RESEARCH ARTICLE

Editorial Process: Submission:04/27/2018 Acceptance:10/18/2018

Influence of Income on Cancer Incidence and Death among Patients in Aomori, Japan

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Abstract

Background: Aomori Prefecture has experienced the highest cancer-related mortality rates since the 2000s in Japan. In addition, income of residents in Aomori Prefecture is lower than that of a countrywide average. Aims of this study were to examine the relationships of the incidence and mortality rates of common cancers (stomach, colorectal, liver, lung, breast, cervical, and prostate) with the income levels of residential income area and clarify the factors contributing to the high mortality rates in Aomori prefecture.**Methods:** We included data on all patients diagnosed with stomach, colorectal, liver, lung, breast, cervical, or prostate cancer in the Aomori cancer registry database between 2010 and 2012. Age-standardized incidence rates and incidence rate ratios were calculated. Risk of cancer mortality related to economic disparities was determined via multivariable Cox regression analysis and adjusted for age, sex, and stage at diagnosis in the multivariable model. **Results:** We identified 21,240 eligible cancer patients. There were no differences in AIRs and IRRs among patients with stomach, colorectal, or lung cancer according to income. Contrarily, AIRs and IRRs were higher in higher-income areas than in lower-income areas among patients with breast, cervical, or prostate cancer. There were no significant differences in HRs according to income for any cancer type. **Conclusions:**Patients with higher income were diagnosed with early-stage disease more frequently, and they had higher AIRs for breast, cervical, and prostate cancers than those with middle and low incomes. However, there were no significant differences in hazard ratios.

Keywords: Incidence- mortality- socioeconomic status

Asian Pac J Cancer Prev, **19 (11)**, 3193-3202

Introduction

The incidence and mortality rates of stomach, liver, and cervical cancers are higher in lower-income countries than in higher-income countries (Ott et al., 2011). By contrast, those of lung, colorectal, and breast cancer are higher in higher-income countries (Torre et al., 2016). Individuals with higher levels of income and education are more likely to participate in cancer screening and treatment, thus explaining the lower rates of certain forms of cancer.

Meanwhile, risk factors for cancer include smoking, overweight and obesity, drinking, and certain chronic infections (Anand et al., 2008). Specifically, infections caused by Helicobacter pylori, human papillomavirus, and the hepatitis B and C viruses are the leading causes of stomach, cervical, and liver cancers, respectively (Oh et al., 2014). Previous studies reported that chronic infections are more likely to cause cancer in lower-income countries, further explaining differences in cancer incidence between lower- and higher-income nations (Ott et al., 2011; Bruni et al., 2016). Although the incidence of infection-related cancers declined in most higher-income countries, that of liver and stomach cancers is higher in Japan than in other countries (Ferlay et al., 2012).

In Japan, the overall incidence of cancer is increasing, and the disease has been a leading cause of death since 1981 (Vital statistics Japan). Specifically, the incidence of colorectal, lung, breast, pancreas, cervical, and prostate cancers has been increasing in Japan due to its aging society, although general cancer-related mortality has been decreasing (Vital statistics Japan). Some Japanese studies noted the inverse associations of cervical, endometrial, and colorectal cancer incidence and survival with area deprivation (Ueda et al., 2006; Miki et al., 2014). However, there have been few population-based studies of the association of area income with cancer death in Japan.

Aomori Prefecture has experienced the highest cancer-related mortality rates since the 2000s in Japan. Conversely, other prefectures successfully decreased cancer mortality rates. Thus, revealing the barriers to improving cancer-related mortality rates in Aomori Prefecture is of the utmost importance. It is assumed that access to hospitals and medical treatment may be an important factor in Aomori Prefecture because of its

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aging population and shortage of public transportation. In addition, the annual income of residents in Aomori Prefecture is lower than that of a countrywide average, 2,405,000 yen vs. 3,057,000 yen (System of National Accounts).

Aomori Prefecture consists of 40 municipal governments, and these regions have varied economic conditions (Supplement and supporting data). It is presumed that this inequality of economic conditions might be associated with cancer incidence and mortality. Therefore, the aims of this study were to examine the relationships of the incidence and mortality rates of common cancers (stomach, colorectal, liver, lung, breast, cervical, and prostate) in Japan with the income levels of the 40 municipalities in Aomori Prefecture and clarify the factors contributing to the high mortality rates in the prefecture.

Materials and Methods

Patients

We included data on all patients diagnosed with stomach, colorectal, liver, lung, breast, cervical, or prostate cancer in the Aomori cancer registry database between 2010 and 2012, and the patients were followed up until December 2013. Death certificate only (DCO) cases were excluded. The percentage of DCO cases (%DCO) is one of the quality indicators of cancer registry data, and the %DCO values of the Aomori cancer registry for 2010, 2011, and 2012 were 5.1%, 2.6%, and 2.0%, respectively.

Data collection

We obtained the following clinical and demographic information via data extraction: sex, age at diagnosis, date of diagnosis, survival duration, primary tumor site (International Classification of Disease for Oncology, Third Edition; site code C16, C18–C20, C22, C33–C34, C50, C53, C61), stage at diagnosis, treatment administered (surgery, endoscopy, radiotherapy, chemotherapy, endocrine therapy, and other treatment), and address code. Stage at diagnosis was classified as in situ, localized (confined to the organ of origin), regional (invasion of adjacent organs or tissues and/or regional lymph node metastasis), distant (the presence of any distant metastasis), or unknown according to the Surveillance, Epidemiology, and End Results summary stage at diagnosis (Young et al., 2001). Income data for the 40 municipalities in 2010 were obtained from the Aomori Prefectural Government homepage (Municipal inhabitant's accounts statistics in Aomori prefecture), and income was classified into four groups by quartile as follows: lowest, mid-low, mid-high, and highest (Supplement and supporting data). The population of the municipalities in 2011–2012 was calculated using the interpolation method based on the population data of the National Census of Japan in 2010 and 2015 (National Census of Japan).

Statistical analysis

Age-standardized incidence rates (AIRs) were calculated using the direct method based on the Japanese standard population. The incidence rate ratios (IRRs) were calculated using the lowest income area as the reference. The risk of cancer mortality related to economic disparities was determined via multivariable Cox regression analysis and adjusted for age, sex, and stage at diagnosis in the multivariable model. Hazard ratios (HRs) were calculated using Stata 13 statistical software (StataCorp LLP, College Station, TX, USA).

Results

We identified 21,858 eligible patients, but the data for 618 patients were excluded for the following reasons: DCO, 616 cases; unknown address, 1 case; and unknown sex, 1 case.

Table 1 presents the characteristics of patients with various cancer. The proportions of patients with stomach or colorectal cancer who were diagnosed at early and late stages were similar among the income groups, although treatment was not equitable among the groups. The proportions of patients with stomach or colorectal cancer who were treated with surgery, radiotherapy, and chemotherapy were higher in higher-income areas than in lower-income areas. However, the proportion of patients with stomach cancer who were treated with endoscopic therapy was highest in the lowest income area. A higher proportion of patients with liver cancer received chemotherapy in higher-income areas than in lower-income areas. The proportion of patients who received other treatments (percutaneous ethanol injection therapy, radiofrequency ablation, and hepatic transcatheter arterial chemoembolization) was higher in higher-income areas than in lower-income areas. No significant differences in stage at diagnosis according to income were noted among patients with lung cancer. However, the proportion of patients with lung cancer who were treated with chemotherapy increased with increasing income. Meanwhile, the proportion of patients with breast cancer who were diagnosed at an early stage (in situ or localized) was higher in higher-income areas than in lower-income areas. Additionally, the proportions of patients with breast cancer who were treated with radiotherapy and endocrine therapy were highest in the highest income area. Among patients with cervical cancer, the proportion of patients who were diagnosed at an early stage (in situ or localized) was lowest in the lowest income area, and the proportion of patients treated with surgery was higher in higher-income areas than in lower-income areas. Conversely, the proportion of patients treated with chemotherapy was lower in lower-income areas. Among patients with prostate cancer, patients in the highest income group were most likely to be diagnosed at an early stage (localized). Additionally, the proportion of patients who received radiotherapy was higher in higher-income areas than in lower-income areas.

Table 2 shows the AIRs and IRRs by income and cancer type. Figure 1 shows scatter plot between AIRs and residential income. There were no differences in AIRs and IRRs among patients with stomach, colorectal, or lung cancer according to income. Contrarily, AIRs and IRRs were higher in higher-income areas than in lower-income areas among patients with breast, cervical,

Table 1. Characteristics of Patients with Cancer

Community income	Stomach							
	Lowest n=496		Mid-low n=583		Mid-high n=1297		Highest n=1933	
	N	%	N	%	N	%	N	%
Sex								
Men	353	71.2	392	67.2	877	67.6	1,347	69.7
Women	143	28.8	191	32.8	420	32.4	586	30.3
Age at diagnosis, years								
-59	54	10.9	66	11.3	160	12.3	304	15.7
60-69	116	23.4	132	22.6	343	26.4	501	25.9
70-79	193	38.9	219	37.6	445	34.3	671	34.7
80+	133	26.8	166	28.5	349	26.9	457	23.6
Stage at diagnosis								
In situ	9	1.8	6	1.0	4	0.3	3	0.2
Localized	237	47.8	266	45.6	598	46.1	833	43.1
Regional	97	19.6	119	20.4	243	18.7	462	23.9
Distant	90	18.1	126	21.6	282	21.7	428	22.1
Unknown	63	12.7	66	11.3	170	13.1	207	10.7
Surgical treatment								
Surgery	214	43.1	280	48.0	631	48.7	969	50.1
Non-surgery	235	47.4	274	47.0	593	45.7	871	45.1
Unknown	47	9.5	29	5.0	73	5.6	93	4.8
Endoscopic therapy								
Endoscopic therapy	121	24.4	105	18.0	224	17.3	363	18.8
Non-endoscopic therapy	333	67.1	447	76.7	994	76.6	1,473	76.2
Unknown	42	8.5	31	5.3	79	6.1	97	5.0
Radiotherapy treatment								
Radiotherapy	1	0.2	5	0.9	12	0.9	17	0.9
Non-radiotherapy	444	89.5	548	94	1,208	93.1	1,819	94.1
Unknown	51	10.3	30	5.1	77	5.9	97	5.0

	Colorectal							
	Lowest n=664		Mid-low n=810		Mid-high n=1885		Highest n=3119	
Sex								
Men	382	57.5	483	59.6	1071	56.8	1785	57.2
Women	282	42.5	327	40.4	814	43.2	1334	42.8
Age at diagnosis, years								
-59	121	18.2	108	13.3	338	17.9	514	16.5
60-69	154	23.2	213	26.3	501	26.6	879	28.2
70-79	219	33	293	36.2	620	32.9	1079	34.6
80+	170	25.6	196	24.2	426	22.6	647	20.7
Stage at diagnosis								
In situ	139	20.9	166	20.5	341	18.1	620	19.9
Localized	191	28.8	244	30.1	585	31	1032	33.1
Regional	135	20.3	176	21.7	429	22.8	690	22.1
Distant	104	15.7	148	18.3	334	17.7	515	16.5
Unknown	95	14.3	76	9.4	196	10.4	262	8.4

Table 1. Continued

	Colorectal							
	Lowest		Mid-low		Mid-high		Highest	
	n=664		n=810		n=1,885		n=3,119	
Surgical treatment								
Surgery	359	54.1	512	63.2	1,168	62.0	2,000	64.1
Non-surgery	212	31.9	250	30.9	612	32.5	972	31.2
Unknown	93	14.0	48	5.9	105	5.6	147	4.7
Endoscopic therapy								
Endoscopic therapy	169	25.5	166	20.5	404	21.4	721	23.1
Non-endoscopic therapy	426	64.2	591	73.0	1,371	72.7	2229	71.5
Unknown	69	10.4	53	6.5	110	5.8	169	5.4
Radiotherapy treatment								
Radiotherapy	2	0.3	3	0.4	12	0.6	27	0.9
Non-radiotherapy	560	84.3	754	93.1	1758	93.3	2913	93.4
Unknown	102	15.4	53	6.5	115	6.1	179	5.7

	Liver							
	Lowest		Mid-low		Mid-high		Highest	
	n=124		n=169		n=433		n=566	
Sex								
Men	84	67.7	107	63.3	291	67.2	376	66.4
Women	40	32.3	62	36.7	142	32.8	190	33.6
Age at diagnosis, years								
-59	22	17.7	18	10.7	62	14.3	73	12.9
60-69	39	31.5	39	23.1	100	23.1	159	28.1
70-79	39	31.5	70	41.4	149	34.4	189	33.4
80+	24	19.4	42	24.9	122	28.2	145	25.6
Stage at diagnosis								
Localized	57	46	93	55	218	50.3	262	46.3
Regional	17	13.7	27	16	81	18.7	101	17.8
Distant	20	16.1	25	14.8	49	11.3	77	13.6
Unknown	30	24.2	24	14.2	85	19.6	126	22.3
Surgical treatment								
Surgery	20	16.1	30	17.8	41	9.5	63	11.1
Non-surgery	87	70.2	130	76.9	346	79.9	434	76.7
Unknown	17	13.7	9	5.3	46	10.6	69	12.2
Radiotherapy treatment								
Radiotherapy	1	0.8	3	1.8	2	0.5	11	1.9
Non-radiotherapy	106	85.5	157	92.9	385	88.9	484	85.5
Unknown	17	13.7	9	5.3	46	10.6	71	12.5
Other treatment								
Yes	51	41.1	58	34.3	194	44.8	248	43.8
No	56	45.2	102	60.4	193	44.6	248	43.8
Unknown	17	13.7	9	5.3	46	10.6	70	12.4

Table 1. Continued

	Lung							
	Lowest		Mid-low		Mid-high		Highest	
	n=434		n=472		n=1,062		n=1,700	
Sex								
Men	320	73.7	334	70.8	745	70.2	1,198	70.5
Women	114	26.3	138	29.2	317	29.8	502	29.5
Age at diagnosis, years								
-59	55	12.7	44	9.3	106	10	208	12.2
60-69	89	20.5	116	24.6	258	24.3	467	27.5
70-79	155	35.7	175	37.1	405	38.1	602	35.4
80+	135	31.1	137	29.0	293	27.6	423	24.9
Stage at diagnosis								
In situ	1	0.2	0	0.0	1	0.1	1	0.1
Localized	105	24.2	110	23.3	198	18.6	391	23.0
Regional	100	23.0	121	25.6	250	23.5	404	23.8
Distant	152	35.0	169	35.8	437	41.1	642	37.8
Unknown	76	17.5	72	15.3	176	16.6	262	15.4
Surgical treatment								
Surgery	90	20.7	98	20.8	207	19.5	439	25.8
Non-surgery	293	67.5	326	69.1	745	70.2	1,100	64.7
Unknown	51	11.8	48	10.2	110	10.4	161	9.5
Radiotherapy treatment								
Radiotherapy	108	24.9	116	24.6	214	20.2	416	24.5
Non-radiotherapy	276	63.6	305	64.6	739	69.6	1122	66.0
Unknown	50	11.5	51	10.8	109	10.3	162	9.5

	Breast							
	Lowest		Mid-low		Mid-high		Highest	
	n=186		n=272		n=711		n=1,456	
Sex								
Men	2	1.1	3	1.1	4	0.6	12	0.8
Women	184	98.9	269	98.9	707	99.4	1,444	99.2
Age at diagnosis, years								
-59	84	45.2	143	52.6	362	50.9	750	51.5
60-69	45	24.2	70	25.7	181	25.5	366	25.1
70-79	36	19.4	42	15.4	108	15.2	225	15.5
80+	21	11.3	17	6.3	60	8.4	115	7.9
Stage at diagnosis								
In situ	15	8.1	15	5.5	75	10.5	132	9.1
Localized	89	47.8	140	51.5	365	51.3	774	53.2
Regional	52	28	70	25.7	169	23.8	366	25.1
Distant	8	4.3	15	5.5	43	6	79	5.4
Unknown	22	11.8	32	11.8	59	8.3	105	7.2
Surgical treatment								
Surgery	154	82.8	208	76.5	596	83.8	1179	81
Non-surgery	16	8.6	40	14.7	79	11.1	201	13.8
Unknown	16	8.6	24	8.8	36	5.1	76	5.2
Radiotherapy treatment								
Radiotherapy	36	19.4	49	18	152	21.4	547	37.6
Non-radiotherapy	134	72	197	72.4	522	73.4	828	56.9
Unknown	16	8.6	26	9.6	37	5.2	81	5.6

Table 1. Continued

	Breast							
	Lowest n=186		Mid-low n=272		Mid-high n=711		Highest n=1,456	
Endocrine treatment								
Endocrinotherapy	71	38.2	81	29.8	227	31.9	810	55.6
Non-endocrinotherapy	99	53.2	164	60.3	446	62.7	566	38.9
Unknown	16	8.6	27	9.9	38	5.3	80	5.5

	Cervical							
	Lowest n=76		Mid-low n=109		Mid-high n=299		Highest n=601	
Sex								
Women	76	100	109	100	299	100	601	100
Age at diagnosis, years								
-59	58	76.3	86	78.9	244	81.6	500	83.2
60-69	8	10.5	12	11	21	7.0	53	8.8
70-79	6	7.9	9	8.3	18	6.0	33	5.5
80+	4	5.3	2	1.8	16	5.4	15	2.5
Stage at diagnosis								
In situ	44	57.9	75	68.8	204	68.2	401	66.7
Localized	16	21.1	17	15.6	36	12.0	88	14.6
Regional	13	17.1	12	11	32	10.7	56	9.3
Distant	2	2.6	4	3.7	15	5.0	25	4.2
Unknown	1	1.3	1	0.9	12	4.0	31	5.2
Surgical treatment								
Surgery	58	76.3	97	89	246	82.3	491	81.7
Non-surgery	12	15.8	10	9.2	42	14.0	76	12.6
Unknown	6	7.9	2	1.8	11	3.7	34	5.7
Radiotherapy treatment								
Radiotherapy	12	15.8	10	9.2	39	13.0	72	12.0
Non-radiotherapy	57	75	96	88.1	243	81.3	466	77.5
Unknown	7	9.2	3	2.8	17	5.7	63	10.5

	Prostate							
	Lowest n=169		Mid-low n=220		Mid-high n=502		Highest n=892	
Sex								
Men	169	100	220	100	502	100	892	100
Age at diagnosis, years								
-59	9	5.3	13	5.9	29	5.8	53	5.9
60-69	53	31.4	76	34.5	140	27.9	258	28.9
70-79	78	46.2	89	40.5	249	49.6	433	48.5
80+	29	17.2	42	19.1	84	16.7	148	16.6
Stage at diagnosis								
In situ	-		-		-		-	
Localized	85	68.5	101	59.8	261	60.3	501	88.5
Regional	35	28.2	47	27.8	101	23.3	138	24.4
Distant	12	9.7	23	13.6	75	17.3	122	21.6
Unknown	37	29.8	49	29	65	15	131	23.1

Table 1. Continued

	Prostate							
	Lowest		Mid-low		Mid-high		Highest	
	n=169		n=220		n=502		n=892	
Surgical treatment								
Surgery	53	31.4	56	25.5	126	25.1	228	25.6
Non-surgery	87	51.5	124	56.4	319	63.5	537	60.2
Unknown	29	17.2	40	18.2	57	11.4	127	14.2
Radiotherapy treatment								
Radiotherapy	20	11.8	32	14.5	104	20.7	165	18.5
Non-radiotherapy	121	71.6	148	67.3	341	67.9	601	67.4
Unknown	28	16.6	40	18.2	57	11.4	126	14.1
Endocrine treatment								
Endocrinotherapy	76	45	96	43.6	264	52.6	462	51.8
Non-endocrinotherapy	69	40.8	85	38.6	182	36.3	308	34.5
Unknown	24	14.2	39	17.7	56	11.2	122	13.7

or prostate cancer.

Table 3 presents the adjusted HRs for each income category. Although the adjusted HRs tended to be highest in the lowest income area, there were no significant differences according to income for any cancer type.

Discussion

Certain chronic infections are risk factors for cancer, and they can explain variations in cancer incidence among low-, middle-, and high-income countries. A study by Ott et al. clearly indicated that the AIRs and mortality rates of lung, colorectal, and breast cancers were higher in high-income countries than in low- and middle-income countries (Ott et al., 2011). Moreover, they said that the AIRs and mortality rates of infection-related cancers (stomach, liver, and cervical cancers) were higher in low- and middle-income than in high-income countries (Ott et al., 2011). This can be explained by the fact that infection-related cancers account for more than 26% of

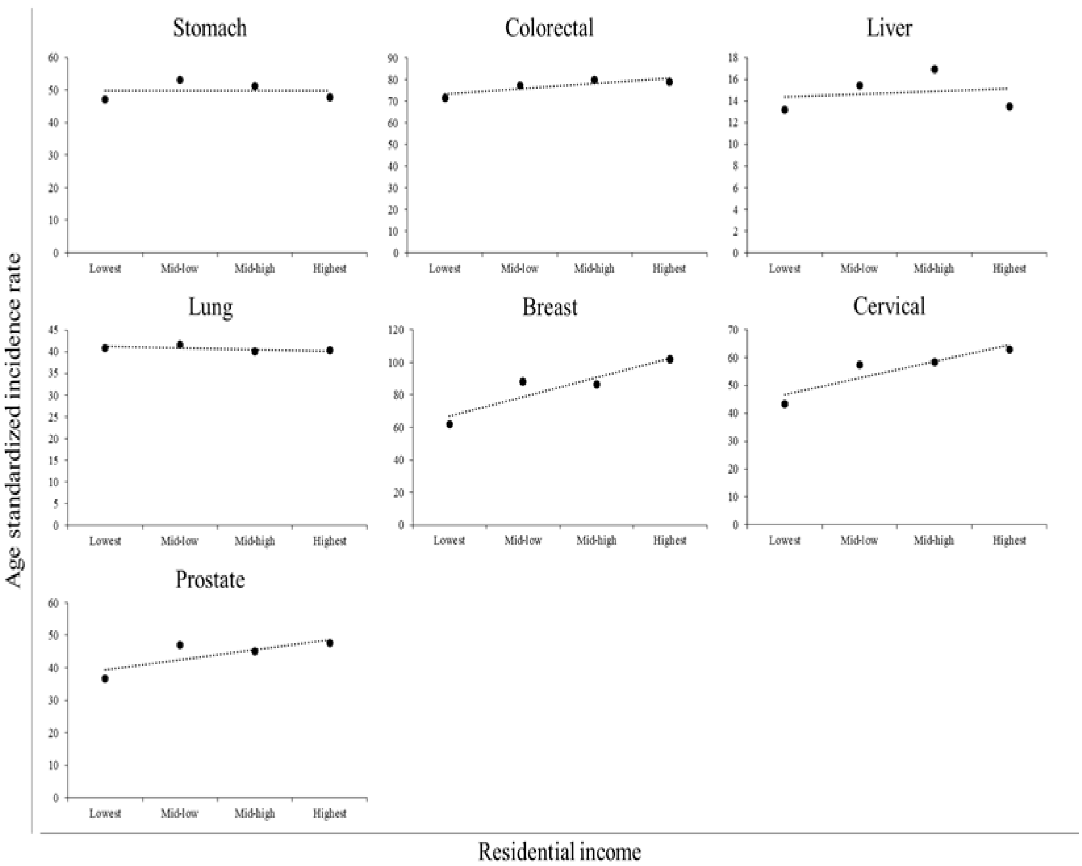

Figure 1. Scatter Plots between AIRs and Residential Income for Various Cancers

the total cancers in low- and middle-income countries (Parkin et al., 2006). Conversely, the incidence rate of non-infection-related cancers has continued to increase in many countries including high-, middle-, and low-income countries (Global Burden of Disease Cancer Collaboration, et al., 2015). This unfavorable increase reflects an increased prevalence of known risk factors (e.g., obesity, physical inactivity, smoking) and the increased use of screening modalities (e.g., mammography, pap smear). Although mammography is the most effective method for detecting breast cancer at an early stage, it also leads to overdiagnosis of the disease (Marmot et al., 2013). A recent study that estimated that the rate of overdiagnosis due to mammography ranged 0%–54% (Puliti et al., 2011). By contrast, cancer-related mortality is affected by patients' access to cancer treatment. Because cancer treatment is not adequately accessible in low-income countries, cancer-related mortality rates have not declined in these countries (Fidler et al., 2017).

Our data identified disparities of AIRs for breast, cervical, and prostate cancers according to income, whereas those of stomach, colorectal, lung, and liver cancers were not influenced by income. However, the adjusted HRs were not significantly different according to income. Recent study investigated socioeconomic inequality in cancer mortality in South Korea (Khang et al., 2016). In this study, poor people had higher risk of cancer death. Although South Korea is similar to Japan, our results differed from previous study. These findings can be explained by several factors. First, the prevalence of risk factors for cervical, breast, and prostate cancers was higher in high-income areas than in middle- and low-income areas. Risk factors for these cancers include HPV infection, alcohol consumption habit, obesity, and aging (Key et al., 2002). In Aomori Prefecture, the average BMI among women was 23.2 in 2012, compared with a countrywide average of 22.5 (National Health and Nutrition Survey in 2012). In addition, 30.1% of people in Aomori Prefecture are older than 65, compared with 26.6% for the entire country (National Census of Japan). This higher proportion of elderly people might explain the findings in the prefecture. Second, because there were no significant differences in adjusted HRs according to age, overdiagnosis due to easy access to hospitals would increase the incidence rates and overtreatment for patients with breast, cervical, and prostate cancers simultaneously in higher-income areas. Several studies have underlined the problems of overdiagnosis and overtreatment (Nagler et al., 2017; Morgan et al., 2017; Jegerlehner et al., 2017). The Norwegian Breast Cancer Screening Program was conducted in 1995 and 1996 (Falk et al., 2013). This study reported the frequency of overdiagnosis among a cohort of women over a period of 10 years after they participated in cancer screening. Falk et al. estimated the number of women overdiagnosed in mammographic screening using English, Welsh, and Norwegian data (Falk et al., 2016). Moreover, Kilpeläinen et al., (2016) reported the association of prostate cancer with socioeconomic status in Finland. Their study found that higher socioeconomic status was associated with the overdiagnosis of low-risk

Table 3. Adjusted Hazard Ratios (HRs) for Various Cancers

		Stomach			Colorectal			Liver			Lung			Breast			Cervical			Prostate		
		HR*	(95% CI)	P value	HR*	(95% CI)	P value	HR*	(95% CI)	P value	HR*	(95% CI)	P value	HR*	(95% CI)	P value	HR*	(95% CI)	P value	HR*	(95% CI)	P value
Residential income	Lowest	1	(reference)		1	(reference)		1	(reference)		1	(reference)		1	(reference)		1	(reference)		1	(reference)	
	Mid-low	0.97	(0.81 to 1.16)	0.72	1.07	(0.89 to 1.02)	0.46	0.86	(0.64 to 1.16)	0.34	1.09	(0.92 to 1.29)	0.31	0.71	(0.38 to 1.31)	0.27	0.72	(0.29 to 1.79)	0.48	0.65	(0.41 to 1.02)	0.06
	Mid-high	0.89	(0.75 to 1.04)	0.14	0.95	(0.81 to 1.12)	0.56	0.73	(0.57 to 0.94)	0.01	1.06	(0.92 to 1.22)	0.45	1.08	(0.65 to 1.81)	0.77	0.77	(0.38 to 1.57)	0.47	0.7	(0.48 to 1.03)	0.07
	Highest	1	(0.86 to 1.17)	0.99	1.02	(0.87 to 1.18)	0.84	0.85	(0.67 to 1.08)	0.19	1.18	(1.03 to 1.35)	0.02	0.91	(0.56 to 1.49)	0.71	0.57	(0.28 to 1.16)	0.12	0.82	(0.57 to 1.16)	0.26

*Adjusted for age, sex, and stage at diagnosis.; CI, confidence interval

Table 2. Age-Standardized Incidence Rates (AIRs) and Incidence Rate Ratios (IRRs) for Various Cancers

		Stomach			Colorectal			Liver			Lung			Breast			Cervical			Prostate		
		AIR	IRR	(95% CI)	AIR	IRR	(95% CI)	AIR	IRR	(95% CI)	AIR	IRR	(95% CI)	AIR	IRR	(95% CI)	AIR	IRR	(95% CI)	AIR	IRR	(95% CI)
Residential income	Lowest	47.2	1.0	(reference)	71.5	1.0	(reference)	13.2	1.0	(reference)	40.9	1.0	(reference)	61.8	1.0	(reference)	43.4	1.0	(reference)	36.6	1.0	(reference)
	Mid-low	53.1	1.1	(−0.8 to 7.0)	77.4	1.1	(−0.3 to 6.2)	15.4	1.2	(−4.1 to 10.5)	41.7	1.0	(−1.5 to 7.1)	88.1	1.4	(0.9 to 7.4)	57.3	1.3	(−0.2 to 7.7)	46.9	1.3	(−0.7 to 7.9)
	Mid-high	51.3	1.1	(−1.0 to 6.9)	79.9	1.1	(−0.1 to 6.3)	16.9	1.3	(−3.6 to 10.8)	40.0	1.0	(−1.7 to 7.0)	86.6	1.4	(0.8 to 7.3)	58.4	1.3	(−0.1 to 7.8)	45.0	1.2	(−0.9 to 7.8)
	Highest	47.8	1.0	(−1.3 to 6.8)	78.9	1.1	(−0.2 to 6.2)	13.5	1.0	(−4.8 to 10.3)	40.3	1.0	(−1.7 to 7.0)	101.8	1.6	(2.0 to 8.3)	62.8	1.4	(0.4 to 8.1)	47.6	1.3	(−0.6 to 8.0)

IRR, incidence rate ratio; CI, confidence interval prostate cancer, as well as a lower risk of incurable prostate cancer and lower prostate cancer-related mortality. Unnecessary treatment, higher treatment costs, and otiose anxiety might be burdensome to patients. Third, it was suspected that accessibility to cancer treatment was not significantly affected by residential income. Dreyer et al., (2017) reported socioeconomic disparities in the receipt of treatment for incident breast cancer. They observed that poor and near-poor women were less likely to receive treatment than women of a higher socioeconomic status. Kumachev et al., (2016) studied the associations among socioeconomic status, screening, and treatments. In this study, they demonstrated that higher socioeconomic status was associated with greater frequencies of screening and treatments and higher survival rates. Therefore, our results partially coincided with these previous findings. However, age standardized mortality rates for cancer in Aomori Prefecture are the highest in Japan. Thus, the quality of cancer treatment might not be sufficient to decrease the number of cancer-related deaths in this region.

Our study had several limitations. First, the income data do not exactly reflect patients' individual income. Our data reflected the average annual income in municipal areas. However, residential income might not reflect access to health and medical services for cancer because local governments have a responsibility to formulate cancer policy and ensure cancer control. Second, we did not include data for cancer risk factors at the individual level. Third, we did not include patients' individual educational levels and occupations. These socioeconomic factors have been examined to explain the disparities regarding cancer incidence and death. Because this study was designed to clarify the effect of income disparities on cancer, we did not include these data.

In conclusion, the relationships of mean residential income with cancer incidence and mortality differed from previous findings. Patients with higher income were diagnosed with early-stage disease more frequently, and they had higher AIRs for breast, cervical, and prostate cancers than those with middle and low incomes. However, there were no significant differences in cancer survival rates. Our results might be helpful for policymakers to develop a cancer policy. Policymakers should take steps HPV infection control and stopping excess prostatic specific antigen test in higher income area. Although the associations of socioeconomic status with cancer incidence and mortality have been reported for developed countries, socioeconomic disparities exist among individual areas in the countries. The differences in cancer mortality rates between affluent and poor individuals have reportedly widened in high-income countries. Thus, inequalities of cancer mortality rates between affluent and poor areas should be also investigated.

Conflict of interest

The authors declare no conflicts of interest associated with this manuscript.

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