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Original Article

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Socioeconomic Burden of Cancer in Korea from 2011 to 2015

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Purpose

Though the socioeconomic burden of cancer on patients is increasing in South Korea, there is little research regarding the type of cancer that incurs the highest costs. This study analyzed the socioeconomic burden on cancer patients from 2011 to 2015 according to sex and age.

Materials and Methods

A prevalence-based approach was applied utilizing claim data of the National Health Insurance Service in Korea to estimate the socioeconomic burden of cancer on patients. Patients who received treatment for cancer from 2011 to 2015 were the study subjects. The total socioeconomic burden of their disease and treatment was divided into direct and indirect costs.

Results

There was an increase of 50.7% for 5 years, from 821,525 to 1,237,739 cancer patients. The cancer costs for men and women increased $8,268.4 million to $9,469.7 million and $3,626.5 million to $4,475.6 million, respectively. Furthermore, the 50-59-year-old age group accounted for a large portion of the total disease cost. Liver, lung, stomach, and colorectal cancers created the heaviest economic burdens on patients.

Conclusion

Overall, this study indicates new policies for cancer prevention, early detection, and post-cancer treatment management are necessary to help limit the costs associated with cancer, especially in the elderly, and provides a foundation for establishing cancer-related health care policies, particularly by defining those cancers with heavier disease burdens.

Key words

Cost of illness, Socioeconomic burden, Cancer, Cancer prevalence

Introduction

The incidence and mortality of cancer are rapidly increasing worldwide. According to the International Agency for Research on Cancer (IARC), there were 18.1 million new cases and 9.6 million deaths due to cancer worldwide in 2018 [1]. In the case of South Korea, the incidence of cancer has been reported since 1999, and the annual average increase in age-adjusted cancer incidence from 1999 to 2011 was 3.8%. Since 2011, although the incidence of cancer has decreased by 3.0% annually (except for a 3.1% increase between 2015 and 2016 [2]), the death rate from cancer has been steadily increasing. Based on 2017 data, cancer was still the leading cause of death in South Korea, accounting for 27.8% of all deaths. Also, the cancer mortality rate was 153.0 per 100,000 population, with a 1.4% increase from the previous year [3].

As Korea became an aged society in 2017 [4], the increase in the elderly population will lead to higher numbers of the elderly living with cancer [5]. Although new developments in cancer diagnostics and treatment have led to increases in cancer survival rates, the prevalence of cancer is still increasing [6]. The economic burden on cancer patients has been growing due to aging, increased survival rates, and increased use of medical care after diagnosis [7]. However, little is known about which type of cancer is the costliest in Korea. Likewise, it is not known what the year-to-year trends in cancer costs are in Korea.

According to previous studies, the economic burden of all cancers in Korea was approximately $9.4 billion in 2002 [8], about $12.1 billion (14.1 trillion won) in 2005 [9], and $20.9 billion in 2010 [10]. However, it is difficult to directly compare estimates of economic burden across studies because of differences in methodology, particularly differences related to calculations used and variables examined. For these reasons, there are very few studies comparing the economic burden of cancer year-to-year using recent data.

Data on the economic burden of disease are significant, as they can be used for a variety of purposes, such as formation of medical, health, and economic policies and the generation of reports on the general health of the population [11]. Furthermore, data regarding the performance of the national health system could be utilized for the post-evaluation of policies and comparisons with other countries [12,13], as well as evaluations of the effectiveness of medical and health research resource distribution [14]. As such, some countries routinely assess the economic burden of all diseases at the national level [15,16].

The present study was carried out to confirm and compare the prevalence and economic burden of cancer by cancer type, age, and sex utilizing claims data of the National Health Insurance Service (NHIS) of Korea.

Materials and Methods

Yearly economic cost was estimated using claims data of the NHIS for the period January 1, 2011, to December 31, 2015, which represented the latest available economic and prevalence data.

The selection criteria for subjects used to calculate disease cost were as follows. Subjects were defined as patients who filed claims with the NHIS from 2011 to 2015 for International Classification of Diseases, 10th revision, Clinical Modification (ICD-10-CM) codes indicating cancer (C00-C97) and (1) visited the outpatient department three or more times or (2) were hospitalized one or more times due to same cancer within 1 year of the diagnosis [8]. Cancer (C00-C97) was classified into the following 24 types: lip, oral cavity, and pharynx (C00-C14); esophagus (C15); stomach (C16); colon and rectum (C18-C20); liver (C22); gallbladder (C23-C24); pancreas (C25); larynx (C32); lung (C33-C34); breast (C50); cervix uteri (C53); corpus uteri (C54); ovary (C56); prostate (C61); testis (C62); kidney (C64); bladder (C67); brain and CNS (C70-C72); thyroid (C73); Hodgkin's lymphoma (C81); non-Hodgkin's lymphoma (C82-85, C96); multiple myeloma (C90); leukemia (C91-C95); and other unspecified cancer [17].

The economic burden of disease can be divided into direct and indirect costs. Direct costs consisted of direct medical and non-medical costs. NHIS claims data were used to estimate direct medical costs incurred by cancer patients stemming from hospitalization and outpatient care. The non-benefit service cost was defined as the coinsurance rate of the non-benefit service of cancer patients, as presented in the "Survey on the Benefit Coverage Rate of National Health Insurance" [18].

Direct non-medical costs included transportation and nursing costs. Transportation costs were defined as the expenses incurred by cancer patients visiting medical institutions for hospitalization and outpatient treatment. The total annual transportation cost for cancer patients was calculated by multiplying the number of annual visits to the outpatient department and the number of hospitalizations by the average round-trip transportation cost for one visit to the hospital. For this, the annual hospitalization and outpatient transportation costs of cancer patients, per the Korea Health Panel Survey, were used, and the formula used for the calculations was as follows [19].

1. Transportation cost calculation

$$\begin{aligned}&\text{Transportation cost}=\\&\{(\text{Number of visits to the outpatient department per year}\times\\&\text{The average transportation cost per visit})+\\&(\text{Number of hospitalizations per year}\times\\&\text{The average transportation cost per hospitalization})\}\quad(1)\end{aligned}$$

Nursing costs were measured based on the average daily wage of workers listed in the Financial Supervisory Service (Ministry of Employment and Labor) database. The average daily wage was multiplied by the rate of caregiver use, provided by the Korea Health Panel Survey, to calculate the average daily nursing cost. Since informal care by family members and relatives is needed during hospitalization, the hospitalization nursing cost was calculated by multiplying the number of hospital visits for hospitalization by the average daily nursing cost. We calculated the nursing cost only for patients who were either ≥ 65 years of age or < 20 years of age and needed help with outpatient care. Each outpatient visit was weighted to reflect half of 1 day of inpatient hospitalization due to the outbreak of productivity loss. The formula used for nursing cost calculations was as follows.

2. Nursing cost calculation

$$\text{Nursing cost}=\sum(D_{ij}+0.5\ O_{ij})\times I_{ij}\times E_{ij} \quad (2)$$

, where i is age, j is sex, D_{ij} is length of stay for hospitalization, O_{ij} is the number of outpatient visits (< 20 years old, ≥ 65 years old), I_{ij} is the average daily wage for nursing, and E_{ij} is the caregiver use rate.

Indirect costs are economic costs/losses resulting from the inability to work due to cancer treatment and productivity losses due to the premature death of cancer patients [7]. To calculate indirect costs, we first determined the average daily wage based on sex and age using raw survey data on work status by employment type to calculate loss. The age of the productive population was divided into separate groups for analysis. We used three groups for examining the productive population: those aged 60 years (the retirement age for civil servants) and younger, 64 years (the representative economically active population) and younger, and 15 years and older. Those aged 14 years and under were considered as non-working individuals. The formula for calculating productivity loss was as follows.

3. Productivity loss due to outpatient care and hospitalization

$$\text{Productivity loss due to outpatient care and hospitalization}=\sum(D_{ij}+0.5\ O_{ij})\times I_{ij}\times E_{ij} \quad (3)$$

, where i is age (15 years or older), j is sex, D_{ij} is length of stay for hospitalization, O_{ij} is the number of outpatient visits, I_{ij} is the average daily wage for a given sex and age, and E_{ij} is the employment rate for a given sex and age.

Productivity loss due to death was defined as the expected future income had the patient survived and the discount rate used to evaluate the costs and benefits at different times from the current perspective. We applied a standard discount rate of 3%. For the sensitivity analysis, discount rates of 5% and 0% were applied and compared to the standard [20]. Data from Statistics Korea were used to determine the number of deaths. Life expectancy values used for analysis were drawn from age-specific complete life tables (rather than abridged life tables) for each year and applied to the total number of deaths due to cancer for that year, multiplied by the total income the patient would have received during the period between the time of premature death and the patients' predicted life expectancy. The employment rate according to sex and age for each year was then applied. It was assumed that there was no income earned for individuals aged 0-14 years, and calculations were performed using the three aforementioned groups, with the age of the economically active populations being no more than 60 years, no more than 64 years, and 15 years and older to determine the loss of productivity due to death.

4. Productivity loss due to premature death

$$\text{Productivity loss due to death}=\sum\{(DN)_{ij}\times(\frac{(I_{t+1}\times P_{t+1})_{ij}}{(1+r)}+\frac{(I_{t+2}\times P_{t+2})_{ij}}{(1+r)^2}+\cdots+\frac{(I_{t+n}\times P_{t+n})_{ij}}{(1+r)^n})\} \quad (4)$$

, where i is age, j is sex, $(DN)_{ij}$ is the number of cancer deaths by sex and age, t is the age at death, I_{t+n} is the average annual wage in $t+n$ by sex and age, P_{t+n} is the employment rate in $t+n$ by sex and age, n is life expectancy $-t$, and r is the discount rate.

In terms of total cost, $1 was equal to 1,131.52 won in 2015, according to Statistics Korea [21].

5. Ethical statement

This study was approved by the Institutional Review Board of the National Cancer Center (approval No. ncc2016-0076). Informed consent from individual patients was waived as this study involves only de-identified administrative data.

Results

The number of patients accessing medical services for cancer was 821,525 in 2011, 955,703 in 2012, 1,080,199 in 2013, 1,184,681 in 2014, and 1,237,739 in 2015, showing a continuous, upward trend of approximately 50.7% when comparing 2011 to 2015. In terms of cancer type, thyroid cancer exhibited the highest prevalence (n=189,711) in 2011, followed by stomach cancer (n=102,836), colorectal cancer (n=88,730), and breast cancer (n=88,594). In terms of prevalence by sex, in 2011, the number of female and male cancer patients was 451,427 (54.9%) and 370,098 (45.1%), respectively. In 2015, the number of female and male patients was 695,293 (56.2%) and 542,446 (43.8%), respectively. Overall, the number of female patients exceeded that of male patients each year (Table 1).

The number of deaths from cancer was 71,944 in 2011, 74,214 in 2012, 75,848 in 2013, 77,137 in 2014, and 76,854 in 2015. In terms of cancer type, the mortality rate of lung cancer was the highest, at 31.8 deaths per 100,000 persons in 2011, followed by liver cancer (22.0 per 100,000), stomach cancer (19.5 per 100,000), and colorectal cancer (15.4 per 100,000). In 2015, the mortality rate was higher for lung cancer (34.1 per 100,000), unchanged for liver cancer (22.2 per 100,000), lower for stomach cancer (16.7 per 100,000), and

Table 1. Prevalence of cancer by type in 2011-2015

Cancer type	Prevalence (No. of cases)					Prevalence rate (per 100,000 persons)				
	2011	2012	2013	2014	2015	2011	2012	2013	2014	2015
Total: all patients with cancer	821,525	955,703	1,080,199	1,184,681	1,237,739	1,639.4	1,898.3	2,136.5	2,333.7	2,429.2
Male	370,098	425,252	475,855	520,228	542,446	1,475.6	1,688.3	1,882.1	2,050.2	2,130.7
Female	451,427	530,451	604,344	664,453	695,293	1,803.6	2,108.5	2,391.0	2,618.6	2,727.3
Lip, oral cavity, and pharynx	9,837	11,345	12,654	13,891	14,538	19.6	22.5	25.0	27.4	28.5
Esophagus	6,693	7,254	7,958	8,597	8,914	13.4	14.4	15.7	16.9	17.5
Stomach	102,836	119,157	134,209	147,142	149,900	205.2	236.7	265.5	289.9	294.2
Colon and rectum	88,730	104,557	117,520	128,005	132,078	177.1	207.7	232.4	252.2	259.2
Liver	53,908	57,870	61,264	64,305	66,142	107.6	114.9	121.2	126.7	129.8
Gallbladder, etc.	13,682	14,746	15,831	17,389	18,166	27.3	29.3	31.3	34.3	35.7
Pancreas	10,152	11,065	11,642	12,653	13,514	20.3	22.0	23.0	24.9	26.5
Larynx	5,160	5,745	6,344	6,797	6,891	10.3	11.4	12.5	13.4	13.5
Lung	53,630	58,994	64,425	69,623	73,392	107.0	117.2	127.4	137.2	144.0
Breast	88,594	102,950	117,583	132,084	142,123	176.8	204.5	232.6	260.2	278.9
Cervix uteri	19,578	21,797	23,996	25,737	25,778	39.1	43.3	47.5	50.7	50.6
Corpus uteri	7,578	9,142	10,749	12,140	12,949	15.1	18.2	21.3	23.9	25.4
Ovary	9,695	10,971	12,260	13,482	14,308	19.3	21.8	24.2	26.6	28.1
Prostate	37,353	44,048	50,592	56,575	60,787	74.5	87.5	100.1	111.4	119.3
Testis	960	1,156	1,354	1,521	1,648	1.9	2.3	2.7	3.0	3.2
Kidney	13,701	16,563	19,231	21,782	23,300	27.3	32.9	38.0	42.9	45.7
Bladder	18,889	21,468	23,904	26,369	27,677	37.7	42.6	47.3	51.9	54.3
Brain and CNS	9,258	9,795	10,262	10,658	10,879	18.5	19.5	20.3	21.0	21.4
Thyroid	189,711	232,852	273,130	299,967	311,584	378.6	462.5	540.2	590.9	611.5
Hodgkin lymphoma	1,230	1,464	1,626	1,795	1,838	2.5	2.9	3.2	3.5	3.6
Non-Hodgkin lymphoma	14,124	16,369	18,498	20,206	21,374	28.2	32.5	36.6	39.8	41.9
Multiple myeloma	3,948	4,585	5,042	5,647	6,119	7.9	9.1	10.0	11.1	12.0
Leukemia	12,743	14,016	15,408	16,916	18,018	25.4	27.8	30.5	33.3	35.4
Other and unspecified	49,535	57,794	64,717	71,400	75,822	98.8	114.8	128.0	140.7	148.8

CNS, central nervous system.

Table 2. Number of deaths due to cancer in 2011-2015

Cancer type	No. of deaths					Mortality rate (per 100,000 persons)				
	2011	2012	2013	2014	2015	2011	2012	2013	2014	2015
Total cancer	71,944	74,214	75,848	77,137	76,854	143.6	147.4	150.0	152.0	150.8
Lip, oral cavity, and pharynx	943	1,039	1,082	1,100	1,170	1.9	2.1	2.1	2.2	2.3
Esophagus	1,517	1,413	1,463	1,552	1,531	3.0	2.8	2.9	3.1	3.0
Stomach	9,764	9,403	9,243	8,988	8,525	19.5	18.7	18.3	17.7	16.7
Colon and rectum	7,698	8,182	8,253	8,393	8,301	15.4	16.3	16.3	16.5	16.3
Liver	11,017	11,399	11,477	11,653	11,311	22.0	22.6	22.7	23.0	22.2
Gallbladder, etc.	3,713	3,708	3,802	3,955	4,211	7.4	7.4	7.5	7.8	8.3
Pancreas	4,406	4,809	4,865	5,150	5,439	8.8	9.6	9.6	10.1	10.7
Larynx	388	414	406	411	344	0.8	0.8	0.8	0.8	0.7
Lung	15,942	16,743	17,294	17,548	17,399	31.8	33.3	34.2	34.6	34.1
Breast	2,027	2,032	2,262	2,283	2,354	4.0	4.0	4.5	4.5	4.6
Cervix uteri	992	890	896	962	967	2.0	1.8	1.8	1.9	1.9
Corpus uteri	218	245	249	266	319	0.4	0.5	0.5	0.5	0.6
Ovary	909	914	1,043	1,024	1,055	1.8	1.8	2.1	2.0	2.1
Prostate	1,411	1,467	1,642	1,675	1,700	2.8	2.9	3.2	3.3	3.3
Testis	20	13	19	14	10	0.0	0.0	0.0	0.0	0.0
Kidney	838	924	944	953	952	1.7	1.8	1.9	1.9	1.9
Bladder	1,172	1,232	1,287	1,358	1,299	2.3	2.4	2.5	2.7	2.5
Brain and CNS	1,216	1,188	1,199	1,289	1,266	2.4	2.4	2.4	2.5	2.5
Thyroid	390	377	394	348	341	0.8	0.7	0.8	0.7	0.7
Hodgkin lymphoma	49	64	63	70	49	0.1	0.1	0.1	0.1	0.1
Non-Hodgkin lymphoma	1,393	1,532	1,598	1,580	1,693	2.8	3.0	3.2	3.1	3.3
Multiple myeloma	663	824	807	869	889	1.3	1.6	1.6	1.7	1.7
Leukemia	1,563	1,673	1,599	1,684	1,720	3.1	3.3	3.2	3.3	3.4
Other and unspecified	3,695	3,729	3,961	4,012	4,009	7.4	7.4	7.8	7.9	7.9

CNS, central nervous system.

Table 3. Cost of cancer by sex in millions of US dollars for 2011-2015

	2011				2012				2013				2014				2015			
	Men		Women		Men		Women		Men		Women		Men		Women		Men		Women	
	Cost	%	Cost	%	Cost	%	Cost	%	Cost	%	Cost	%	Cost	%	Cost	%	Cost	%	Cost	%
Total	8,268.4	100.00	3,626.5	100.00	8,810.9	100.00	3,924.9	100.00	9,224.8	100.00	4,201.8	100.00	9,315.8	100.00	4,403.2	100.00	9,469.7	100.00	4,475.6	100.00
Lip, oral cavity, and pharynx	168.7	2.04	31.3	0.86	207.4	2.35	33.2	0.85	212.9	2.31	42.2	1.00	221.2	2.37	41.7	0.95	247.0	2.61	42.5	0.95
Esophagus	199.8	2.42	9.2	0.25	193.6	2.20	10.0	0.25	215.7	2.34	10.9	0.26	231.8	2.49	11.8	0.27	230.4	2.43	10.5	0.23
Stomach	1,191.8	14.41	359.6	9.92	1,208.8	13.72	362.2	9.23	1,265.6	13.72	381.1	9.07	1,201.9	12.90	372.3	8.45	1,167.6	12.33	379.7	8.48
Colon and rectum	918.4	11.11	395.2	10.90	990.3	11.24	412.3	10.50	1,034.0	11.21	420.9	10.02	1,048.3	11.25	434.5	9.87	1,051.9	11.11	459.0	10.26
Liver	1,881.1	22.75	220.8	6.09	1,996.3	22.66	240.9	6.14	2,043.4	22.15	251.1	5.98	2,062.5	22.14	252.2	5.73	2,020.3	21.33	245.8	5.49
Gallbladder, etc.	216.2	2.61	97.9	2.70	223.4	2.54	108.0	2.75	230.6	2.50	106.0	2.52	250.3	2.69	116.9	2.65	274.2	2.90	127.1	2.84
Pancreas	354.8	4.29	107.8	2.97	388.5	4.41	122.3	3.12	417.9	4.53	130.0	3.09	423.8	4.55	144.3	3.28	458.3	4.84	153.6	3.43
Larynx	53.1	0.64	2.4	0.07	61.0	0.69	2.1	0.05	63.0	0.68	2.5	0.06	59.4	0.64	3.1	0.07	60.2	0.64	2.6	0.06
Lung	1,310.2	15.85	310.8	8.57	1,428.8	16.22	334.3	8.52	1,516.4	16.44	357.6	8.51	1,476.8	15.85	382.9	8.70	1,538.6	16.25	390.1	8.72
Breast	4.3	0.05	780.1	21.51	3.9	0.04	851.7	21.70	3.4	0.04	963.1	22.92	4.2	0.05	1,019.0	23.14	5.1	0.05	1,044.3	23.33
Cervix uteri	0	0.00	174.1	4.80	0	0.00	176.0	4.48	0	0.00	189.6	4.51	0	0.00	202.3	4.59	0	0.00	197.3	4.41
Corpus uteri	0	0.00	47.3	1.30	0	0.00	56.8	1.45	0	0.00	59.3	1.41	0	0.00	72.5	1.65	0	0.00	74.6	1.67
Ovary	0	0.00	156.0	4.30	0	0.00	170.6	4.35	0	0.00	189.4	4.51	0	0.00	197.2	4.48	0	0.00	201.9	4.51
Prostate	231.7	2.80	0	0.00	240.8	2.73	0	0.00	265.0	2.87	0	0.00	277.1	2.98	0	0.00	294.1	3.11	0	0.00
Testis	12.2	0.15	0	0.00	11.0	0.13	0	0.00	13.3	0.14	0	0.00	13.5	0.15	0	0.00	11.2	0.12	0	0.00
Kidney	131.2	1.59	29.0	0.80	151.2	1.72	31.7	0.81	150.0	1.63	32.4	0.77	154.5	1.66	36.7	0.83	170.6	1.80	37.4	0.83
Bladder	117.8	1.42	20.3	0.56	123.7	1.40	21.0	0.54	134.5	1.46	21.4	0.51	156.8	1.68	26.8	0.61	153.1	1.62	28.6	0.64
Brain and CNS	239.3	2.89	96.3	2.66	242.5	2.75	106.7	2.72	239.1	2.59	109.1	2.60	263.5	2.83	109.4	2.48	278.1	2.94	121.8	2.72
Thyroid	72.1	0.87	254.3	7.01	85.7	0.97	298.7	7.61	102.3	1.11	320.7	7.63	91.7	0.98	317.8	7.22	77.2	0.81	249.6	5.58
Hodgkin lymphoma	14.7	0.18	5.0	0.14	17.8	0.20	5.9	0.15	16.5	0.18	6.2	0.15	19.5	0.21	6.4	0.15	14.2	0.15	5.0	0.11
Non-Hodgkin lymphoma	217.2	2.63	88.7	2.44	247.0	2.80	97.3	2.48	251.0	2.72	100.5	2.39	252.6	2.71	104.1	2.36	284.8	3.01	116.4	2.60
Multiple myeloma	75.4	0.91	42.6	1.18	100.0	1.13	49.1	1.25	101.4	1.10	54.0	1.29	115.1	1.24	64.7	1.47	122.0	1.29	71.6	1.60
Leukemia	370.7	4.48	169.3	4.67	396.7	4.50	184.1	4.69	397.4	4.31	178.4	4.24	421.2	4.52	186.8	4.24	421.2	4.45	196.4	4.39
Other and unspecified	487.6	5.90	228.5	6.30	492.4	5.59	250.1	6.37	551.5	5.98	275.6	6.56	570.1	6.12	300.0	6.81	589.9	6.23	319.5	7.14

CNS, central nervous system.

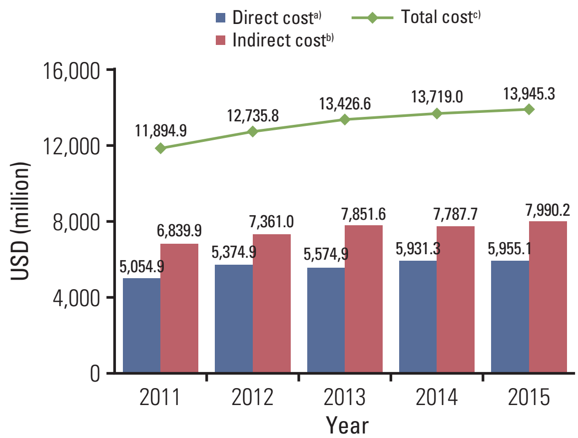

Fig. 1. Economic burden of cancer in millions of US dollars for 2011-2015. [a)]Direct cost=Direct medical+Non-medical costs, [b)]Indirect cost=Productivity+Premature death costs, [c)]Total cost=Direct+Indirect costs.

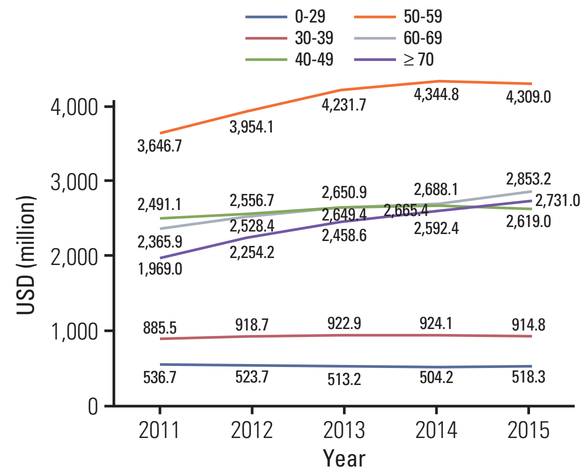

Fig. 2. Economic burden of cancer by age group in millions of US dollars for 2011-2015.

higher for colorectal cancer (16.3 per 100,000) (Table 2).

The cost for all cancer patients was $11,894.9 million in 2011, $12,735.8 million in 2012, $13,426.6 million in 2013, $13,719.0 million in 2014, and $13,945.3 million in 2015, exhibiting a steady increase from 2011-2015 of ~17% (Table 3). In 2011, the direct cost of disease was $5,054.9 million, and the indirect cost was $6,839.9 million. In 2015, the direct cost was $5,955.1 million, and the indirect cost was $7,990.2 million. Thus, the indirect cost was relatively higher than the direct cost (Fig. 1).

Broken down by sex, the cost for male and female patients was $8,268.4 million and $3,626.5 million, respectively, in 2011. In 2015, the cost for men was $9,469.7 million, roughly 2.12 times the cost for women ($4,475.6 million). From 2011 to 2015, the economic burden continued to increase for both sexes (Table 3).

In 2011, the most expensive cancers for men were liver cancer ($1,881.1 million), lung cancer ($1,310.2 million), stomach cancer ($1,191.8 million), and colorectal cancer ($918.4 million). This was also true in 2015: the cost of liver cancer was the highest ($2,020.3 million), followed by lung cancer ($1,538.6 million), stomach cancer ($1,167.6 million), and colorectal cancer ($1,051.9 million). The cost of colorectal cancer continued to increase from 2011 to 2015; the cost of lung cancer increased until 2013, decreased in 2014, and increased in 2015; and the cost of liver cancer increased until 2014, when it declined modestly. The cost of stomach cancer increased until 2013 and began decreasing in 2014.

For women, in 2011, the cost was highest for breast cancer ($780.1 million), followed by colorectal cancer ($395.2 million), stomach cancer ($359.6 million), and lung cancer ($310.8 million). In 2015, the cost was highest for breast cancer ($1,044.3 million), followed by colorectal cancer ($459.0 million), lung cancer ($390.1 million), and stomach cancer ($379.7 million). Since 2014, lung cancer has been more economically burdensome than stomach cancer (Table 3).

When costs were ranked based on age, the highest costs were incurred by those 50-59 years old ($36,464.7 million, 30.7% of all cancer costs), followed by those 40-49 years old ($2,491.1 million, 20.9%), 60-69 years old ($2,365.9 million, 19.9%), and ≥ 70 years old ($1,969.0 million, 16.6%). In 2015, those 50-59 years old accounted for the highest costs ($4,309.0 million, 30.9%), followed by those 60-69 years old ($2,853.2 million, 20.5%), ≥ 70 years old ($2,731.0 million, 19.6%), and 40-49 years old ($2,619.0 million, 18.8%) (Fig. 2).

When a discount rate of 3% was applied (the standard for this study) to the indirect cost calculation, the productivity loss due to medical treatment in 2015 was $474.7 million for the economically active population of 60 years old and younger, $539.6 million for the population 64 years old and younger, and $622.2 million for the population ≥ 65 years old. The premature death cost for these age groups was $3,530.7 million, $4,671.9 million, and $7,367.9 million, respectively. For the sensitivity analysis, discount rates of 5%, 3%, and 0% were applied to calculate the economic loss due to premature death. When a discount rate of 5% was applied to each of the three age groups, the premature death cost was $3,140.6 million, $4,155.8 million, and $6,447.4 million, respectively. When no discount rate was applied (0%), the premature death cost was $4,392.1 million, $5,806.6 million, and $9,442.9 million, respectively. Thus, the premature death cost difference was $6,302.3 million, depending on to the methodology used. When a friction cost approach rather than human capital approach was used to calculate indirect costs, the premature death cost for the three age groups in 2015 was $176.0

Table 4. Sensitivity analysis of the indirect cost of cancer in millions of US dollars for 2011-2015

Year	15-60 years old					15-64 years old					≥ 15 years old				
	Productivity loss[a)]	Productivity loss due to premature death			Friction cost[c)]	Productivity loss[a)]	Productivity loss due to premature death			Friction cost[c)]	Productivity loss[a)]	Productivity loss due to premature death			Friction cost[c)]
		0%[b)]	3%[b)]	5%[b)]			0%[b)]	3%[b)]	5%[b)]			0%[b)]	3%[b)]	5%[b)]	
2011	351.8	4,194.5	3,346.4	2,967.0	155.5	397.4	5,332.1	4,246.7	3,759.6	184.3	452.9	8,241.9	6,387.1	5,572.7	237.1
2012	419.5	4,266.8	3,411.4	3,028.0	162.3	473.5	5,507.3	4,397.4	3,898.0	192.3	542.8	8,790.5	6,818.2	5,950.9	252.5
2013	450.2	4,445.5	3,563.4	3,165.8	171.8	509.1	5,802.0	4,647.9	4,125.8	205.2	584.7	9,338.9	7,266.9	6,350.4	269.9
2014	474.1	4,420.4	3,559.4	3,168.9	176.8	535.2	5,773.6	4,647.3	4,134.4	210.1	610.6	9,184.1	7,177.1	6,284.7	272.9
2015	474.7	4,392.1	3,530.7	3,140.6	176.0	539.6	5,806.6	4,671.9	4,155.8	210.9	622.2	9,442.9	7,367.9	6,447.4	278.0

a)Productivity loss (opportunity costs incurred due to the time spent at outpatient visits and hospitalization), b)% indicates the applied discount rate, c)The friction cost represents losses incurred by an employer during the defined friction period.

million, $210.9 million, and $278.0 million, respectively, for the economically active populations of 60 years and younger, 64 years and younger, and 15 years and older (Table 4).

Discussion

This study estimated the socioeconomic costs for cancer patients from 2011 to 2015 using NHIS claims data. The number of patients who received medical treatment for cancer was 821,525 in 2011 and 1,237,739 in 2015, an increase of approximately 50%. From 2011 to 2015, the total annual costs for cancer patients increased by 17%, from $11,894.9 million to $13,945.3 million. Ongoing studies of the socioeconomic burden of cancer indicate that in countries that rank highly on the Human Development Index, cancer is already a leading cause of death and will soon become a major cause of death worldwide. By 2030, global cancer incidence is expected to increase by 75%, leading to an enormous increase in the economic burden of cancer [22].

The prevalence rate of cancer in Korea increased from 1,639.4 to 2,429.2 cases per 100,000 persons between 2011 and 2015, with thyroid, stomach, breast, and colorectal cancers being the four most common types, in that order. However, the economic burden of disease in 2015 was the highest for liver, lung, stomach, colorectal, and breast cancers, in that order. Thus, the most common cancers do not necessarily incur the highest costs. Indeed, from 2011 to 2015, liver cancer was the most burdensome, but it was not among the most common cancers overall. The economic burden of liver and stomach cancers has decreased since 2013, whereas the economic burden of colorectal and breast cancers has steadily increased since 2014. Although liver cancer was not one of the most common cancers between 2011 and 2015, it had the highest economic burden for men, followed by lung cancer, stomach cancer, and colorectal cancer. For women, breast cancer imparted the highest economic burden, followed by colorectal cancer, liver cancer, and stomach cancer. Thus, the economic burden of various cancers differs according to sex.

It is therefore necessary to consider sex when establishing relevant policies and identify risk factors for particular cancer types in order to develop effective intervention and prevention strategies. According to Globocan 2018, lung cancer has the highest incidence and mortality rate of all cancers worldwide, and one in four women is affected by breast cancer [1]. In light of these data, the government of South Korea included lung cancer on the National Cancer Screening Program form for 2019.

The economic burden of cancer among patients over 60 years old has continued to grow over time. The proportion of the total cost of cancer for patients aged 60 years and older increased from 36.4% in 2011 to 40.0% in 2015, an increase of 3.6%. This trend is thought to result from increases in life expectancy and the overall aging of the Korean population [23], combined with higher cancer survival rates due to advances in treatment [2]. Regardless of the reason, however, this finding reveals that policy interventions may be required to mitigate rising cancer costs.

The indirect costs associated with cancer increased steadily from $6,839.9 million in 2011 to $7,990.2 million in 2015, an increase of approximately 16.9%. Although the socioeconomic cost of the disease varies according to the applied variable, indirect costs could also vary depending upon how the age of the productive population is defined. In the case of premature death costs, a time discount rate can be applied to calculate future costs; however, the results could vary depending on whether a human capital approach or a friction cost approach is applied.

When calculating the socioeconomic burden of disease, there is considerable debate surrounding methodologies for calculating the wages of the elderly. Most studies consider those over 65 years of age as being economically inactive [10,20]. However, when recent wage and employment rate data for this group were included, the economic costs increased by 22% to 28% for males and 52% to 54% for females. Furthermore, when the elderly population was included, the productive population among all age groups increased sharply [24]; consequently, the assumption that those over 65 years of age earn no income results in underestimation of the economic burden of disease. Therefore, we used the Ministry of Employment and Labor's raw survey data to determine the actual work status of and wages earned by men and women aged 65 years and older. The employment rate was calculated by applying the results of the survey to the actual work status of the elderly.

The retirement age for public servants in Korea is 60 years [25], but not all individuals retire at that age. Therefore, in this study, three productive population groups were considered: those 60 years old and younger, those 64 years old and younger, and those 15 years old and older. Additionally, we compared the results obtained by applying time discount rates of 0%, 3%, and 5% for our sensitivity analyses. In this study, we applied the basic discount rate of 3% to the income of those aged ≥ 15 years ($13,945.3 million). The socioeconomic burden of cancer ranged from $9,570.4 million (5%, 60 years old and younger) to $16,020.3 million (0%, 15 years old and older) in 2015, a difference of 60%, depending on the methodology used.

The friction cost approach can also be applied to the indirect cost calculation, in addition to the human capital approach [26] applied in this study. The human capital approach estimates the expected income lost due to disease morbidity or premature death from the patient's perspective, whereas the friction cost approach calculates costs from an employer's perspective. Therefore, the friction cost approach calculates the losses incurred until the patient's workload is reassigned or a replacement is hired [27], and it only reflects the value of the substitute employee during the friction period. The human capital approach has the limitation that the loss could be overestimated because it measures potential loss without considering the possibility of labor substitution [28]. However, the friction period can vary from 3-4 months to 22 weeks, or to 58 days based on country, occupation, and specific disease [15].

Canada, which periodically calculates the economic burden of all diseases, recently reported these costs for 2005-2008 and 2010 calculated using the friction cost approach [15]. In Canada, the cost of premature death due to cancer was $278 million in 2010. Unfortunately, there were not enough Korean data available to accurately determine a friction period in the present study; therefore, the Canadian friction period was used to calculate a friction cost of $278 million in 2015 for those ≥ 15 years of age in Korea. When defining the age of the economically active population as those under 60 years old, the friction cost was $176 million. A comparison of the friction cost for those under 60 years old to the highest cost of premature death in our study ($9,442.9 million) showed that estimated costs can vary by up to 192.8%, depending on the applied variables.

This study has several limitations. First, the data used in this study were limited. Only NHIS insurance claims data were used to calculate the cost of cancer to patients, and these data are limited because the system was created for the purpose of claims processing [29]; thus, the scope and scale of any non-benefit service items could not be determined [30]. To compensate for this limitation, non-benefit service costs were estimated using the coinsurance rate of non-benefit services based on the "Report on the Actual Status of Medical Service Cost of Health Insurance Patients," published by the NHIS. Moreover, this study failed to consider differences in economic activities and wages earned between women and men. In the case of women, if a wider range of costs is applied by including household activities (such as childrearing) in addition to economic activities, the socioeconomic burden of cancer is expected to be higher. There are also limitations related to cost items. In this study, all other costs, including informal medical costs, were excluded from the calculations. Therefore, there were limitations in estimating the costs of purchasing assistive devices and medicines, costs of exercise and diet management, and the use of medical services, such as complementary, alternative, and traditional medicine. Follow-up studies should determine a more precise scale of costs.

Despite these limitations, this study estimated the socioeconomic burden on cancer patients from 2011 to 2015 using the latest Korean data—the NHIS claims data and Statistics Korea's death data. The economic burden for each of 24 cancer types was also determined based on indirect cost calculations. During the period 2011 to 2015, the economic burden of cancer increased and is expected to increase further. Follow-up studies aimed at predicting the future economic burden of cancer in Korea using trend analyses could be designed based on the results of this study. The results of these follow-up studies could then be used as the basis for allocating limited health care resources and guiding the decisions of policymakers. To reduce the disease burden of cancer, it will be necessary to emphasize changes in lifestyle and promote early cancer detection and treatment [21]. Social and national efforts should continue to establish measures and policies for improving the quality of life for patients and reducing their psychological pain and economic burden.

Conflicts of Interest

Conflict of interest relevant to this article was not reported.

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