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BRIEF REPORT
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Economic burden of cancer attributable to modifiable risk factors in Japan

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Abstract: Controlling avoidable causes of cancer may save cancer-related healthcare costs and indirect costs of premature deaths and productivity loss. This study aimed to estimate the economic burden of cancer attributable to major lifestyle and environmental risk factors in Japan in 2015. We evaluated the economic cost of cancer attributable to modifiable risk factors from a societal perspective. We obtained the direct medical costs for 2015 from the National Database of Health Insurance Claims and Specific Health Checkups of Japan, and estimated the indirect costs of premature mortality and of morbidity due to cancer using the relevant national surveys in Japan. Finally, we estimated the economic cost of cancer associated with lifestyle and environmental risk factors. The estimated cost of cancer attributable to lifestyle and environmental factors was 1,024,006 million Japanese yen (¥) (8,460 million US dollars [$]) for both sexes, and ¥673,780 million ($5,566 million) in men and ¥350,226 million ($2,893 million) in women, using the average exchange rate in 2015 ($1 = ¥121.044). A total of ¥285,150 million ($2,356 million) was lost due to premature death in Japan in 2015. Indirect morbidity costs that could have been prevented were estimated to be ¥200,602 million ($1,657 million). Productivity loss was highest for stomach cancer in men (¥28,735 million/$237 million) and cervical cancer in women (¥24,448 million/$202 million). Preventing and controlling cancers caused by infections including *Helicobacter pylori*, human papillomavirus and tobacco smoking will not only be life-saving but may also be cost-saving in the long run.

***Keywords*:** cost of illness, economic burden, cancer, population attributable fraction

Introduction

Cancer is a major public health issue, and has also been the leading cause of death in Japan since 1981 (*1*). Around 378,000 people died from cancer in 2020, and 999,000 cancer cases were newly diagnosed in 2019 (*2*). Recent statistics suggest that one in two Japanese people will be diagnosed with cancer during their lifetime (*2*). There is also wide agreement that many cancers are caused by lifestyle and environmental risk factors, which can be prevented if appropriate measures are taken (*3*).

The proportion of cancers that are associated with certain risk factors, such as lifestyle and environmental factors, is often referred to as the population attributable fraction (PAF). PAF is defined as the fraction of cancer attributable to a particular exposure that could be averted if the exposure were reduced to a theoretically minimal level. To date, several comprehensive assessments of the

PAF of cancer have been reported in western countries *(4-6)* and in Asia (*7*). Further, updated findings on the disease burden of cancer associated with preventable risk factors in Japan were reported in 2022 (*8*), providing the PAF of major lifestyle and environmental risk factors.

Despite mounting evidence on disease burden, however, only a few studies have evaluated the economic burden cancer poses on society (*9-12*). According to the Estimates of National Medical Care Expenditure in fiscal year 2015, the direct medical and non-medical costs of all diseases amounted to 30,046 billion Japanese yen (248 billion US dollars as of 2015), of which cancer-related costs constituted 12% (*13*). Beyond direct costs, cancer incurs a heavy economic burden due to premature deaths, temporary work cessation during treatment, and permanent exit from the workforce. Preventing causes of cancer may save cancer-related healthcare costs and indirect costs of premature death and productivity loss. Hence, quantification of the avoidable costs of cancer is important in identifying the financial impact of cancer control policies.

Here, we aimed to estimate the economic burden of cancer attributable to major lifestyle and environmental risk factors using the latest data on population attributable fractions in Japan.

Materials and Methods

We evaluated the economic cost of cancer attributable to modifiable risk factors based on the prevalence-based cost-of-illness approach (*14*). We adopted a societal perspective for our analysis, which included direct healthcare costs, indirect morbidity costs and indirect mortality costs due to lifestyle and environmental risk factors.

Data sources

We obtained the number of cancer patients who received any type of healthcare service and the associated direct medical costs for 2015 from the aggregated datasets of the National Database of Health Insurance Claims and Specific Health Checkups of Japan (the NDB Japan) by the Ministry of Health, Labour and Welfare, which covers 99.9% of hospital or medical clinic claims nationwide. Details of the NDB Japan data can be found elsewhere (*15,16*). We classified sex- and age-specific number of patients and associated costs in 2015 by 20 cancer sites reported as the principal diagnosis according to the WHO International Classification of Diseases, 10th Revision (ICD-10) diagnosis codes. The list of ICD-10 codes used in the current study is shown in Table 1. Because the NDB data and other public statistics were obtained in an aggregated format, ethical approval for this study was not necessary.

The most up-to-date data on population attributable fraction (PAF) of cancer due to lifestyle and environmental risk factors in Japan is for 2015 (*8*), namely tobacco smoking (both active and passive) (*17*), alcohol drinking (*18*), excess bodyweight (*19*), physical inactivity (*19*), infectious agents (*Helicobacter pylori [H. pylori]*, hepatitis C virus, hepatitis B virus, human papillomavirus [HPV], Epstein-Barr virus, and human T-cell leukemia virus type 1) (*20*), dietary intake (highly salted food (*21*), fruit, vegetables, dietary fiber (*22*), red and processed meat (*23*)), exogenous hormone use (*24*), never breastfeeding (*25*) and air pollution (*26*). All of the aforementioned factors are considered potentially modifiable *via* environmental policy, lifestyle change, population-based screening or through vaccination programs.

Direct medical costs

Direct medical costs denote the cost of resources consumed for treatment of the disease, and includes all costs of healthcare and medical examinations during hospitalization and outpatient visits, prescriptions and drugs. The cost of each cancer site attributable to modifiable risk factors was calculated using the following equation (*27*).

$$\text{Attributable cost of cancer } i = \sum \text{PAF}_{ijk} \times \text{THC}_{ijk}$$

where:

Attributable cost of cancer i = direct medical costs of cancer site i attributable to lifestyle and environmental risk factors, including inpatient hospitalizations, outpatient visits, prescriptions and drugs

PAF_{ijk} = PAF of cancer incidence i due to lifestyle and environmental risk factors among people in 5-year age group j by gender k

THC_{ijk} = total direct medical costs for treating cancer i among people in age group j by gender k

Table 1 lists site-specific data on the number of patients extrapolated from the NDB Japan. A total of 2.1 million men and 1.9 million women received cancer treatment in 2015.

Indirect mortality costs

We also estimated the economic cost of potential work-life lost due to premature deaths from cancer, which are attributable to modifiable risk factors. Indirect mortality costs attributable to lifestyle and environmental risk factors were calculated by the net present value of future productivity using the following equation (*27*) :

$$\text{Indirect mortality cost of cancer } i = \sum \text{PAF}_{ijk} \times \text{NDEATH}_{ijk} \times \text{PVLE}_{jk} \times \text{EMP}_{jk}$$

where:

Indirect mortality cost of cancer i = indirect mortality costs from productivity losses due to premature deaths from cancer site i that are attributable to lifestyle and

Table 1. Number of cancer patients by cancer site in Japan, 2015

Cancer site	ICD-10	Number of patients
Both sexes, all cancers	C00-C97	4,045,940
Men		
All cancers	C00-C97	2,107,331
Prostate	C61	551,195
Stomach	C16	316,112
Colon	C18	230,125
Lung, trachea	C33-C34	211,306
Bladder	C67	146,038
Rectum	C19-C20	122,297
Liver	C22	75,478
Kidney and other urinary organs	C64-C66 C68	73,708
Malignant lymphoma	C81-C85 C96	69,500
Esophagus	C15	67,276
Oral cavity and pharynx	C00-C14	47,589
Pancreas	C25	37,090
Leukemia	C91-C95	34,314
Gallbladder and bile ducts	C23-C24	27,351
Larynx	C32	26,669
Women		
All cancers	C00-C97	1,938,609
Breast	C50	659,970
Colon	C18	197,745
Stomach	C16	154,807
Lung, trachea	C33-C34	134,500
Corpus uteri	C54	79,055
Rectum	C19-C20	74,965
Cervix uteri	C53	73,972
Malignant lymphoma	C81-C85 C96	67,830
Ovary	C56	60,852
Bladder	C67	41,767
Liver	C22	36,636
Kidney and other urinary organs	C64-C66 C68	35,338
Pancreas	C25	33,146
Leukemia	C91-C95	28,457
Gallbladder and bile ducts	C23-C24	22,383
Oral cavity and pharynx	C00-C14	19,267
Esophagus	C15	14,707
Larynx	C32	2,163

environmental risk factors

PAF_{ijk} = PAF of cancer mortality *i* due to lifestyle and environmental risk factors among people in 5-year age group *j* by gender *k*

$NDEATH_{ijk}$ = number of deaths from cancer site *i* among people in age group *j* by gender *k*

$PVLE_{jk}$ = present value of potential lifetime earnings in age group j by gender k discounted at an annual rate of 3%

EMP_{jk} = average employment rate among people in age group *j* by gender *k*

The number of cancer deaths during 2015 by cancer site, 5-year age group, and gender were obtained from the Cancer Statistics available on the Cancer Information Service website (*2*). This was then used to derive the remaining years of working life by subtracting the age at death from the retirement age of 65 years. Subsequently, we multiplied the remaining years of working life by the average annual income for the 5-year age group reported in the Basic Survey on Wage Structure 2015 (*28*) and adjusted the future earnings lost to the present values with a discount rate of 3% according to the WHO guide to cost-effectiveness (*29*).

Indirect morbidity costs

We estimated the indirect costs of cancer following the human capital approach (*30*). The indirect costs of cancer in this study denote the economic value of productivity loss associated with absenteeism due to hospitalization and receipt of healthcare treatment. The costs of indirect morbidity costs attributable to modifiable risk factors were calculated using the following equation (*27*).

$$\text{Indirect morbidity cost of cancer } i = \sum \text{PAF}_{ijk} \times \text{TWLD}_{ijk} \times \text{ADW}_{j} \times \text{EMP}_{jk}$$

where:

Indirect morbidity cost of cancer *i* = indirect morbidity costs from productivity losses due to cancer site *i* that are attributable to lifestyle and environmental risk factors

PAF_{ijk} = PAF of cancer incidence *i* due to lifestyle and environmental risk factors among people in 5-year age group *j* by gender *k*

$TWLD_{ijk}$ = total annual work-loss days due to hospitalization and outpatient visits for cancer site *i* among people in age group *j* by gender *k*

ADW_j = average daily wage among people in age group j

EMP_{jk} = average employment rate among people in age group *j* by gender *k*

We estimated the indirect morbidity cost of cancer attributable to modifiable risk factors by multiplying the total number of work-loss days among patients aged 20 to 65 years by the average daily income and adjusted by the average employment rates of the corresponding age group. The number of work-loss days was estimated by multiplying the annual hospitalization days and outpatient visits for each cancer site reported in the Patient Survey 2014 (*31*) by the age-, gender- and site-specific number of patients. We estimated the average daily wage for the 5-year age group from the Basic Survey on Wage Structure 2015 (*28*). The average employment rates by gender and 5-year age group were obtained from the Labour Force Survey 2015 (*32*).

Further, we performed disaggregated estimation of the total economic costs of cancer by major five modifiable risk factors, namely active tobacco smoking (PAF: 15.2% of all cancer incidence), alcohol drinking (PAF: 6.2%), infectious agents (*H. pylori*, hepatitis C virus, hepatitis B virus, HPV, Epstein-Barr virus, and human T-cell leukemia virus type) (PAF: 16.6%), excess bodyweight (PAF: 0.7%), and physical inactivity (PAF: 1.3%) (*8*). These risk factors could be avoided if the exposure were either eliminated or reduced to the theoretical minimum risk exposure distribution. In this study, all the economic costs are presented in 2015 prices in Japanese yen (JPY), which was converted to US

dollars (USD) using the annual average exchange rate of the same year (1 USD = 121.044 yen).

Results and Discussion

Total economic costs of cancer

In 2015, the total number of cancer patients who received any type of healthcare service and were reported to the NDB Japan was 4,045,940 persons (men, 2,107,331 persons; women, 1,938,609 persons). Prostate was the most common cancer site in men (551,195 persons), followed by stomach (316,112 persons) and colon (230,125 persons). In women, breast was the most common cancer site (659,970 persons), followed by colon (197,745 persons) and stomach (154,807 persons). Population attributable fraction of cancer incidence was highest in stomach cancer in men (85.05%) and cervical cancer in women (100%) (*8*).

Table 2 lists the total economic costs and associated cost components of cancer as of 2015. The overall estimated cost of cancer inclusive of direct medical costs, indirect mortality costs and indirect morbidity costs was ¥2,859,727 million ($23,626 million) for both sexes, ¥1,494,581 million ($12,347 million) in men, and ¥1,365,146 million ($11,278 million) in women. The direct medical costs of cancer, which include all costs of healthcare and medical examinations during hospitalization and outpatient visits, and prescriptions and drugs were highest in male prostate cancer (¥189,723 million /$1,567 million), and breast cancer in women (¥200,249 million/$1,654 million).

Table 2 also summarizes the economic cost of potential work-life lost due to premature deaths from cancer, with a cut-off age of 65 (age of retirement in Japan). A total of ¥726,943 million ($6,006 million) was estimated to be lost due to premature death in Japan in 2015. Lung cancer incurred the highest indirect mortality

Table 2. Total economic costs of cancer by cancer site, Japan, 2015

Cancer Site	Direct medical costs*		Indirect mortality costs*		Indirect morbidity costs*		Total costs*	
	JPY	USD	JPY	USD	JPY	USD	JPY	USD
Both sexes, all cancers	1,520,487	12,561	726,943	6,006	612,297	5,058	2,859,727	23,626
Men								
All cancers	848,537	7,010	393,309	3,249	252,736	2,088	1,494,581	12,347
Stomach	79,565	657	49,565	409	33,794	279	162,923	1,346
Lung, trachea	101,021	835	68,795	568	23,303	193	193,118	1,595
Colon	76,649	633	37,361	309	29,233	242	143,243	1,183
Liver	34,089	282	30,573	253	8,679	72	73,341	606
Leukemia	45,636	377	20,782	172	12,738	105	79,156	654
Rectum	52,361	433	27,884	230	20,919	173	101,165	836
Esophagus	20,837	172	16,845	139	8,512	70	46,194	382
Bladder	25,655	212	4,422	37	12,756	105	42,833	354
Oral cavity and pharynx	15,985	132	14,960	124	11,835	98	42,780	353
Kidney and other urinary organs	21,925	181	9,712	80	13,524	112	45,161	373
Pancreas	24,510	202	33,786	279	5,565	46	63,861	528
Larynx	5,543	46	660	5	3,283	27	9,486	78
Prostate	189,723	1,567	2,312	19	19,051	157	211,087	1,744
Malignant lymphoma	33,136	274	14,394	119	16,930	140	64,459	533
Gallbladder and bile ducts	10,846	90	8,421	70	4,085	34	23,353	193
Women								
All cancers	671,950	5,551	333,634	2,756	359,561	2,971	1,365,146	11,278
Stomach	38,100	315	28,389	235	16,136	133	82,625	683
Breast	200,249	1,654	86,107	711	146,491	1,210	432,846	3,576
Lung, trachea	62,664	518	22,299	184	13,261	110	98,224	811
Liver	17,418	144	5,222	43	2,027	17	24,667	204
Cervix uteri	9,936	82	29,593	244	24,448	202	63,977	529
Colon	61,993	512	25,644	212	18,919	156	106,557	880
Leukemia	28,358	234	10,770	89	8,709	72	47,837	395
Rectum	27,082	224	11,606	96	10,539	87	49,227	407
Corpus uteri	12,330	102	9,602	79	16,736	138	38,669	319
Esophagus	4,600	38	4,188	35	1,651	14	10,440	86
Pancreas	20,453	169	14,657	121	3,130	26	38,239	316
Malignant lymphoma	27,281	225	6,656	55	12,353	102	46,290	382
Oral cavity and pharynx	4,885	40	4,872	40	3,663	30	13,420	111
Bladder	6,903	57	1,425	12	2,744	23	11,072	91
Kidney and other urinary organs	9,247	76	2,467	20	4,249	35	15,962	132
Ovary	18,528	153	27,826	230	14,277	118	60,631	501
Gallbladder and bile ducts	8,957	74	4,432	37	1,488	12	14,877	123
Larynx	386	3	114	1	338	3	838	7

*Data are millions of Japanese yen (JPY) and US dollars (USD).

cost in men (¥68,795 million/$568 million). In women, breast cancer caused the highest cost of indirect mortality (¥86,107 million/$711 million). The indirect morbidity costs, which means the annual productivity loss due to the absenteeism associated with cancer treatment, was estimated at ¥612,297 million/$5,058 million in 2015. The type of cancer that incurred the greatest productivity loss in men was stomach cancer (¥33,794 million/$279 million). In women, the highest productivity loss was seen in breast cancer (¥146,691 million/$1,210 million).

Economic costs of cancer attributable to modifiable risk factors

Table 3 lists the cost components of economic costs attributable to modifiable risk factors of cancer. The overall estimated cost of cancer inclusive of direct medical costs, indirect mortality costs and indirect morbidity costs that were attributable to lifestyle and environmental factors was ¥1,024,006 million ($8,460 million) for both sexes, ¥673,780 million ($5,566 million) in men, and ¥350,226 million ($2,893 million) in women. The direct medical costs of cancer associated with modifiable risk factors were highest in stomach cancer in both men (¥67,655 million /$559 million) and women (¥33,187 million/$274 million).

Table 3 also shows the indirect cost of mortality from cancer due to modifiable risk factors. A total of ¥285,150 million ($2,356 million) was lost due to premature death in Japan in 2015 which could have been potentially averted. Lung cancer incurred the highest indirect mortality cost in men (¥45,132 million/$373 million) and cervical cancer in women (¥29,593 million/$244 million). Similarly, the estimated indirect morbidity costs that could have been theoretically prevented were ¥200,602 million ($1,657 million) in 2015. Modifiable productivity loss was the highest in stomach cancer in men (¥28,735 million/$237 million), and cervical cancer

Table 3. Total economic costs attributable to modifiable risk factors, Japan, 2015

Cancer Site	Direct medical costs*		Indirect mortality costs*		Indirect morbidity costs*		Total costs*	
	JPY	USD	JPY	USD	JPY	USD	JPY	USD
Both sexes, all cancers	538,254	4,447	285,150	2,356	200,602	1,657	1,024,006	8,460
Men								
All cancers	368,460	3,044	195,574	1,616	109,746	907	673,780	5,566
Stomach	67,655	559	42,930	355	28,735	237	139,320	1,151
Lung, trachea	67,025	554	45,132	373	15,461	128	127,618	1,054
Colon	32,221	266	15,222	126	12,289	102	59,731	493
Liver	25,317	209	23,033	190	6,446	53	54,796	453
Leukemia	17,904	148	6,544	54	4,998	41	29,445	243
Rectum	17,871	148	9,267	77	7,140	59	34,278	283
Esophagus	17,163	142	13,718	113	7,011	58	37,893	313
Bladder	10,680	88	1,801	15	5,310	44	17,791	147
Oral cavity and pharynx	10,011	83	9,139	76	7,412	61	26,562	219
Kidney and other urinary organs	8,512	70	4,148	34	5,250	43	17,910	148
Pancreas	6,580	54	9,017	74	1,494	12	17,091	141
Larynx	4,268	35	498	4	2,528	21	7,294	60
Prostate	2,621	22	69	1	263	2	2,953	24
Malignant lymphoma	2,178	18	668	6	1,113	9	3,959	33
Gallbladder and bile ducts	332	3	226	2	125	1	684	6
Women								
All cancers	169,793	1,403	89,576	740	90,857	751	350,226	2,893
Stomach	33,187	274	25,570	211	14,055	116	72,812	602
Breast	27,992	231	12,190	101	20,477	169	60,658	501
Lung, trachea	20,820	172	6,962	58	4,406	36	32,188	266
Liver	12,199	101	3,793	31	1,419	12	17,411	144
Cervix uteri	9,936	82	29,593	244	24,448	202	63,977	529
Colon	9,382	78	3,870	32	2,863	24	16,116	133
Leukemia	8,242	68	2,723	22	2,531	21	13,495	111
Rectum	2,640	22	1,023	8	1,028	8	4,691	39
Corpus uteri	1,984	16	1,782	15	2,693	22	6,458	53
Esophagus	1,975	16	1,682	14	709	6	4,366	36
Pancreas	1,568	13	1,060	9	240	2	2,868	24
Malignant lymphoma	1,565	13	291	2	708	6	2,564	21
Oral cavity and pharynx	1,557	13	1,316	11	1,168	10	4,041	33
Bladder	659	5	115	1	262	2	1,035	9
Kidney and other urinary organs	277	2	63	1	127	1	466	4
Ovary	193	2	321	3	149	1	663	5
Gallbladder and bile ducts	78	1	36	0	13	0	126	1
Larynx	51	0	13	0	45	0	109	1

*Data are millions of Japanese yen (JPY) and US dollars (USD).

in women (¥24,448 million/$202 million).

Table 4 presents the total economic costs of cancer attributable to each of the five modifiable risk factors for both sexes. The economic burden of cancer caused by infection was highest among all modifiable risk factors (¥478,774 million/$3,955 million), followed by active tobacco smoking (¥434,048 million/$3,586 million) and alcohol drinking (¥172,129 million/$1,422 million).

Discussion

This report draws on updated estimates of cancer burden attributable to modifiable factors in Japan in 2015 published by Inoue *et al.* (*8*). Because cancer constitutes 12% of the direct costs of healthcare in Japan as of 2015 (*13*), and 35.4% of the direct medical costs of cancer are associated with lifestyle and environmental factors, controlling the modifiable risk factors may save more than 4% of healthcare costs. Further, this study found that the indirect costs of cancer made up around 46.8% of the total costs. The indirect cost of morbidity in our study is analogous to that in a previous report in Japan in 2011, which estimated this cost to be around ¥295,900 million for men (*33*). On the other hand, our estimate of the indirect morbidity cost in women was higher (¥359,561 million) than their estimate (¥156,900 million) (*33*). This difference is because they used the sex- and age-specific average daily wage, whereas we used the age-specific average daily wage common for both men and women, to take account of the potential full earnings lost according to market value.

Our study found that there were around 1.1 times more male cancer patients than female patients in Japan in 2015, and that the total economic costs of cancer did not considerably differ between men and women. This is because female breast cancer, which is by far the most common female cancer in Japan, accounted for by far the greatest economic burden in terms of not only direct costs but also indirect mortality costs and indirect morbidity costs. Breast cancer begins to occur in working-age women in their 40s (*2*), and the indirect costs of cancer rise when premature deaths occur or patients receive treatment at a younger age. For the same reason, cervical cancer ranked second in indirect morbidity and mortality costs in women although the direct medical costs ranked only 12th among all the cancer sites investigated in this study.

It was not surprising to find that lung, stomach, colon and male prostate cancer incurred a heavy economic burden in terms of both direct medical costs and indirect costs, as these are the most commonly reported types of cancer in Japanese (*2*). Previous reports from the European Union are consistent with our findings - lung cancer showed the highest economic cost followed by breast cancer, colorectal cancer and prostate cancer but not stomach cancer (*10*). In Korea, where *Helicobacter pylori* infection is prevalent (*34*), the economic burden of cancer was heaviest in stomach cancer, followed by liver, lung, and colorectal cancers in 2015 (*11*).

Economic burden attributable to modifiable risk factors

According to our estimation, the economic burden of cancer was highest in cancers that are caused by infection, namely *Helicobacter pylori (H.pylori)* for

Table 4. Breakdown of total economic costs by major modifiable risk factors*, both sexes, Japan, 2015

Cancer Site	Active smoking		Alcohol		Infections		Excess body weight		Physical inactivity	
	JPY	USD	JPY	USD	JPY	USD	JPY	USD	JPY	USD
All cancers	434,048	3,586	172,129	1,422	478,774	3,955	19,041	157	33,726	279
Oral cavity and pharynx	19,951	165	13,049	108	6,933	57	0	0	0	0
Esophagus	28,435	235	29,784	246	0	0	162	1	0	0
Stomach	35,472	293	10,731	89	210,993	1,743	1,110	9	0	0
Colon	16,303	135	33,146	274	0	0	4,619	38	9,890	82
Rectum	12,456	103	21,562	178	0	0	3,082	25	6,991	58
Liver	24,401	202	26,145	216	60,655	501	3,102	26	0	0
Gallbladder and bile ducts	0	0	0	0	0	0	820	7	0	0
Pancreas	19,952	165	0	0	0	0	0	0	0	0
Larynx	6,486	54	2,667	22	0	0	0	0	0	0
Lung, trachea	138,553	1,145	0	0	0	0	0	0	0	0
Breast	0	0	27,186	225	0	0	1,904	16	22,159	183
Cervix uteri	9,241	76	0	0	63,977	529	0	0	0	0
Corpus uteri	0	0	0	0	0	0	270	2	5,896	49
Ovary	0	0	0	0	0	0	0	0	0	0
Prostate	0	0	0	0	0	0	2,992	25	0	0
Bladder	18,809	155	0	0	0	0	0	0	0	0
Kidney and other urinary organs	17,596	145	0	0	0	0	1,029	9	0	0
Malignant lymphoma	0	0	0	0	6,531	54	0	0	0	0
Leukemia	14,873	123	0	0	28,072	232	0	0	0	0

*Data are millions of Japanese yen (JPY) and US dollars (USD). Note that the sum of the economic costs of all risk factors occasionally exceeds the total economic costs presented in Table 2 because of the co-prevalence of multiple risk factors in a person.

stomach cancer (85%) and human papillomavirus (HPV) for cervical cancer in women (100%) (*20*). In other words, ¥210,993 million ($1,743 million) could have been saved if no infection from *H.pylori* had occurred, and ¥63,977 million ($529 million) could have been saved if no one had been infected by HPV in Japan. Further, active tobacco smoking constituted as much as 23.6% in men and 4.0% in women of the total population attributable fraction of cancer incidence in Japan in 2015 (*17*). This implies that a total of ¥434,048 million ($3,586 million) was lost in Japan due to tobacco smoking.

Limitations

Some limitations of this study warrant mention. First, we were not able to consider direct non-medical costs in our analysis. Access to medical facilities to receive treatment varies by geographic region in Japan, where islands are sparsely located, yet the NDB Japan data do not record the place of residence of patients. Therefore, we were unable to estimate distance to medical facilities. Second, although we considered productivity loss due to premature mortality and absenteeism from work, we were not able to estimate the impact of presenteeism (partial loss of productivity on days a patient did work) in our productivity loss estimation due to a paucity of data. Third, we were not able to estimate the informal care provided by family members, because data on the days and hours of informal care for each type of cancer were not available. Nonetheless, this study provides the first evidence on the direct medical costs, indirect morbidity and mortality costs, and costs associated with lifestyle and environmental factors in Japan from a societal perspective.

In conclusion, this study reported that the overall cost of cancer attributable to lifestyle and environmental factors was ¥1,024,006 million ($8,460 million) in Japan in 2015. Productivity loss associated with modifiable factors was highest in stomach cancer in men (¥28,735 million/$237 million) and cervical cancer in women (¥24,448 million/$202 million). Preventing and controlling cancers caused by infections, including *H.pylori* and HPV, and tobacco smoking will not only be life-saving but may also be cost-saving in the long run.

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