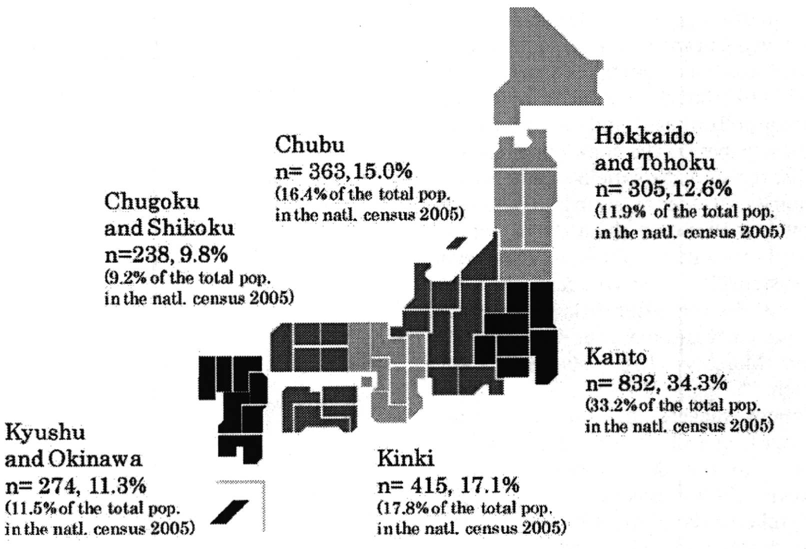

Fig. 1. Geographical distribution of the respondents.

3. Results

3.1. Respondents

A valid response was obtained from 2430 people, giving a response rate of 81.0%. Table 1 shows the socio-demographic background of respondents. When we analyzed attributes of those who responded to questions, male to female proportion was 47.9:52.1; 16% were in their 20 s, 20% were in their 30 s, 19% were in their 40 s, 24% were in their 50 s, and 20% were in their 60 s. Geographical distribution of the respondents is shown in Fig. 1. The distribution of the respondents was close to the population distribution according to the 2005 national census. No significant difference was found in participation in the study according to these socio-demographic variables.

3.2. British and Japanese results

Table 2 shows the results for each question for the present Japanese respondents and the original British respondents. A few of the Japanese respondents (9%) felt that their privacy was violated when they received invitations to cancer screening (Q1). Four percent of all respondents in Japan had heard about cancer registries before reading the questionnaire, whereas this proportion in the UK was 17% (Q2). However, among Japanese respondents, 77% thought the cancer registry system was useful, while 3% answered that it was not (Q3). On the other hand, 95% of British respondents considered the cancer registry system useful. Regarding support for a new law that required medical information of cancer patients to be registered (Q4), more than 30% of Japanese respondents answered "I don't know," although nearly 60% supported such a law. In contrast, 81% of British respondents supported such a law.

In Japan, 43% answered that, regardless of the strictness of data protection, privacy had been violated if the registration occurred without an individual explanation (Q5), while over 80% of the British respondents replied that privacy had not been violated in this situation. The largest difference in response between the two countries was seen for this question. The proportion of Japanese respondents who believed privacy had been violated when individuals were contacted for research participation based on the cancer registry list decreased to 24% (Q6).

In Q7, an original question in the present study, 57% of respondents stated that residents of prefectures that had a registry system would be at an unfair advantage if this system was not available elsewhere (Table 3). For Q8, which asked about the balance between the violation of privacy and the usefulness of cancer registration, the mode of responses was 4. Answers were slightly skewed toward recognition of the system's usefulness.

3.3. Relationship between responses and socio-economic background

An overview of the relationship between responses and socio-economic background of the subjects is presented in Table 4. Because we conducted univariate analysis, all variables on socio-economic background were related to the question answers.

When compared with women, male respondents were more likely to believe that cancer registration provides useful information. Men were also more likely to support a new law to enforce cancer registration, and they were less likely to report invasion of privacy in Q5 and 6. Moreover, the number of respondents who felt that provision of information to a cancer registry constituted a violation of privacy decreased with age in both sexes (Fig. 2).

In Q5, a geographical difference was seen when respondents were divided into six regions. In the Kanto region, which includes the capital, Tokyo, 37.9% of respondents did not feel that their privacy was violated by provision of information to a cancer registry. The variation according to geographical region was remarkable; this proportion was 49.6% in the Kyushu and Okinawa area, in the south of Japan.

As for profession of the respondents, 85.3% of public officers answered "yes" in Q3, and this proportion was the highest. In contrast, home makers and part-time workers were less likely to answer "yes" (73.9% and 70.0%, respectively). Self-employed people and the unemployed/retired were most supportive of the cancer registration: 67.3% and 64.4%, respectively, answered "yes" to Q4. These groups were also less likely to report violation of privacy in response to Q5 (36.0% and 28.8%, respectively). Freelance professionals (doctors, lawyers, etc.) were significantly more aware of the cancer registry system; 15.6% answered that they had heard of it. At the same time, 51.1% of this group thought that registration without individual explanation violated their privacy (Q5). Respondents with higher levels of education (university/graduate school) tended to have positive opinions about cancer registration in Q5 and 6.

Table 2
Results of the surveys in Japan and the UK.

	Yes			No			Don't know		
	n	%	95% CI	*n*	%	95% CI	*n*	%	95% CI
Q1. Many people get letters from their primary care trust (previously called the health authority) about screening tests for cancer, such as cervical smear tests or bowel cancer screening. If your primary care trust sent you a letter inviting you to a screening test, do you think this would be an invasion of your privacy? (corresponding to Q3 in the UK study)									
Japan	209	9	7–10	2037	84	82–85	179	7	6–8
UK	93	3	2–4	2740	95	94–97	39	1	1–2
JP-UK		6			−11			6	
Q2. In Japan we have regional cancer registries, which are confidential databases of people who have cancer. Information is held under strict security. Have you ever heard of a cancer registry before? (corresponding to Q4 in the UK study)									
Japan	103	4	3–5	2254	93	92–94	72	3	2–4
UK	479	17	15–18	2362	82	81–84	32	1	1–2
JP-UK		−13			11			2	
Q3. The cancer registry is the only reliable source of information for monitoring trends in the risk of getting cancer and trends in cancer survival. The information is used to compare the effectiveness of cancer treatment around the country, and to evaluate the success of cancer screening programs. Do you think this is useful information for us to have in this country? (corresponding to Q5 in the UK study)									
Japan	1863	77	75–78	75	3	2–4	491	20	19–22
UK	2737	95	94–96	68	2	2–3	69	2	2–3
JP-UK		−18			1			18	
Q4. In the USA, Denmark, Sweden, South Korea, and many other countries, all cases of cancer have to be notified to the cancer registry by law. In the future, there may need to be a similar law in Japan, to ensure that the cancer registries continue to have the information needed for monitoring cancer in Japan. Would you support a new law that meant all cases of cancer have to be notified to the cancer registries? (corresponding to Q6 in the UK study)									
Japan	1423	59	57–61	258	11	9–12	748	31	29–33
UK	2335	81	79–83	343	12	10–13	194	7	6–8
JP-UK		−22			−1			24	
Q5. Currently, survival rates from cancer can only be compared between regions of the country by knowing cancer patients' names and addresses. If you had cancer and your name and address was included automatically in the cancer registries, to be held confidentially and under strict security, do you think this would be an invasion of your privacy? (corresponding to Q8 in the UK study)									
Japan	1033	43	41–44	1029	42	40–44	366	15	14–17
UK	446	16	14–17	2326	81	79–83	101	4	3–4
JP-UK		27			−39			11	
Q6. Finally, suppose that a research group from a university medical school wanted to do research with people who had a particular type of cancer. If you had cancer and the cancer registries sent you a letter, via your doctor, asking if you wanted to take part in the research, do you think this would be an invasion of your privacy? (corresponding to Q9 in the UK study)									
Japan	594	24	23–26	1486	61	59–63	348	14	13–16
UK	261	9	8–10	2508	87	86–89	104	4	3–5
JP-UK		15			−26			10	
Q16. Have any members of your immediate family (for instance, parents, children, husband/wife/partner, brothers, sisters) ever had cancer? (corresponding to Q2 in the UK study)									
Japan	1056	44	42–45	1340	55	53–57	24	1	1–1
UK	1298	45	43–47	1528	53	51–56	50	2	1–2
JP-UK		−1			2			−1	
Q17. Could I please start by asking if you have, or you have ever had, cancer? (corresponding to Q1 in the UK study)									
Japan	96	4	3–5	2274	94	93–95	49	2	1–3
UK	174	6	5–7	2701	94	93–95	–	–	–
JP-UK		−2			0			–	

Cancer experience, either of the individual or their family, was related to awareness of the cancer registry system (6.0% for "without experience" and 8.3% for "with an experience", respectively). Cancer experience also seemed to be related to a positive opinion of cancer registration in Q5 and 6; however, this correlation disappeared when age was adjusted for.

In Q8, we performed ordered logit modeling in order to calculate the adjusted odds ratio (OR) of the respondents'

Table 3
Results for Q7 and Q8 (original questions in the Japanese questionnaire).

Yes			No			Don't know		
n	%	95% CI	*n*	%	95% CI	*n*	%	95% CI
Q7. Suppose that there is no cancer registry in your region which is monitoring trends in the risk of getting cancer and trends in cancer survival. Do you feel that other regions have an unfair advantage by using their cancer registry information for evaluation of regional cancer screening and treatment, or for cancer control?								
1393	57	55–59	631	26	24–28	401	17	16–18

I think this is an invasion of our privacy	1		2		3		4		5		I think this is useful information for us to have in this country
	n	%	*n*	%	*n*	%	*n*	%	*n*	%	
Q8. Cancer registries are reliable information sources for cancer control, as they allow us to compare the outcomes of treatment and to evaluate anti-cancer programs by providing cancer patients' names and addresses. What would you think if this were done without the individual consent of the patients? Please circle the number that best represents your opinion.											
	314	13	542	22	545	22	658	27	362	15	