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Original Article

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The Clinical Utilization of Radiation Therapy in Korea between 2011 and 2015

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Purpose

The purpose of this study was to estimate the clinical utilization of radiation therapy (RT) in Korea between 2011 and 2015.

Materials and Methods

We analyzed the claims data from the Health Insurance Review and Assessment Service to estimate the clinical utilization of RT. The source population consisted of all patients who had any of the International Classification of Diseases 10th revision cancer diagnoses (C00-C97) and those with diagnostic codes D00-D48, who were also associated with at least one of the procedure codes related to RT.

Results

The total number of patients who received RT in 2011, 2012, 2013, 2014, and 2015 were 54,810, 59,435, 61,839, 64,062, and 66,183, respectively. Among them, the total numbers of male and female patients were 24,946/29,864 in 2011, 27,211/32,224 in 2012, 28,111/33,728 in 2013, 29,312/34,750 in 2014, and 30,266/35,917 in 2015. The utilization rate of RT in cancer patients has also increased steadily over the same period from 25% to 30%. The five cancers that were most frequently treated with RT between 2011 and 2012 were breast, lung, colorectal, liver, and uterine cervical cancers. However, the fifth most common cancer treated with RT that replaced uterine cervical cancer in 2013 was prostate cancer. More than half of cancer patients (64%) were treated with RT in the capital area (Seoul, Gyeonggi, and Incheon).

Conclusion

The total number of patients who underwent RT increased steadily from 2011 to 2015 in Korea. The utilization rate of RT in cancer patients is also increasing.

Key words
Neoplasms, Radiotherapy, Statistics, Korea

Introduction

Because of the decreases in the incidence of thyroid cancer, the annual cancer incidence has decreased in Korea after 2011 following a steady increase [1]. However, cancer is still a major public health problem in Korea. Radiation therapy (RT) is an effective and widespread method for treating cancer in conjunction with surgery and chemotherapy. RT is required in at least 45%-55% of newly diagnosed cancer cases [2]. A steady rise in the number of patients with cancer has increased the demand for RT in Korea. As we have reported previously [3,4], the number of patients with cancer needing RT has steadily increased over the 5 years between 2009 and 2013.

In the present study, we analyzed the claims data from the Health Insurance Review and Assessment Service (HIRA) to estimate the clinical utilization of RT in the 2011-2015 period.

Materials and Methods

We analyzed open claims data from the HIRA. The analysis methods using claims data from the HIRA are described in detail in a previous study [4]. The customized source population criteria for this study are shown in Table 1. In our previous study [3], type of healthcare facility included tertiary and secondary hospitals. However, in this study, primary and sanatorium hospitals were also included. In addition, information about patriots and veterans affairs' insurance

Table 1. Customized source population

List	Criteria
Treatment period	1 Jan 2011-31 Dec 2015
Type of healthcare facility	Tertiary, secondary, primary, sanatorium
Diagnostic code	C00-C97, D00-D48
Type of insurance	Health insurance, medical aid, patriots and veterans affairs' insurance expenditure by government
Hospital region	National
Sex	Male, female
Age	All ages

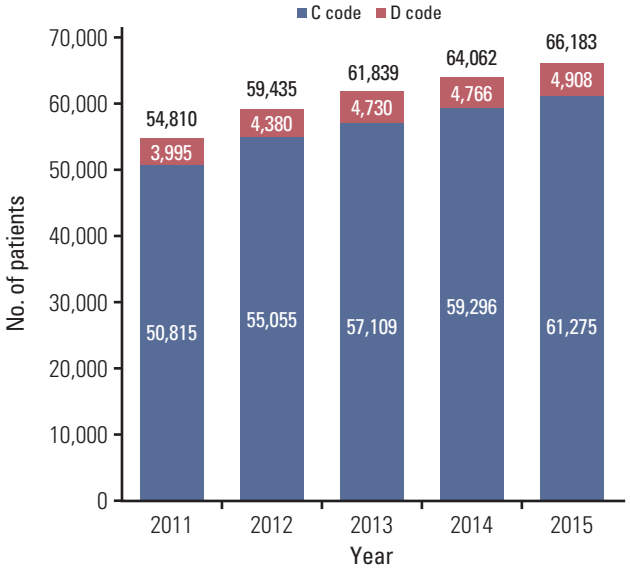

Fig. 1. The total number of patients who underwent radiation therapy between 2011 and 2015 in Korea.

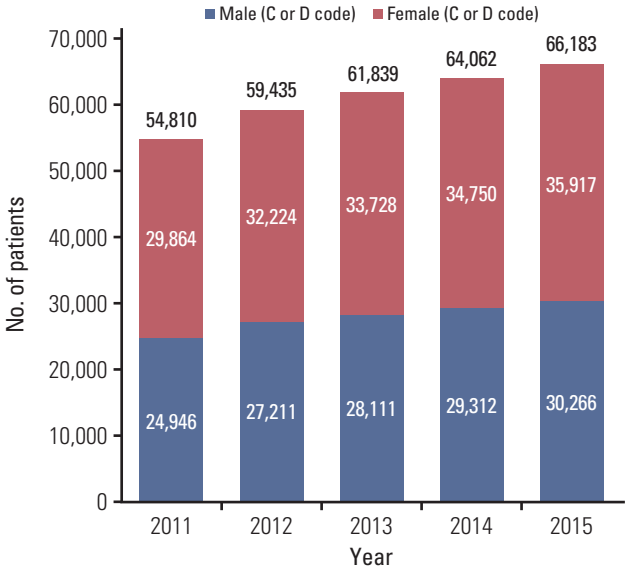

Fig. 2. The total numbers of male and female patients who received radiation therapy between 2011 and 2015 in Korea.

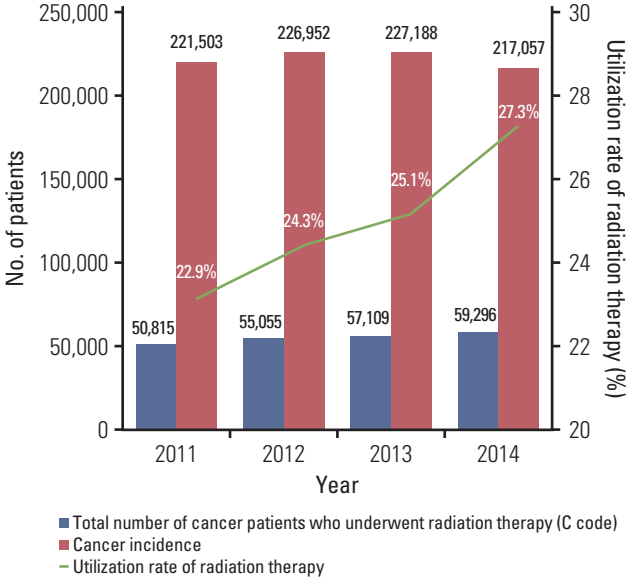

Fig. 3. Cancer incidence and the total number of patients who received radiation therapy between 2009 and 2013 in Korea.

Table 2. Distribution of cancer patients who underwent radiation therapy based on primary diagnosis between 2011 and 2015 in Korea

Category	Primary diagnosis (diagnostic code)	Year[a]				
		2011	2012	2013	2014	2015
Breast	(C50)	13,765	15,059	15,766	16,549	17,302
Gastrointestinal	Colorectum (C18-C20)	5,054	5,048	4,920	4,901	4,898
	Liver (C22)	3,027	3,446	3,641	3,679	4,112
	Esophagus (C15)	1,250	1,335	1,380	1,397	1,472
	Stomach (C16)	1,070	1,048	1,026	992	1,013
	Pancreas (C25)	782	942	906	948	998
	Gallbladder and biliary (C23-C24)	778	856	879	954	985
	Anus (C21)	193	213	211	203	199
	Small bowel (C17)	42	39	43	35	32
	Other (C26)	4	5	3	3	3
	Subtotal	12,200	12,932	13,009	13,112	13,712
Thoracic	Lung (C34)	8,991	9,425	10,187	10,846	10,863
	Thymus (C37)	258	238	249	307	323
	Mediastinum (C38)	41	44	48	47	54
	Trachea (C33)	16	18	16	22	25
	Other (C39)	4	3	2	1	1
	Subtotal	9,310	9,728	10,502	11,223	11,266
Head and neck	Larynx (C32)	773	884	964	912	903
	Oropharynx (C01, C09-C10)	509	615	595	621	619
	Oral cavity (C02-C06)	500	601	588	605	632
	Nasopharynx (C11)	414	489	488	488	516
	Salivary gland (C07-C08)	298	346	347	398	374
	Hypopharynx (C12-C13)	354	394	352	437	395
	Paranasal sinus (C31)	149	166	145	179	166
	Nasal cavity (C30)	93	129	110	128	142
	Eye and orbit (C69)	44	54	51	41	58
	Lip (C00)	11	8	13	9	18
	Other (C14)	19	20	14	16	17
	Subtotal	3,164	3,706	3,667	3,834	3,840
Gynecologic	Uterine cervix (C53)	2,453	2,481	2,540	2,425	2,466
	Uterine corpus (C54-C55)	635	724	741	810	813
	Ovary and tube (C56)	217	204	247	248	258
	Vagina and vulva (C51-C52)	111	111	100	90	122
	Other (C57-C58)	15	14	12	9	11
	Subtotal	3,431	3,534	3,640	3,582	3,670
Genitourinary	Prostate (C61)	1,952	2,451	2,577	2,634	2,778
	Ureter and bladder (C66-C67)	498	484	531	608	602
	Kidney (C64-C65)	443	422	445	454	525
	Penis and testis (C60, C62-C63)	65	57	66	57	62
	Other (C68)	11	14	12	18	19
	Subtotal	2,969	3,428	3,631	3,771	3,986
CNS	Brain (C70-C71)	1,388	1,513	1,567	1,623	1,605
	Spinal cord (C72)	60	61	52	48	47
	Other (C47)	45	36	52	32	46
	Subtotal	1,493	1,610	1,671	1,703	1,698
Lymphoma	Non-Hodgkin's lymphoma (C82-C88)	1,169	1,322	1,321	1,389	1,493
	Hodgkin's disease (C81)	98	108	91	93	100
	Other (C96)	22	23	21	30	33
	Subtotal	1,289	1,453	1,433	1,512	1,626

(Continued to the next page)

Table 2. Continued

Category	Primary diagnosis (diagnostic code)	Year[a]				
		2011	2012	2013	2014	2015
Soft tissue	(C46, C49)	545	581	631	648	715
Mesothelioma	(C45)	14	19	18	19	29
Myeloma and plasmacytoma	(C90)	316	414	442	450	459
Thyroid	(C73)	354	381	357	360	309
Leukemia	(C91-C95)	359	353	351	411	396
Skin	(C44)	244	287	264	284	279
Malignant melanoma	(C43)	215	209	225	244	241
Primary bone and cartilage	(C40-C41)	213	219	170	206	223
Endocrine	(C74-C75)	56	72	93	101	104
Unknown primary	(C48, C76-C80, C97)	878	1,070	1,239	1,287	1,420
Total No. of cancer patients	-	50,815	55,055	57,109	59,296	61,275
Carcinoma *in situ* of the breast	(D05)	1,388	1,653	1,918	1,912	2,062
Benign neoplasm of meninges	(D32)	1,022	960	1,041	1,112	1,032
Benign neoplasm of CNS	(D33)	726	750	744	694	713
Benign neoplasm of endocrine	(D34-D35)	229	283	304	319	308
Other D code diseases	(D00-D04, D06-D31, D36-D48)	630	734	723	729	793
Total D code patients	-	3,995	4,380	4,730	4,766	4,908
Total	-	54,810	59,435	61,839	64,062	66,183

CNS, central nervous system. [a]Number of patients who received radiation therapy.

expenditure by the government, which were not included in the previous study, were also included in this study. The source population consisted of all patients who had any of the International Classification of Diseases 10th revision cancer diagnoses (C00-C97) and those with diagnostic codes D00-D48 (including carcinoma *in situ* or benign neoplasms), who were also associated with at least one of the procedure codes related to RT treatment [3]. The detailed methods of categorization for diagnostic codes are described in a previous study [3].

We analyzed the claims data from the HIRA in order to identify the total number of patients who underwent RT, and the number of patients who received RT by primary cancer diagnosis, sex, and age group between 2011 and 2015 in Korea. In addition, through the classification of the procedure codes related to RT [3], we estimated the total number of patients who received specific RT modalities, including brachytherapy, intensity-modulated radiation therapy (IMRT), stereotactic radiation therapy (SRT), and proton therapy. Considering the annual cancer incidence [1], the percentage of patients who underwent RT was calculated. We also analyzed the geographic differences for the number of patients who received RT. The number of patients was based on the location of the healthcare facilities.

Results

The total number of patients who received RT in 2011, 2012, 2013, 2014, and 2015 were 54,810, 59,435, 61,839, 64,062, and 66,183, respectively (Fig. 1). Among them, the total numbers of male and female patients were 24,946/29,864 in 2011, 27,211/32,224 in 2012, 28,111/33,728 in 2013, 29,312/34,750 in 2014, and 30,266/35,917 in 2015 (Fig. 2). The absolute number of cancer patients who received RT and the cancer incidence from 2011 to 2014 are shown in Fig. 3. The utilization rate of RT in cancer patients has also increased steadily over the same period from 25% to 30%. Because Korea's cancer incidence in 2015 has not been reported yet, the utilization rate of RT in 2015 could not be calculated.

The distribution of patients who received RT by cancer diagnosis between 2011 and 2015 is shown in Table 2. The five cancers that were most frequently treated with RT between 2011 and 2012 were breast, lung, colorectal, liver, and uterine cervical cancers. However, the fifth most common cancer treated with RT that replaced uterine cervical cancer in 2013 was prostate cancer (Fig. 4A). The five most common types of cancer among the male patients were lung, liver, prostate, colorectal, and esophageal cancers, while the incidence of colorectal cancer showed a decreasing trend (Fig. 4B). Among female

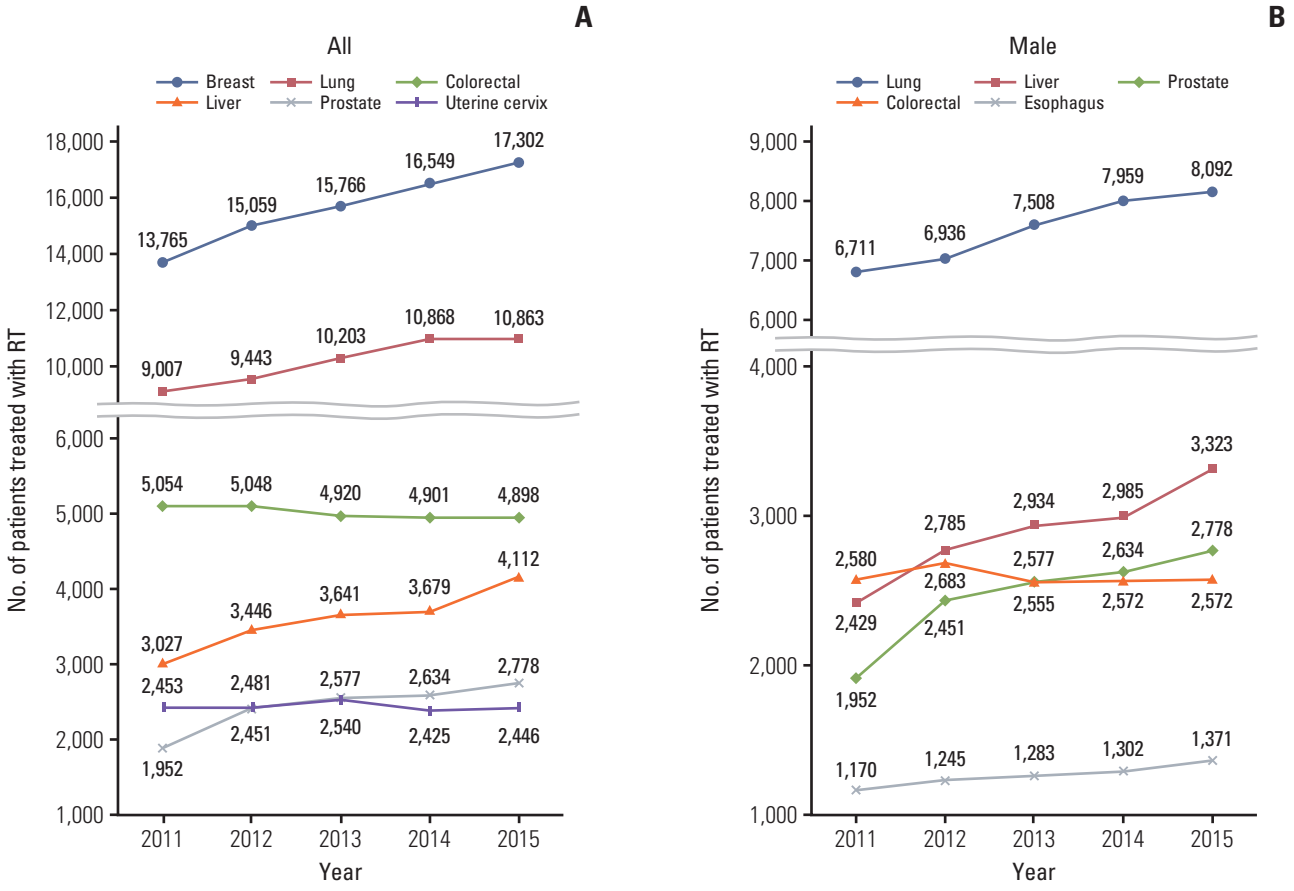

Fig. 4. The fifth most common cancer treated with radiation therapy (RT) between 2011 and 2015 in Korea. (A) All patients. (B) Male patients. *(Continued to the next page)*

patients, the five most common types were breast, lung, uterine cervical, colorectal, and uterine corpus cancers, while the incidence of colorectal and uterine cervix cancer showed a decreasing trend (Fig. 4C).

Breast cancer and carcinoma *in situ* of breast patients accounted for nearly 30% of the total patients who underwent RT, and for approximately half of the female patients (Table 2). The diseases with code 'D' made up 7% of the total patients treated with RT (Fig. 1).

The utilization rates of RT in the 10 most common cancers in Korea [1] are shown in Fig. 5. The utilization rate of RT increased significantly between 2011 and 2014 for breast (from 85% to 90%), lung (from 41% to 45%), liver (from 18% to 25%), and prostate cancer (from 22% to 27%).

The distribution of patients who received RT in 2015 based on cancer diagnosis and age group is shown in Table 3. The most common cancer was that of the central nervous system for patients aged 20 years or less, while breast cancer was the most common cancer in patients aged 30-50 years, and lung cancer was the most common cancer in patients aged 60 years or more. Similar trends were observed for previous years.

The distribution of patients who received RT with specific modalities is shown in Table 4. The use of advanced RT modalities like IMRT, SRT, and proton therapy are steadily increasing every year.

Table 5 shows the distribution of patients who received RT from 2011 to 2015 in Korea for each prefecture. The population of each prefecture in 2015 is shown as a representative value [5]. The number of patients has steadily increased every year in all prefectures. More than half of cancer patients (64%) were treated with RT in the capital area (Seoul, Gyeonggi, and Incheon).

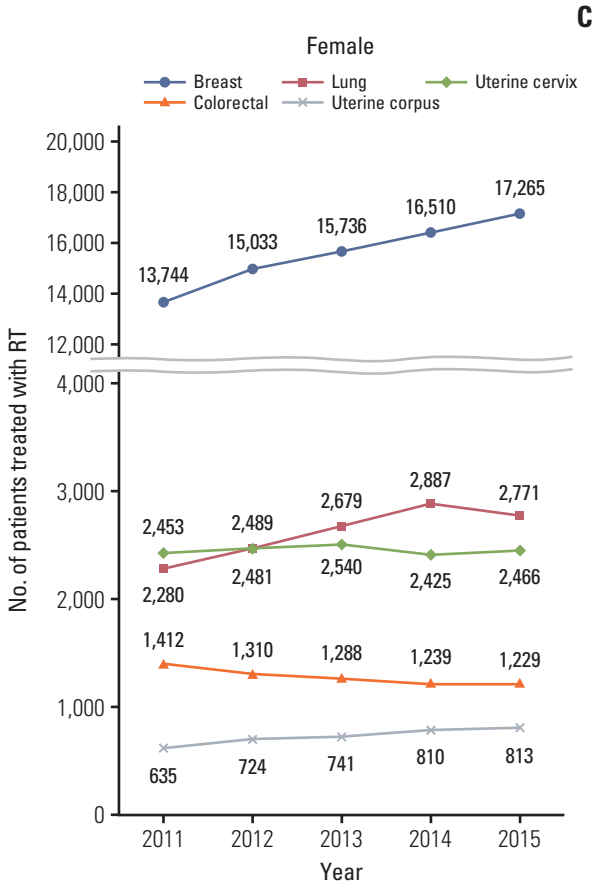

Fig. 4. *(Continued from the previous page)* (C) Female patients.

Discussion

We analyzed the clinical utilization of RT between 2011 and 2015 in Korea using claims data from the HIRA. The total number of patients who underwent RT has increased by 3%-8% per year between 2011 and 2015 (Fig. 1). As shown in Fig. 3, the annual cancer incidence in Korea has slowed after increasing until 2011 [1], and it decreased in 2014 compared with 2013. However, the number of cancer patients who underwent RT increased annually during the same period (Fig. 3). This antithetical pattern seemingly stems from a decrease in the total cancer incidence due to a decrease in the thyroid cancer incidence in recent years in Korea [1]. As shown in Fig. 5, because the role of external beam RT in well-differentiated thyroid cancer remains controversial [6], the decreasing incidence of thyroid cancer does not affect the utilization of RT in cancer patients.

While the numbers of breast, lung, and prostate cancers being treated with RT has increased every year, the numbers of colorectal and uterine cervix cancer treated with RT have not shown any increase (Fig. 4). These trends of RT for these cancers have some correlation with the increasing and decreasing trends in the incidence of these cancers (Fig. 5). Interestingly, liver cancer has shown a significant increase in the number of RT patients (Figs. 4 and 5) although the incidence of liver cancer has been the same or has slightly decreased every year in Korea [1]. The increase of RT for patients with liver cancer seems to have a correlation with the remarkable increase of utilization rate of RT (Fig. 5). This trend may be because recently many studies have reported good clinical outcomes for hepatocellular carcinoma patients receiving high dose radiation in Korea using advanced RT technologies, including IMRT, SRT, and image guided radiotherapy [7-12]. Furthermore, the Korean Practice Guidelines for the Management of Hepatocellular Carcinoma recommend RT for inoperable hepatocellular carcinoma patients [13].

Although the percentage of cancer patients who underwent RT increased from 25% to 30% during these 5 years (Fig. 3), the clinical utilization rate of RT in Korea seems to be lower than of the estimated optimal utilization rate of developed or developing countries (47%-56%) [14-16]. However, recently Mackillop et al. [17] criticized the overestimation of the optimal RT utilization rate in the previous reports and reported that optimal utilization rate is 34% considering the conditions of optimal access to RT. Because the study estimated the optimal utilization rate of RT in Korea under conditions of access to RT of Korea was not reported yet, whether 30% of RT utilization in Korea is appropriate is debatable. Nevertheless, the incidence of breast, lung, and prostate cancers that account for over 50% of RT patients is showing an increasing trend every year [1]. Therefore, the clinical utilization rate of RT among cancer patients in Korea is expected to continue to rise.

There is an overlap in years between the present and a previous study [3]; however, the number of patients who underwent RT are different between the two studies during the same period. Compared to the previous study, annually, an additional 200-300 patients underwent RT between 2011 and 2013. This difference might be because additional healthcare information that was not included in the previous study was integrated in the present study, such as information from primary and sanatorium hospitals and patriots and veterans affairs' insurance expenditure by the government. Besides, there is lately (after 1 or more years) registered claims data in HIRA.

In terms of RT modalities, the number of cases receiving SRT has steadily increased over the last 5 years and it was notably increased especially in 2015. In 2015, the national health insurance coverage of SRT was expanded from only

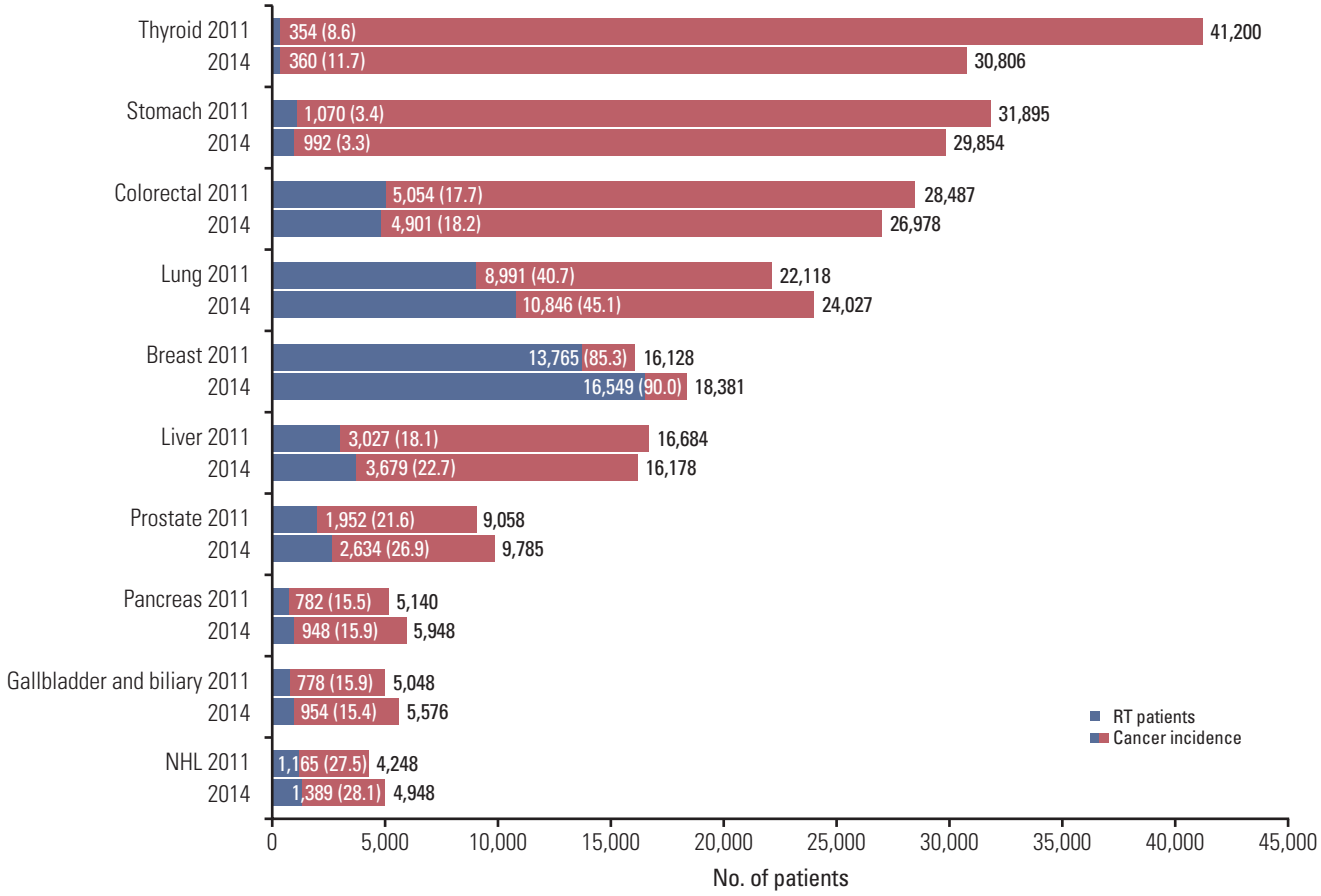

Fig. 5. The utilization rate of radiation therapy (RT) in the 10 most common cancer between 2011 and 2014 in Korea. NHL, non-Hodgkin's lymphoma.

cranio-spinal tumors and inoperable lung cancer to whole body tumors. Similar to SRT, notable increases in the use of IMRT and proton therapy are expected in 2016 because national health insurance coverage of IMRT and proton therapy has been expanded in the second half of 2015. In addition, a second proton therapy center in Korea started operating in 2016 [18]. However, it should be kept in mind that the claims data from the HIRA only included data of the insured cases and the number of uninsured treatments could not be recorded. Therefore, the actual number of patients who received SRT, IMRT, and proton therapy are expected to be higher than the reported number.

In 2015, the population of Seoul was 19.5% of Korea's population; however, nearly half of the patients (43.9%) treated with RT were treated in Seoul (Table 5). If we assume that the optimal rate of RT patients is equal to the percentage of population in each prefecture, Seoul had 2.25 fold of RT patients and Chungbuk had 0.35 fold of RT patients. This phenomenon of concentration in Seoul therefore seems very extreme. To explain this severe disproportion between regions, we need to analyze the infrastructure of RT in Korea. However, unfortunately, no such study has been published after 2007 [19]. We are preparing for the report about the status of the infrastructure of radiotherapy in Korea (2015).

The total number of patients who underwent RT increased steadily from 2011 to 2015 in Korea. The utilization rate of RT in cancer patients is also increasing. These trends are expected to continue because the incidences of breast and lung cancers with treatment heavily dependent on RT are also experiencing a rising trend in Korea.

Table 3. The number of patients who underwent radiation therapy by cancer diagnosis and age group in Korea (2015)

Category	Primary diagnosis	Age group[a)]						
		20s or under	30s	40s	50s	60s	70s or older	Total
Breast	Breast (C50)	114	1,614	5,949	5,908	2,761	956	17,302
Gastrointestinal	Colorectum (C18-C20)	13	140	563	1,330	1,376	1,476	4,898
	Liver (C22)	10	89	447	1,332	1,326	908	4,112
	Esophagus (C15)	0	2	50	328	498	594	1,472
	Stomach (C16)	9	66	151	279	258	250	1,013
	Pancreas (C25)	2	16	65	273	340	302	998
	Gallbladder and biliary (C23-C24)	0	8	58	237	347	335	985
	Anus (C21)	3	0	16	52	49	79	199
	Small bowel (C17)	0	3	0	10	12	7	32
	Other (C26)	0	0	0	1	2	0	3
	Subtotal	37	324	1,350	3,842	4,208	3,951	13,712
Thoracic	Lung (C34)	14	124	571	2,232	3,632	4,290	10,863
	Thymus (C37)	9	26	71	86	79	52	323
	Mediastinum (C38)	14	4	8	10	11	7	54
	Trachea (C33)	1	1	5	4	7	7	25
	Other (C39)	0	0	0	0	1	0	1
	Subtotal	38	155	655	2,332	3,730	4,356	11,266
Head and neck	Larynx (C32)	0	5	32	204	344	318	903
	Oropharynx (C01, C09-C10)	2	7	58	229	211	112	619
	Oral cavity (C02-C06)	15	36	77	172	166	166	632
	Nasopharynx (C11)	21	44	109	162	112	68	516
	Salivary gland (C07-C08)	21	23	52	100	103	75	374
	Hypopharynx (C12-C13)	0	1	11	85	140	158	395
	Paranasal sinus (C31)	3	3	28	42	43	47	166
	Nasal cavity (C30)	4	15	20	37	26	40	142
	Eye and orbit (C69)	7	3	7	15	11	15	58
	Lip (C00)	0	0	2	5	3	8	18
	Other (C14)	1	1	0	3	6	6	17
	Subtotal	74	138	396	1,054	1,165	1,013	3,840
Gynecologic	Uterine cervix (C53)	24	274	539	702	440	487	2,466
	Uterine corpus (C54-C55)	9	24	129	339	213	99	813
	Ovary and tube (C56)	1	13	40	98	69	37	258
	Vagina and vulva (C51-C52)	0	2	12	28	21	59	122
	Other (C57-C58)	0	1	1	3	5	1	11
	Subtotal	34	314	721	1,170	748	683	3,670

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Table 3. Continued

Category	Primary diagnosis	Age group[a)]						
		20s or under	30s	40s	50s	60s	70s or older	Total
Genitourinary	Prostate (C61)	1	0	18	257	918	1,584	2,778
	Ureter and bladder (C66-C67)	1	4	31	94	145	327	602
	Kidney (C64-C65)	11	14	56	141	156	147	525
	Penis and testis (C60, C62-C63)	12	14	7	12	7	10	62
	Other (C68)	0	2	2	1	4	10	19
	Subtotal	25	34	114	505	1,230	2,078	3,986
CNS	Brain (C70-C71)	250	186	264	391	304	210	1,605
	Spinal cord (C72)	15	5	7	6	8	6	47
	Other (C47)	9	12	7	7	6	5	46
	Subtotal	274	203	278	404	318	221	1,698
Lymphoma	Non-Hodgkin's lymphoma (C82-C88)	78	128	220	361	331	375	1,493
	Hodgkin's disease (C81)	36	19	10	15	5	15	100
	Other (C96)	5	8	8	8	1	3	33
	Subtotal	119	155	238	384	337	393	1,626
Soft tissue	(C46, C49)	75	73	103	157	135	172	715
Mesothelioma	(C45)	0	0	3	8	12	6	29
Myeloma and plasmacytoma	(C90)	1	5	43	113	163	134	459
Thyroid	(C73)	3	3	24	75	82	122	309
Leukemia	(C91-C95)	138	54	85	69	34	16	396
Skin	(C44)	5	11	14	40	53	156	279
Malignant melanoma	(C43)	3	8	31	60	73	66	241
Primary bone and cartilage	(C40-C41)	58	23	28	39	34	41	223
Endocrine	(C74-C75)	50	11	4	24	7	8	104
Unknown primary	(C48, C76-C80, C97)	20	53	168	377	429	373	1,420
Total No. of cancer patients		1,068	3,178	10,204	16,561	15,519	14,745	61,275
Carcinoma *in situ* of the breast	(D05)	18	184	799	661	323	77	2,062
Benign neoplasm of meninges	(D32)	10	36	161	319	266	240	1,032
Benign neoplasm of CNS	(D33)	53	65	136	208	148	103	713
Benign neoplasm of endocrine	(D34-D35)	19	41	71	84	60	33	308
Other D code diseases	(D00-D04, D06-D31, D36-D48)	88	75	124	189	176	141	793
Total D code patients		188	401	1,291	1,461	973	594	4,908
Total		1,256	3,579	11,495	18,022	16,492	15,339	66,183

CNS, central nervous system. [a)]Number of patients who received radiation therapy.

Table 4. Distribution of patients who received radiation therapy according to specific radiation therapy modalities between 2011 and 2015 in Korea

Radiation therapy modality	Year[a]				
	2011	2012	2013	2014	2015
Brachytherapy	1,421 (2.6)	1,421 (2.4)	1,404 (2.3)	1,255 (2.0)	1,247 (1.9)
Intensity-modulated radiation therapy	6,250 (11.4)	6,372 (10.7)	6,698 (10.8)	7,022 (11.0)	8,397 (12.7)
Stereotactic radiation therapy	3,122 (5.7)	6,670 (11.2)	6,772 (11.0)	7,648 (11.9)	12,228 (18.5)
Proton radiation therapy	25 (0.0)	50 (0.1)	33 (0.1)	34 (0.1)	158 (0.2)

Values are presented as number (%). [a]Percentage of the number of specific radiation therapy modalities over the total number of radiotherapy in each year.

Table 5. Demographic data of patients who received radiation therapy between 2011 and 2015 in Korea for each prefecture

Prefecture	Population (2015) [5], $\times 10^3$ (%)	Year				
		2011	2012	2013	2014	2015
Seoul	9,860 (19.5)	24,713 (45.1)	26,996 (45.4)	27,458 (44.4)	28,303 (44.2)	29,085 (43.9)
Gyeonggi, Incheon	15,284 (30.2)	10,651 (19.4)	11,543 (19.4)	12,228 (19.8)	12,859 (20.1)	13,680 (20.7)
Gangwon	1,506 (3.0)	1,308 (2.4)	1,422 (2.4)	1,365 (2.2)	1,406 (2.2)	1,501 (2.3)
Chungbuk	1,561 (3.1)	654 (1.2)	684 (1.2)	683 (1.1)	696 (1.1)	742 (1.1)
Chungnam, Daejeon	3,822 (7.5)	2,548 (4.6)	2,822 (4.7)	3,029 (4.9)	3,047 (4.7)	3,166 (4.8)
Jeonbuk	1,798 (3.5)	1,299 (2.4)	1,334 (2.2)	1,366 (2.2)	1,466 (2.3)	1,393 (2.1)
Jeonnam, Gwangju	3,274 (6.5)	2,812 (5.1)	3,024 (5.1)	3,119 (5.0)	3,195 (5.0)	3,359 (5.1)
Gyeongbuk, Daegu	5,097 (10.1)	4,062 (7.4)	4,388 (7.4)	4,702 (7.6)	4,922 (7.7)	4,926 (7.4)
Gyeongnam, Busan, Ulsan	7,827 (15.5)	6,393 (11.7)	6,774 (11.4)	7,429 (12.0)	7,652 (11.9)	7,802 (11.8)
Jeju	587 (1.1)	420 (0.7)	448 (0.8)	460 (0.8)	516 (0.8)	529 (0.8)
Total	50,616 (100)	54,810 (100)	59,435 (100)	61,839 (100)	64,062 (100)	66,183 (100)

Values are presented as number (%).

Conflicts of Interest

Conflict of interest relevant to this article was not reported.

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References

1. National Cancer Center. Cancer statistics in Korea: incidence, mortality, survival, and prevalence [Internet]. Goyang: National Cancer Center; 2017 [cited 2017 Jan 17]. Available from: http://ncc.re.kr/cancerStatsView.ncc?bbsnum=397&searchKey=total&searchValue=&pageNum=1.
2. Slotman BJ, Cottier B, Bentzen SM, Heeren G, Lievens Y, van den Bogaert W. Overview of national guidelines for infrastructure and staffing of radiotherapy. ESTRO-QUARTS: work package 1. Radiother Oncol. 2005;75:349-54.
3. Kang JK, Kim MS, Jang WI, Seo YS, Kim HJ, Cho CK, et al. The clinical utilization of radiation therapy in Korea between 2009 and 2013. Radiat Oncol J. 2016;34:88-95.
4. Kang JK, Kim MS, Jang WI, Kim HJ, Cho CK, Yoo HJ, et al. The clinical status of radiation therapy in Korea in 2009 and

2013. Cancer Res Treat. 2016;48:892-8.
5. National Index System, Population in 2015 [Internet]. Daejeon: Statistics Korea; 2017 [cited 2017 Jan 17]. Available from: http://www.index.go.kr/potal/main/EachDtlPageDetail.do?idx_cd=1007.
6. Lee N, Tuttle M. The role of external beam radiotherapy in the treatment of papillary thyroid cancer. Endocr Relat Cancer. 2006;13:971-7.
7. Park SH, Kim JC, Kang MK. Technical advances in external radiotherapy for hepatocellular carcinoma. World J Gastroenterol. 2016;22:7311-21.
8. Kang JK, Kim MS, Cho CK, Yang KM, Yoo HJ, Kim JH, et al. Stereotactic body radiation therapy for inoperable hepatocellular carcinoma as a local salvage treatment after incomplete transarterial chemoembolization. Cancer. 2012;118:5424-31.
9. Paik EK, Kim MS, Jang WI, Seo YS, Cho CK, Yoo HJ, et al. Benefits of stereotactic ablative radiotherapy combined with incomplete transcatheter arterial chemoembolization in hepatocellular carcinoma. Radiat Oncol. 2016;11:22.
10. Rim CH, Seong J. Application of radiotherapy for hepatocellular carcinoma in current clinical practice guidelines. Radiat Oncol J. 2016;34:160-7.
11. Bae BK, Kim JC. The response of thrombosis in the portal vein or hepatic vein in hepatocellular carcinoma to radiation therapy. Radiat Oncol J. 2016;34:168-76.
12. Seol SW, Yu JI, Park HC, Lim DH, Oh D, Noh JM, et al. Treatment outcome of hepatic re-irradiation in patients with hepatocellular carcinoma. Radiat Oncol J. 2015;33:276-83.
13. Korean Liver Cancer Study Group (KLCSG); National Cancer Center, Korea (NCC). 2014 KLCSG-NCC Korea practice guideline for the management of hepatocellular carcinoma. Gut Liver. 2015;9:267-317.
14. Barton MB, Jacob S, Shafiq J, Wong K, Thompson SR, Hanna TP, et al. Estimating the demand for radiotherapy from the evidence: a review of changes from 2003 to 2012. Radiother Oncol. 2014;112:140-4.
15. Borras JM, Lievens Y, Dunscombe P, Coffey M, Malicki J, Corral J, et al. The optimal utilization proportion of external beam radiotherapy in European countries: An ESTRO-HERO analysis. Radiother Oncol. 2015;116:38-44.
16. Rosenblatt E, Barton M, Mackillop W, Fidarova E, Cordero L, Yarney J, et al. Optimal radiotherapy utilisation rate in developing countries: An IAEA study. Radiother Oncol. 2015;116:35-7.
17. Mackillop WJ, Kong W, Brundage M, Hanna TP, Zhang-Salomons J, McLaughlin PY, et al. A comparison of evidence-based estimates and empirical benchmarks of the appropriate rate of use of radiation therapy in ontario. Int J Radiat Oncol Biol Phys. 2015;91:1099-107.
18. Chung K, Han Y, Kim J, Ahn SH, Ju SG, Jung SH, et al. The first private-hospital based proton therapy center in Korea: status of the Proton Therapy Center at Samsung Medical Center. Radiat Oncol J. 2015;33:337-43.
19. Huh SJ; Korean Society of Therapeutic Radiology and Oncology (KOSTRO). Current status of the infrastructure and characteristics of radiation oncology in Korea. Jpn J Clin Oncol. 2007;37:623-7.