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Japanese structure survey of radiation oncology in 2015

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ABSTRACT

This article describes the ongoing structure of radiation oncology in Japan in terms of equipment, personnel, patient load and geographic distribution to identify and overcome any existing limitations. From May 2016 to August 2018, the Japanese Society for Radiation Oncology conducted a questionnaire based on the Japanese national structure survey of radiation oncology in 2015. Data were analyzed based on the institutional stratification by the annual number of new patients treated with radiotherapy per institution. The estimated annual numbers of new and total (new plus repeat) patients treated with radiation were 225 000 and 271 000, respectively. Additionally, the estimated cancer incidence was 891 445 cases with approximately 25.2% of all newly diagnosed patients being treated with radiation. The types and numbers of treatment devices actually used included linear accelerator (linac; $n = 936$), Gamma Knife ($n = 43$), ^{60}Co remote afterloading system (RALS; $n = 21$), and ^{192}Ir RALS ($n = 129$). The linac system used dual-energy functions in 754 units, 3D conformal radiotherapy functions in 867, and intensity-modulated radiotherapy (IMRT) functions in 628. There were 899 Japan Radiological Society/Japanese Society for Radiation Oncology-certified radiation oncologists (RO), 1213.9 full-time equivalent (FTE) ROs, 2394.2 FTE radiotherapy technologists (RTT), 295.7 FTE medical physicists, 210.2 FTE radiotherapy quality managers, and 906.1 FTE nurses. The frequency of IMRT use significantly increased during this time. In conclusion, the Japanese structure of radiation oncology has clearly improved in terms of equipment and utility although there was a shortage of personnel in 2015.

Keywords: structure survey; radiotherapy institution; radiotherapy personnel; radiotherapy equipment

INTRODUCTION

In 1991, the Japanese Society for Radiation Oncology (JASTRO) conducted the first national survey of the structure of radiotherapy institutions in Japan based on their status in 1990, and the results were reported by Tsunemoto *et al.* [1]. The Japanese structure has gradually changed since a greater number of cancer patients are treated with radiation and public awareness of the importance of radiotherapy has grown. JASTRO has conducted national structure surveys every two years since 1991 [2–24]. The consecutive structural data gathered and published by JASTRO have been useful to gain an understanding of our current position and future direction in Japan. Despite some delays, the updated Japanese national structure survey data of radiation oncology in 2015 is now available.

MATERIALS AND METHODS

From May 2016 to August 2018, a questionnaire regarding the 2015 national structure survey of radiation oncology was conducted that included the number of treatment systems by type, number of personnel by category, and number of patients by type, site and treatment modality. To measure variables over a longer time period, data for the year 2015 were also considered. In total, 737 of

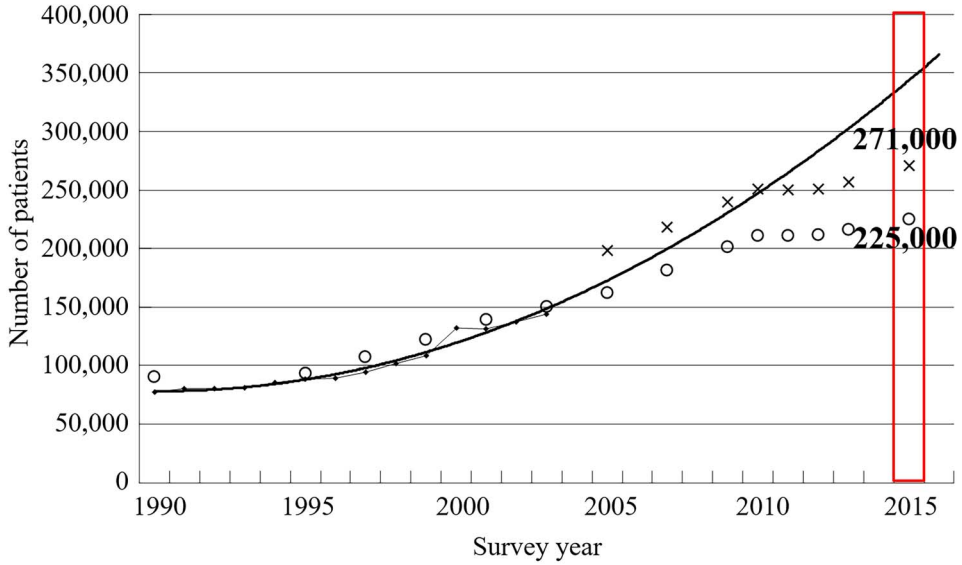

Fig. 1. Estimate of increase in demand for radiotherapy in Japan, based on statistical correction of annual change in the number of new patients per year at Patterns of Care Study survey facilities [25]. x and o denote the estimated number of total (new plus repeat) and new patients by the results in structure surveys by the JASTRO.

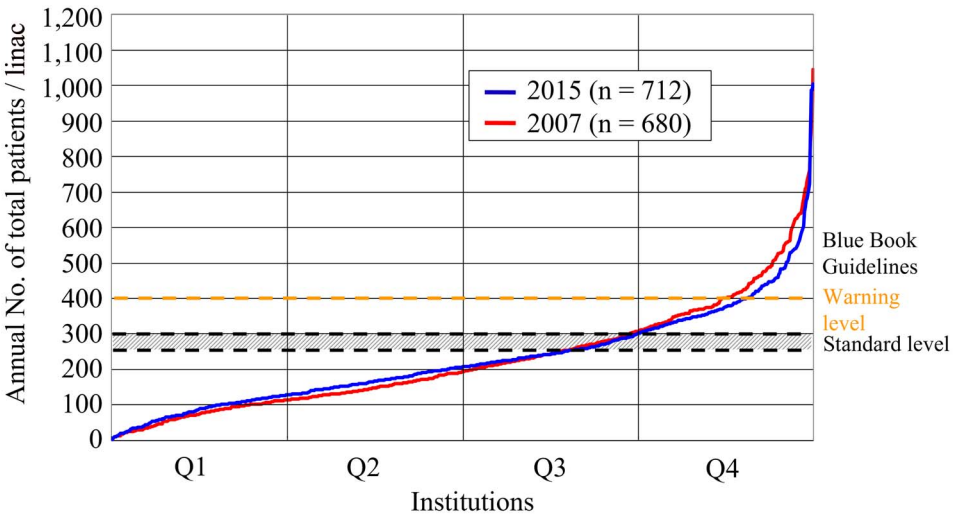

Fig. 2. Distribution of annual total (new plus repeat) patient load per linac in radiotherapy institutions. Horizontal axis represents institutions arranged in order of increasing value of annual number of total patients per linac within the institution. Q1: 0–25%, Q2: 26–50%, Q3: 51–75%, Q4: 76–100%.

846 active institutions attempted the survey; the response rate was 87.1%.

The current report analyzes these institutional structure data (equipment, personnel, patient load and geographic distribution) based on institutional stratification by the annual number of new patients treated with radiotherapy at each institution. Clinical working hours of each staff member performing radiotherapy were derived from full-time equivalent (FTE; 40 hours per week for radiation oncology work only) data. The Japanese Blue Book Guidelines (JBBG) [25, 26] were used for comparison with the results of this study. These guidelines pertain to the structure of radiation oncology in Japan based on Patterns of Care Study (PCS) [27, 28] data. The standard guidelines were set at 250–300 (warning level, 400) for annual patient load per external beam machine, at 200 (warning level, 300) for annual

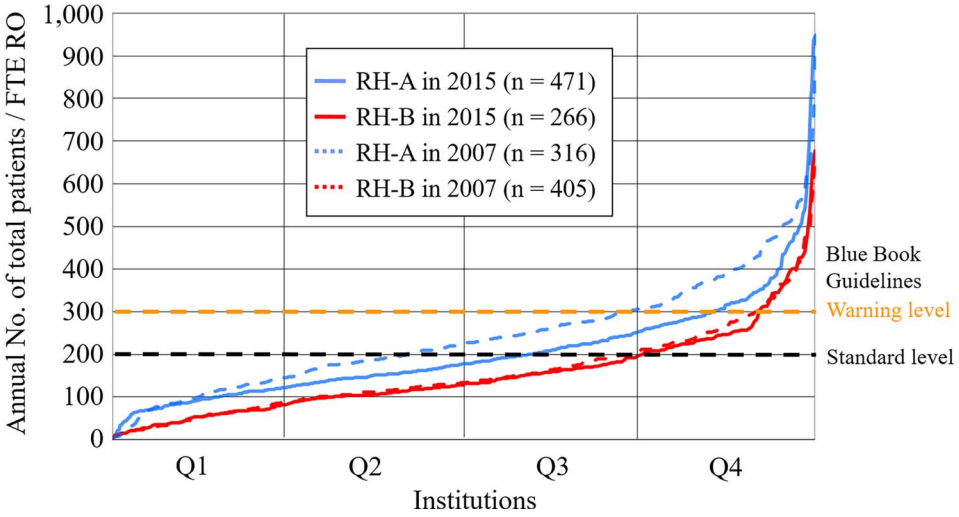

Fig. 3. Distribution of annual total (new plus repeat) patient load per FTE RO according to institution categories shown Table 14; all radiotherapy hospitals. Horizontal axis represents institutions arranged in order of increasing value of annual number of total patients per FTE RO within the institution. Q1: 0–25%, Q2: 26–50%, Q3: 51–75%, Q4: 76–100%.

Table 1. Category of radiotherapy institution

Institution category	
U:	University hospital
G:	Cancer center (including national centers)
N:	National hospital organization (excluding cancer centers)
P:	Public hospital (excluding cancer centers)
O:	Red cross hospital, saiseikai hospital, company hospital, public corporation hospital, national health insurance hospital, social insurance hospital, mutual insurance hospital, industrial accident hospital, association hospital and Japan agricultural co-operatives hospital
H:	Medical corporation hospital, medical association hospital, private hospital and other hospital

patient load per FTE radiation oncologist (RO), and at 120 (warning level, 200) for annual patient load per FTE radiotherapy technologist (RTT).

Furthermore, we analyzed data from the designated cancer care hospital accredited by the Ministry of Health, Labor and Welfare. As on 1 April 2019, Japan had 428 designated cancer care hospitals [29]. A total of 50 institutions did not return the survey; therefore, the structure data for these 378 designated cancer care hospitals were analyzed and compared with the data for all radiotherapy hospitals. The analysis was conducted in two groups: institutions with <1.0 FTE RO and those with ≥ 1.0 FTE RO.

RESULTS

In this report, all results have been presented in Tables 1–18 and Figs 1–6. We have briefly summarized the Japanese national structure survey of radiation oncology for 2015. The values obtained by dividing the real numbers of new patients (196 002) and total (new plus repeat) patients (235 892) by the response rate were 224990.1 and 270779.7, respectively. In addition, there may be radiotherapy institutions not perceived by JASTRO. Therefore, the estimated number of new patients was approximately 225 000 rounded up 224990.1 to the nearest 1000. In the same way, the estimated number of total patients was approximately 271 000 (Fig. 1).

DISCUSSION

It is necessary to carefully consider that the estimated numbers of new patients and total patients reported also vary widely according to the difference in the calculation methods. In this survey, we had a very high response rate of 87.1%, so the estimated number of new patients and total patients were approximately 225 000 and 271 000 by a simple calculation using the response rate. Teshima *et al.* were estimated future prediction for the number of new patients with radiotherapy as shown the solid line in Fig. 1 [28]. About the number of new patients, there has been a large divergence between future prediction (the solid line) and JASTRO survey results (the dots: o) since around 2009.

In 2015, based on Japanese cancer registries, the cancer incidence was measured at 891445 cases (measured value) [30] with approximately 25.2% (225 000 of 891 445) of all newly diagnosed patients

Table 2. Number of radiotherapy institutions by scale classification and institution category

Scale category (annual number of new patients)	Institution category						Total	Institution ratio [%]
	U	G	N	P	O	H		
A (≤99)	5	1	19	45	36	32	138	18.7
B (100–199)	12	2	19	88	59	62	242	32.8
C (200–299)	13	2	5	37	45	26	128	17.4
D (300–399)	20	1	8	21	23	22	95	12.9
E (400–499)	20	2	2	7	7	6	44	6.0
F (≥500)	45	17	1	10	4	13	90	12.2
Total	115	25	54	208	174	161	737	
Institution ratio [%]	15.6	3.4	7.3	28.2	23.6	21.8		100.0

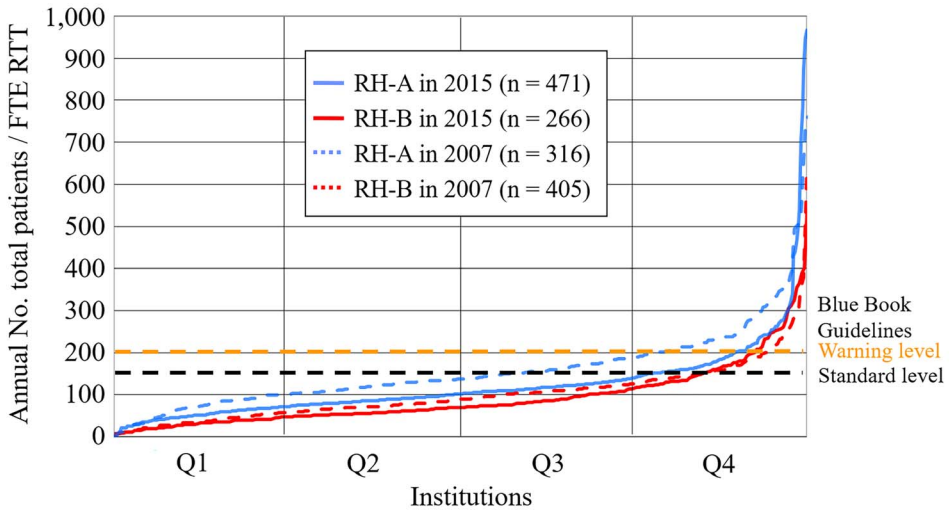

Fig. 4. Distribution of annual total (new plus repeat) patient load per FTE RTT according to institution categories shown Table 14; all radiotherapy hospitals. Horizontal axis represents institutions arranged in order of increasing value of annual number of total patients per FTE RTT within the institution. Q1: 0–25%, Q2: 26–50%, Q3: 51–75%, Q4: 76–100%.

Table 3. Annual number of new patients by scale classification and institution category

Scale category (number of institutions)	Institution category (number of institutions)						Total (737)	Average
	U (115)	G (25)	N (54)	P (208)	O (174)	H (161)		
A (138)	191	36	1033	2428	2431	2121	8240	59.7
B (242)	1814	315	2867	12 321	8732	9287	35 336	146.0
C (128)	3227	465	1189	8826	10 893	6324	30 924	241.6
D (95)	6792	386	2693	7337	7923	7598	32 729	344.5
E (44)	9143	891	826	3089	3098	2645	19 692	447.5
F (90)	32 849	17 522	800	6080	2937	8893	69 081	767.6
Total (737)	54 016	19 615	9408	40 081	36 014	36 868	1,96 002	265.9
Average	469.7	784.6	174.2	192.7	207.0	229.0	265.9	
Median	446	637	141	155	186.5	182	195	

Table 4. Annual number of total (new plus repeat) patients by scale classification and institution category

Scale category (number of institutions)	Institution category (number of institutions)						Total (737)	Average
	U (115)	G (25)	N (54)	P (208)	O (174)	H (161)		
A (138)	207	49	1207	2731	2887	2704	9785	70.9
B (242)	2076	347	3475	14 202	10 066	11 760	41 926	173.2
C (128)	3709	588	1353	10 923	13 107	8136	37 816	295.4
D (95)	8006	496	3079	8929	9489	9382	39 381	414.5
E (44)	11 400	1035	1120	3773	3951	3747	25 026	568.8
F (90)	38 638	21 092	828	6957	3391	11 052	81 958	910.6
Total (737)	64 036	23 607	11 062	47 515	42 891	46 781	2,35 892	320.1
Average	556.8	944.3	204.9	228.4	246.5	290.6	320.1	
Median	520	790	171	177.5	216.5	226	227	

Table 5. Number of treatment devices and their functions by scale classification

Treatment devices and their functions	Scale category (number of institutions)						Total (737)
	A (138)	B (242)	C (128)	D (95)	E (44)	F (90)	
Linac	139	234	142	131	78	212	936
with dual energy function	101	188	117	109	70	169	754
with 3DCRT function (MLC width $\leq$ 1.0 cm)	116	212	137	125	76	201	867
with IMRT function	51	126	101	103	66	181	628
with cone beam CT or CT on rail	55	123	98	92	53	144	565
with treatment position verification system (x-ray perspective image)	47	100	75	77	47	117	463
with treatment position verification system (other than those above)	36	71	56	49	41	74	327
Annual no. patients/linac	70.4	179.2	266.3	300.6	320.8	386.6	252.0
CyberKnife*	4	7	1	4	2	8	26
Novalis*	2	3	12	14	7	11	49
Tomotherapy*	1	14	7	8	1	12	43
Mobetron*	0	0	1	0	0	3	4
Particle	0	1	0	2	0	11	14
Microtoron	1	1	1	0	1	1	5
Telecobalt (actual use)	0 (0)	0 (0)	1 (0)	0 (0)	0 (0)	0 (0)	1 (0)
Gamma Knife*	2	12	8	8	5	8	43
Other accelerator	0	0	0	0	0	3	3
Other external irradiation device	0	0	1	0	0	0	1
New type ^{60}Co RALS (actual use)	0 (0)	3 (3)	5 (5)	5 (5)	3 (3)	5 (5)	21 (21)
Old type ^{60}Co RALS (actual use)	0 (0)	0 (0)	0 (0)	0 (0)	1 (0)	0 (0)	1 (0)
^{192}Ir RALS (actual use)	1 (1)	3 (3)	12 (10)	31 (30)	20 (20)	66 (65)	133 (129)
^{137}Cs RALS (actual use)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)

linac = linear accelerator, 3DCRT = 3D conformal radiotherapy, MLC = multileaf collimator, IMRT = intensity-modulated radiotherapy, CT = computed tomography, Co = cobalt, RALS = remote-controlled after-loading system, Ir = iridium, Cs = Caesium.

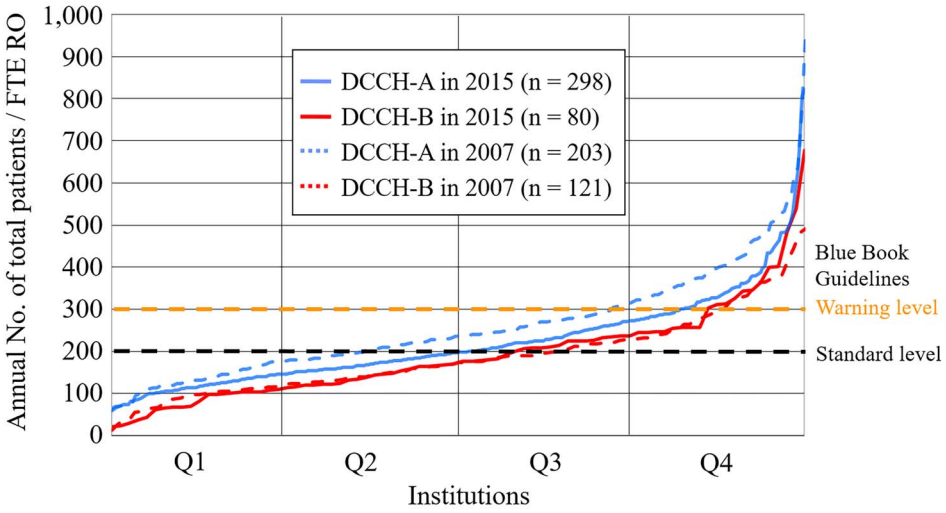

Fig. 5. Distribution of annual total (new plus repeat) patient load per FTE RO according to institution categories shown Table 14; designated cancer care hospitals. Horizontal axis represents institutions arranged in order of increasing value of annual number of total patients per FTE RO within the institution. Q1: 0–25%, Q2: 26–50%, Q3: 51–75%, Q4: 76–100%.

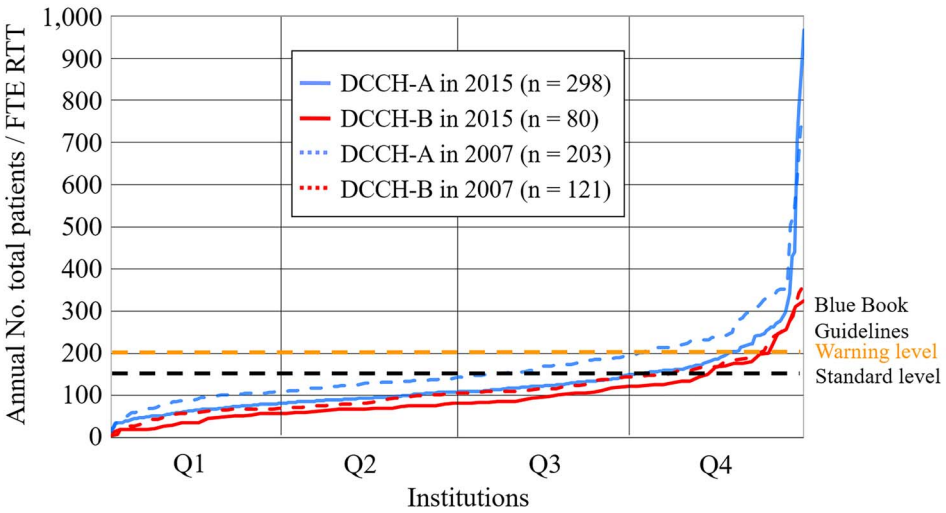

Fig. 6. Distribution of annual total (new plus repeat) patient load per FTE RTT according to institution categories shown Table 14; designated cancer care hospitals. Horizontal axis represents institutions arranged in order of increasing value of annual number of total patients per FTE RTT within the institution. Q1: 0–25%, Q2: 26–50%, Q3: 51–75%, Q4: 76–100%.

being treated with radiation. However, it is also reported 903 914 cases as estimated value. In that case, 24.9% (225 000 of 903 914) of newly cancer patients have treated by radiotherapy.

Regarding the case scale of institution, approximately 48.4% of all radiotherapy institutions had ≥200 new radiotherapy patients per year, whereas 31.1% of the institutions had ≥300. Additionally, 36.1% of all radiotherapy institutions had <1.0 FTE ROs. Compared with the findings of a similar survey conducted data in 2007 [14–17] and 2013 [24], the percentage of institutions that have > = 1.0 FTE ROs had improved a little (2007: 43.8%, 2013: 61.1%, 2015: 63.9%), but was not yet sufficient.

When viewed from the perspective of geographic distributions, radiotherapy institutions cover each region in Japan, although there are considerable differences in the number of radiotherapy

Table 6. Number of treatment planning equipment and accessories by scale classification

Treatment planning equipment and accessories	Scale category (number of institutions)						Total (737)
	A (138)	B (242)	C (128)	D (95)	E (44)	F (90)	
X-ray simulator (1 or more*)	39 (38)	54 (54)	19 (19)	37 (34)	16 (16)	59 (54)	224 (215)
CT simulator (1 or more*)	122 (120)	232 (220)	125 (120)	101 (90)	48 (43)	115 (89)	743 (682)
RTP computer (2 or more*)	195 (30)	369 (86)	303 (78)	328 (75)	207 (39)	632 (89)	2034 (397)
X-ray CT (2 or more*)	256 (87)	590 (202)	401 (116)	353 (86)	201 (43)	453 (87)	2254 (621)
for RT only	57	137	105	82	49	109	539
MRI (2 or more*)	175 (42)	375 (128)	246 (92)	219 (84)	124 (41)	283 (78)	1422 (465)
for RT only	3	4	3	2	1	6	19
Computer use for RT recording*	80	150	75	66	28	60	459
Water phantom (2 or more*)	156 (31)	299 (67)	191 (57)	145 (43)	74 (19)	202 (60)	1067 (277)
Film densitometer (2 or more*)	54 (1)	125 (2)	92 (4)	89 (9)	44 (3)	98 (17)	502 (36)
Dosemeter (3 or more*)	416 (71)	893 (157)	595 (102)	503 (74)	274 (34)	755 (82)	3436 (520)

*The number of institutions. CT = computed tomography, RTP = radiotherapy planning, MRI = magnetic resonance imaging, RT = radiotherapy.

institutions in prefectures. Concerning the equipment, much of the equipment had been rapidly replaced with ones with excellent functions, although there are differences depending on the scale of the institution. The numbers of staff (ROs, RTTs, medical physicists, radiotherapy quality manager, and nurses) steadily increased. Annual total patient load per RO was 194.3, which was lower than 243.8 of 2007 survey. This patient load has fallen below 200.0 as the standard value of JBBG [25, 26] for the first time in this survey. However, it is conceivable that the burden on radiotherapists has not changed or may have increased, because the burden on each patient by the high-precision radiotherapy has increased. For example, since the 2007 survey, SBRT cases has increased about 4.3 times (2007: 1658, 2015: 7104) and intensity-modulated radiotherapy (IMRT) cases has increased about 29.4 times (2007: 755, 2015: 22168).

With regard to other staff, the numbers of medical physicists and radiotherapy quality managers are absolutely insufficient. Compared with the other types of staff mentioned above, a sufficient number of RTTs is ensured in Japan. Therefore, RTTs partially act as medical physicists and radiotherapy quality managers in most institutions.

The average of structure data of designated cancer care hospitals was better than the national average. Annual patient load per designated cancer care hospital was about 100 patients more than the national average, however annual patient load per FTE RO and annual patient load per FTE RTT were almost the same as the national average. These data suggest that the number of radiotherapy patients in all radiotherapy hospitals may be near to saturation. On the other hand, 21.1% of designated cancer care hospitals had <1.0 FTE RO. Compared with the findings of a similar survey conducted from 8 years ago [17], the above percentages had improved as 16.2%, but it was not yet sufficient. It is conceivable that the more the number of radiotherapy staffs (especially ROs, medical physicists and radiotherapy quality managers) increases, the more the number of patients who can undergo radiotherapy.

In conclusion, the Japanese structure of radiation oncology has clearly and steadily improved over the past 25 years in terms of installation and use of equipment and its functions, nevertheless there are still problems of the shortages of manpower and the structure gap by institution type. We expect that this updated national structure survey of radiation oncology for 2015 will aid the continuous improvement of all aspects of radiation oncology in Japan.

Table 7. Number of personnel and annual number of patients by scale classification

	Scale category (number of institutions)						Total (737)
	A (138)	B (242)	C (128)	D (95)	E (44)	F (90)	
Scale (annual no. of new patients)	≤99	100–199	200–299	300–399	400–499	≥500	
Institution ratio [%]	18.7%	32.8%	17.4%	12.9%	6.0%	12.2%	100%
New patients	8240	35 336	30 924	32 729	19 692	69 081	1,96 002
New patients/institution	59.7	146.0	241.6	344.5	447.5	767.6	265.9
Total patients	9785	41 926	37 816	39 381	25 026	81 958	2,35 892
Total patients/institution	70.9	173.2	295.4	414.5	568.8	910.6	320.1
Beds	41 929	95 285	60 735	53 671	29 398	64 826	3,45 844
Institutions with RT beds (%)	22 (15.9)	39 (16.1)	27 (21.1)	35 (36.8)	20 (45.5)	54 (60)	197 (26.7)
RT beds	96.0	185.5	156.0	158.5	156.0	703.0	1455.0
RT beds/total beds [%]	0.2%	0.2%	0.3%	0.3%	0.5%	1.1%	0.4%
RT beds/institution	0.7	0.8	1.2	1.7	3.5	7.8	2.0
RT beds/institution with RT beds	4.4	4.8	5.8	4.5	7.8	13.0	7.4
JRS-certified institutions (%)	2 (1.4)	17 (7)	39 (30.5)	43 (45.3)	32 (72.7)	75 (83.3)	208 (28.2)
JRS-cooperation institutions (%)	45 (32.6)	130 (53.7)	62 (48.4)	39 (41.1)	10 (22.7)	24 (26.7)	310 (42.1)
JASTRO-certified institutions (%)	4 (2.9)	32 (13.2)	40 (31.3)	56 (58.9)	30 (68.2)	76 (84.4)	238 (32.3)
JRS membership (full time)	54	183	164	176	124	470	1171
JASTRO membership (full time)	50	173	163	172	114	468	1140
JRS/JASTRO-certified ROs (full time)	35	147	139	139	86	353	899
Institutions with full time RO (%)	52 (37.7)	160 (66.1)	113 (88.3)	89 (93.7)	44 (100)	90 (100)	548 (74.4)
ROs (full time)	69	203	174	182	130	474	1232
ROs (full time)/institution	0.5	0.8	1.4	1.9	3.0	5.3	1.7
FTE RO (full time)	24.4	145.0	125.3	121.9	103.1	359.4	878.9
FTE RO (full time)/institution	0.34	0.68	1.18	1.69	2.31	4.46	1.39
ROs (part time)	153	260	115	90	36	144	798
ROs (part time)/institution	1.11	1.07	0.90	0.95	0.82	1.60	1.08
FTE RO (part time)	25.1	53.7	20.5	18.4	9.0	60.5	187.1
FTE RO (part time)/institution	0.2	0.2	0.2	0.2	0.2	0.7	0.3
FTE RO (full plus part time)	71.5	218.3	172.2	179.1	110.7	462.2	1213.9
FTE RO (full plus part time)/institution	0.52	0.90	1.34	1.89	2.52	5.14	1.65
Radiologists (full time)	163.0	445.4	402.8	425.0	328.0	828.0	2592.2
Radiologists (part time)	144.2	433.5	212.2	177.2	96.0	242.0	1305.1
Radiologists (full time)/institution	1.2	1.8	3.1	4.5	7.5	9.2	3.5
RTTs (full time)*	422	900	604	573	307	876	3682
FTE RTT	249.2	528.2	342.3	385.1	208.4	681.2	2394.2
Medical physicists (full-time)*	34	107	108	81	58	167	555
FTE Medical physicist	16.9	46.5	51.4	44.0	28.0	109.1	295.7
RT quality manager (full-time)*	50	167	112	106	64	113	612
FTE RT quality manager	13.6	58.6	40.6	41.2	19.6	36.7	210.2
Dosimetrists (full-time)*	13	33	30	26	17	60	179
FTE Dosimetrist	3.0	4.6	7.0	5.7	4.3	14.1	38.6
Craftworkers (full-time)*	29	65	68	56	33	84	335
FTE Craftworker	4.6	8.0	13.0	5.4	3.8	13.9	48.7
Nurses (full time)	118	371	270	224	131	333	1447
FTE Nurse	59.2	168.2	154.54	153.25	82.21	288.7	906.1
Nursing assistants	8	15.3	10.9	12.4	12.3	31.6	90.5
Clerks	21.9	79.2	89.6	105.6	51.2	149.3	496.8

*Overlap is included in the total number of each staff type (radiotherapy technologist, medical physicist, radiotherapy quality manager, dosimetrist and craftworker). RT = radiotherapy, JRS = Japan Radiological Society, RO = radiation oncologist, JASTRO = Japanese Society for Radiation Oncology, FTE = full-time equivalent, RTT = radiotherapy technologist.

Table 8. Population, number of patients, institutions and patient load according to prefecture

Prefecture	Population ($\times 10^3$) [31]	Institutions	New patients	New patients/ institution	Total patients	Total patients/ institution
Hokkaido	5382	29	8202	282.8	10 538	363.4
Aomori	1308	12	2404	200.3	2704	225.3
Iwate	1280	11	2298	208.9	2768	251.6
Miyagi	2334	14	4267	304.8	5290	377.9
Akita	1023	11	2061	187.4	2513	228.5
Yamagata	1124	7	1502	214.6	1682	240.3
Fukushima	1914	11	3051	277.4	3472	315.6
Ibaraki	2917	15	3498	233.2	4074	271.6
Tochigi	1974	9	2711	301.2	3334	370.4
Gunma	1973	12	3871	322.6	4333	361.1
Saitama	7267	23	7319	318.2	8668	376.9
Chiba	6223	27	8950	331.5	10 719	397.0
Tokyo	13 515	78	26 764	343.1	32 445	416.0
Kanagawa	9126	41	13 436	327.7	15 474	377.4
Niigata	2304	12	3064	255.3	3798	316.5
Toyama	1066	10	1779	177.9	2115	211.5
Ishikawa	1154	8	1746	218.3	2297	287.1
Fukui	787	6	1099	183.2	1327	221.2
Yamanashi	835	4	1186	296.5	1438	359.5
Nagano	2099	10	2755	275.5	3425	342.5
Gifu	2032	14	2860	204.3	4071	290.8
Shizuoka	3700	25	6334	253.4	8103	324.1
Aichi	7483	35	10 542	301.2	12 811	366.0
Mie	1816	10	1499	149.9	1816	181.6
Shiga	1413	12	2196	183.0	2662	221.8
Kyoto	2610	16	4230	264.4	5102	318.9
Osaka	8839	60	15 490	258.2	17 979	299.7
Hyogo	5535	35	9075	259.3	10 741	306.9
Nara	1364	7	2074	296.3	2567	366.7
Wakayama	964	6	1202	200.3	1522	253.7
Tottori	573	3	651	217.0	747	249.0
Shimane	694	5	1059	211.8	1153	230.6
Okayama	1922	11	2844	258.5	3414	310.4
Hiroshima	2844	21	4784	227.8	6129	291.9
Yamaguchi	1405	10	1640	164.0	1909	190.9
Tokushima	756	6	1265	210.8	1592	265.3
Kagawa	976	8	1405	175.6	1619	202.4
Ehime	1385	8	1980	247.5	2269	283.6
Kochi	728	5	978	195.6	1190	238.0
Fukuoka	5102	28	8786	313.8	10 585	378.0
Saga	833	6	1505	250.8	1659	276.5
Nagasaki	1377	9	2157	239.7	2646	294.0
Kumamoto	1786	12	2542	211.8	3188	265.7
Oita	1166	11	1736	157.8	2156	196.0
Miyazaki	1104	7	1606	229.4	1765	252.1
Kagoshima	1648	11	2235	203.2	2404	218.5
Okinawa	1434	6	1364	227.3	1679	279.8
Total	1,27 095	737	1,96 002	265.9	2,35 892	320.1

Table 9. Number of total patients, radiation oncologists and patient load according to prefecture

Prefecture	Total patients	JRS/JASTRO-certified RO	FTE RO	Total patients/FTE RO
Hokkaido	10 538	40	52.8	199.6
Aomori	2704	10	12.7	212.9
Iwate	2768	10	13.6	203.5
Miyagi	5290	13	23.7	223.4
Akita	2513	3	8.4	301.0
Yamagata	1682	6	8.1	207.7
Fukushima	3472	17	25.4	137.0
Ibaraki	4074	12	23.3	175.2
Tochigi	3334	12	15.1	220.8
Gunma	4333	23	31.1	139.3
Saitama	8668	27	31.0	279.6
Chiba	10 719	46	55.5	193.1
Tokyo	32 445	100	151.0	214.9
Kanagawa	15 474	56	75.9	203.9
Niigata	3798	17	20.2	188.0
Toyama	2115	6	10.3	205.3
Ishikawa	2297	8	12.0	191.4
Fukui	1327	13	13.9	95.5
Yamanashi	1438	9	9.7	148.2
Nagano	3425	12	14.5	236.2
Gifu	4071	9	17.3	235.0
Shizuoka	8103	24	31.2	259.7
Aichi	12 811	50	69.3	185.0
Mie	1816	9	11.7	155.2
Shiga	2662	9	14.1	188.8
Kyoto	5102	26	35.8	142.5
Osaka	17 979	76	104.1	172.7
Hyogo	10 741	49	64.2	167.3
Nara	2567	14	16.1	159.4
Wakayama	1522	6	8.7	174.9
Tottori	747	5	4.2	177.9
Shimane	1153	6	10.2	113.0
Okayama	3414	16	21.0	163.0
Hiroshima	6129	24	28.5	215.1
Yamaguchi	1909	9	11.9	160.4
Tokushima	1592	7	6.6	241.2
Kagawa	1619	9	10.8	149.9
Ehime	2269	9	12.0	189.1
Kochi	1190	4	4.2	283.3
Fukuoka	10 585	36	46.9	225.7
Saga	1659	10	14.2	116.8
Nagasaki	2646	10	10.4	254.4
Kumamoto	3188	15	14.8	215.4
Oita	2156	5	8.0	269.5
Miyazaki	1765	4	5.3	333.0
Kagoshima	2404	11	12.0	200.3
Okinawa	1679	7	12.4	135.4
Total	2,35 892	899	1213.9	194.3

JRS = Japan Radiological Society, JASTRO = Japanese Society for Radiation Oncology, RO = radiation oncologist, FTE = full-time equivalent

Table 10. Number of total patients, staff and patient load according to prefecture

Prefecture	Total patients	FTE RTT	Total patients/FTE RTT	FTE MP	FTE RTQM
Hokkaido	10 538	76.7	137.5	14.5	7.4
Aomori	2704	30.2	89.5	4.0	3.7
Iwate	2768	35.8	77.3	5.0	1.8
Miyagi	5290	50.6	104.5	7.5	3.1
Akita	2513	25.4	98.9	1.1	3.0
Yamagata	1682	22.3	75.4	1.1	1.1
Fukushima	3472	36.2	96.0	4.4	1.7
Ibaraki	4074	53.5	76.1	5.8	3.7
Tochigi	3334	33.3	100.1	2.7	2.7
Gunma	4333	54.5	79.5	7.5	3.0
Saitama	8668	73.4	118.1	7.4	6.0
Chiba	10 719	94.6	113.4	19.0	4.4
Tokyo	32 445	281.6	115.2	45.1	17.5
Kanagawa	15 474	148.5	104.2	16.6	9.2
Niigata	3798	45.3	83.8	5.2	2.9
Toyama	2115	23.3	91.0	4.3	3.3
Ishikawa	2297	20.5	112.0	2.0	2.3
Fukui	1327	24.7	53.8	3.1	2.0
Yamanashi	1438	9.7	148.2	0.4	2.6
Nagano	3425	34.9	98.1	4.3	2.5
Gifu	4071	41.1	99.2	2.3	4.7
Shizuoka	8103	92.3	87.8	11.5	8.4
Aichi	12 811	124.8	102.7	16.6	14.5
Mie	1816	22.9	79.5	2.8	3.9
Shiga	2662	34.3	77.6	3.9	5.4
Kyoto	5102	61.2	83.4	11.0	3.9
Osaka	17 979	191.1	94.1	28.2	18.4
Hyogo	10 741	117.8	91.2	13.7	5.2
Nara	2567	25.7	99.9	2.8	4.5
Wakayama	1522	20.9	72.8	0.0	2.4
Tottori	747	8.6	86.9	1.0	2.0
Shimane	1153	12.1	95.3	1.2	2.6
Okayama	3414	39.6	86.2	3.3	3.4
Hiroshima	6129	62.3	98.4	10.3	7.6
Yamaguchi	1909	22.8	83.7	0.7	2.3
Tokushima	1592	19.1	83.4	0.3	0.6
Kagawa	1619	22.0	73.6	1.7	0.9
Ehime	2269	24.1	94.3	2.6	4.0
Kochi	1190	9.6	124.0	2.1	1.5
Fukuoka	10 585	97.1	109.1	7.1	11.6
Saga	1659	22.4	74.1	0.6	2.3
Nagasaki	2646	22.0	120.3	3.2	3.5
Kumamoto	3188	32.2	99.0	3.1	5.2
Oita	2156	22.6	95.4	1.6	3.1
Miyazaki	1765	15.2	116.1	0.8	1.3
Kagoshima	2404	38.0	63.3	1.2	3.2
Okinawa	1679	18.0	93.4	1.8	0.4
Total	2,35 892	2394.2	98.5	295.7	210.2

FTE = full-time equivalent, RTT = radiotherapy technologist, MP = medical physicist, RTQM = radiotherapy quality manager.

Table 11. Number of institutions and patients with special radiotherapy by scale classification

Specific therapy	2015							2013
	A (138)	B (242)	C (128)	D (95)	E (44)	F (90)	Total (737)	Total (717)
Intracavitary radiotherapy								
Treatment institutions	0	6	15	34	23	69	147	155
Patients	0	48	186	473	391	2019	3117	3128
Interstitial radiotherapy								
Treatment institutions	3	9	16	20	19	51	118	125
Patients	15	260	330	515	608	2152	3880	3958
^{125}I seed implantation therapy for prostate								
Treatment institutions	2	7	14	14	17	43	97	107
Patients	11	203	319	331	550	1608	3022	3292
Radioactive iodine therapy for thyroid cancer								
Treatment institutions	1	7	9	16	16	25	74	70
Patients	205	97	168	677	432	1184	2763	2332
Total body radiotherapy								
Treatment institutions	9	17	29	39	23	63	180	174
Patients	91	115	280	366	279	1156	2287	2327
Intraoperative radiotherapy								
Treatment institutions	0	1	0	1	3	8	13	16
Patients	0	1	0	2	5	41	49	83
Stereotactic brain radiotherapy								
Treatment institutions	16	57	48	58	26	61	266	251
Patients	269	2814	2556	3981	2180	3110	14 910	15 828
Stereotactic body radiotherapy								
Treatment institutions	14	62	71	72	31	79	329	284
Patients	240	663	1810	982	952	2457	7104	5023
IMRT								
Treatment institutions	12	41	47	61	36	80	277	219
Patients	216	2194	3563	3890	2619	9686	22 168	15 119
Thermoradiotherapy								
Treatment institutions	0	5	3	2	3	6	19	22
Patients	0	45	19	62	86	298	510	366
^{90}Sr radiotherapy for pterygia								
Treatment institutions	0	0	1	1	1	1	4	7
Patients	0	0	3	4	1	7	15	47
Internal ^{89}Sr radiotherapy								
Treatment institutions	5	27	26	26	26	39	149	179
Patients	23	102	114	97	114	212	662	863
Internal ^{90}Y radiotherapy								
Treatment institutions	0	3	4	2	5	10	24	30
Patients	0	8	6	3	22	28	67	118

I = iodine, IMRT = intensity-modulated radiotherapy, Sr = strontium, Y = yttrium.

Table 12. Annual number of new patients by disease site*

Primary site	n	%
Cerebrospinal	6837	3.8
Head and neck (including thyroid)	15 932	8.8
Esophagus	9232	5.1
Lung, trachea, and mediastinum	34 540	19.1
Lung	31 655	17.5
Breast	42 100	23.3
Liver, biliary tract, pancreas	7727	4.3
Gastric, small intestine, colorectal	9492	5.2
Gynecologic	8531	4.7
Urogenital	29 688	16.4
Prostate	23 742	13.1
Hematopoietic and lymphatic	8184	4.5
Skin, bone, and soft tissue	3652	2.0
Other (malignant)	2257	1.2
Benign disease	2644	1.5
Pediatric ≤15 years (included in totals above)	736	0.4
Pediatric 16–19 years (included in totals above)	240	0.1
Total	180 816	100.0

*Total number of new patients in Table 3 differ from these data because no data on primary sites were reported by some institutions.

Table 13. Annual number of total patients (new plus repeat) treated for any brain metastasis and bone metastasis by scale classification

Metastasis	Scale category (number of institutions)												Total (737)	
	A (138)		B (242)		C (128)		D (95)		E (44)		F (90)			
	n	%	n	%	n	%	n	%	n	%	n	%	n	%
Brain	601	6.1	3897	9.3	3716	9.8	4563	11.6	2537	10.1	6223	7.6	21 537	9.1
Bone	1643	16.8	5705	13.6	4980	13.2	4933	12.5	2896	11.6	9346	11.4	29 503	12.5

Table 14. Classification of institutions by number of FTE radiation oncologists in all radiotherapy institutions and designated cancer care hospitals

Institution category	Description	Number of Institutions
RH-A	All radiotherapy hospitals (FTE RO ≥ 1.0)	471
RH-B	All radiotherapy hospitals (FTE RO < 1.0)	266
Total		737
DCCH-A	Designated cancer care hospitals (FTE RO ≥ 1.0)	298
DCCH-B	Designated cancer care hospitals (FTE RO < 1.0)	80
Total		378

FTE = full-time equivalent, RO = radiation oncologist

Table 15. Annual numbers of patients receiving radiotherapy, numbers of linacs, numbers of staff, patient load per linac and patient load per personnel according to institution categories shown Table 14; all radiotherapy hospitals

	RH-A (471)		RH-B (266)		Total (737)	
	Average per hospital	Total number	Average per hospital	Total number	Average per hospital	Total number
Total patient	415.3	1,95 584	151.5	40 308	320.1	2,35 892
New patient	344.1	1,62 064	127.6	33 938	265.9	1,96 002
Linac	1.5	686	0.9	250	1.3	936
Annual No. of total patients/linac	285.1		161.2		252.0	
Annual No. of new patients/linac	236.2		135.8		209.4	
FTE RO	2.4	1112.0	0.4	101.9	1.6	1213.9
JRS/JASTRO-certified RO (full time)	1.8	835	0.2	64	1.2	899
Annual No. of total patients/FTE RO	175.9		395.6		194.3	
Annual No. of new patients/FTE RO	145.7		333.1		161.5	
FTE RT technologist	4.0	1894.2	1.9	500.1	3.2	2394.2
Annual No. of total patients/FTE RTT	103.3		80.6		98.5	
Annual No. of new patients/FTE RTT	85.6		67.9		81.9	
FTE RT technologist/linac	2.8		2.0		2.6	
FTE medical physicist	0.55	259.7	0.14	36.0	0.40	295.7
Annual No. of total patients/FTE MP	753.0		1119.4		797.6	
Annual No. of new patients/FTE MP	624.0		942.5		662.8	
FTE RT quality manager	0.37	173.8	0.14	36.4	0.29	210.2
Annual No. of total patients/FTE RTQM	1125.7		1107.4		1122.5	
Annual No. of new patients/FTE RTQM	932.7		932.4		932.7	
FTE RT quality manager/linac	0.25		0.15		0.22	

linac = linear accelerator, FTE = full-time equivalent, RO = radiation oncologist, JRS = Japan Radiological Society, JASTRO = Japanese Society for Radiation Oncology, RTT = radiotherapy technologist, MP = medical physicist, RTQM = radiotherapy quality manager.

Table 16. Annual numbers of patients receiving radiotherapy, numbers of linacs, numbers of staffs, patient load per linac and patient load per personnel according to institution categories shown Table 14; designated cancer care hospitals

	DCCH-A (298)		DCCH-B (80)		Total (378)	
	Average per hospital	Total number	Average per hospital	Total number	Average per hospital	Total number
Total patient	499.7	1,48 904	191.1	15 284	434.4	1,64 188
New patient	415.1	1,23 710	164.6	13 164	362.1	1,36 874
Linac	1.7	495	1.0	81	1.5	576
Annual No. of total patients/linac	300.8		188.7		285.0	
Annual No. of new patients/linac	249.9		162.5		237.6	
FTE RO	2.7	793.4	0.5	40.6	2.2	834.0
JRS/JASTRO-certified RO (full time)	2.1	613	0.4	29	1.7	642
Annual No. of total patients/FTE RO	187.7		376.6		196.9	
Annual No. of new patients/FTE RO	155.9		324.4		164.1	
FTE RT technologist	4.6	1361.5	2.2	176.9	4.1	1538.3

(*Continued*)

Table 16. Continued

	DCCH-A (298)		DCCH-B (80)		Total (378)	
	Average per hospital	Total number	Average per hospital	Total number	Average per hospital	Total number
Annual No. of total patients/FTE RTT	109.4		86.4		106.7	
Annual No. of new patients/FTE RTT	90.9		74.4		89.0	
FTE RT technologist/linac	2.8		2.2		2.7	
FTE medical physicist	0.65	192.5	0.21	16.9	0.55	209.3
Annual No. of total patients/FTE MP	773.7		906.5		784.4	
Annual No. of new patients/FTE MP	642.8		780.8		653.9	
FTE RT quality manager	0.42	125.5	0.20	16.3	0.38	141.8
Annual No. of total patients/FTE RTQM	1186.5		937.7		1157.9	
Annual No. of new patients/FTE RTQM	985.7		807.6		965.3	
FTE RT quality manager/linac	0.25		0.20		0.25	

linac = linear accelerator, FTE = full-time equivalent, RO = radiation oncologist, JRS = Japan Radiological Society, JASTRO = Japanese Society for Radiation Oncology, RTT = radiotherapy technologist, MP = medical physicist, RTQM = radiotherapy quality manager.

Table 17. Number of items of equipment and their functions according to institution categories shown Table 14

	RH-A ($n = 471$)		RH-B ($n = 266$)		Total ($n = 737$)	
	n	%	n	%	n	%
Linac	686	98.5	250	93.2	936	96.6
with dual energy function	557	86.2	197	74.1	754	81.8
with 3DCRT function (MLC width $\leq$ 1.0 cm)	648	94.5	219	82.0	867	90.0
with IMRT function	521	76.6	107	40.2	628	63.5
with cone beam CT or CT on rail	449	71.1	116	43.6	565	61.2
with treatment position verification system (x-ray perspective image)	368	59.2	95	35.7	463	50.7
with treatment position verification system (other than those above)	253	43.9	74	27.8	327	38.1
CT simulator	499	94.7	244	88.7	743	92.5
	DCCH-A ($n = 298$)		DCCH-B ($n = 80$)		Total ($n = 378$)	
	n	%	n	%	n	%
Linac	495	100.0	81	100.0	576	100.0
with dual energy function	413	92.3	70	87.5	483	91.3
with 3DCRT function (MLC width $\leq$ 1.0 cm)	476	98.0	76	93.8	552	97.1
with IMRT function	388	82.6	42	52.5	430	76.2
with cone beam CT or CT on rail	336	78.2	41	51.3	377	72.5
with treatment position verification system (x-ray perspective image)	278	66.4	33	41.3	311	61.1
with treatment position verification system (other than those above)	190	49.0	25	31.3	215	45.2
CT simulator	327	96.6	78	95.0	405	96.3

linac = linear accelerator, 3DCRT = 3D conformal radiotherapy, MLC = multileaf collimator, IMRT = intensity-modulated radiotherapy, CT = computed tomography.

Table 18. Number of radiotherapy institutions, treatment devices, patient load and personnel: trend 1990–2015

	Survey year														
	1990	1993	1995	1997	1999	2001	2003	2005	2007	2009	2010	2011	2012	2013	2015
Institutions	378	629	504	568	636	603	726	712	721	700	705	694	709	717	737
Response rate	48.5%	88.3%	73.9%	78.6%	86.3%	85.3%	100%	96.9%	94.2%	90.9%	90.4%	88.2%	90.0%	89.8%	87.1%
New patients	62 829	—	71 696	84 379	1,07150	1,18 016	1,49 793	1,56 318	1,70 229	1,82 390	1,90 322	1,85 455	1,90 910	1,93 864	1,96 002
Total patients	—	—	—	—	—	—	—	1,91 173	2,05087	2,17 829	2,26 851	2,20 092	2,25 818	2,30 747	2,35 892
Average of new patients	166	—	142	149	168	196	206	220	236	261	270	267	269	270	266
Treatment devices (actual use)															
Linac	311	508	407	475	626	626	744	765	807	816	829	836	864	880	936
Telecobalt	170	213	127	98	83	45	42	11	15	11	9	3	0	0	0
^{192}Ir RALS	—	—	29	50	73	93	117	119	123	130	131	125	130	128	129
Full time ROs	547	748	821	889	925	878	921	1003	1007	1085	1123	1102	1122	1174	1232
FTE RO	—	—	—	—	—	—	—	774	826	939	959	1019	1062	1131	1208
Full time JRS/JASTRO-certified ROs	—	—	—	—	—	308	369	426	477	529	564	756	792	831	899
FTE RT technologist	592	877	665	733	771	918	1555	1635	1634	1836	1841	2027	2124	2215	2394
Treatment planning equipment															
X-ray simulators	295	430	394	452	512	464	532	502	445	361	348	320	305	291	221
CT simulators	30	75	55	96	164	247	329	407	497	575	633	654	677	688	743
RTP computers	238	468	374	453	682	680	874	940	1070	1271	1381	1484	1611	1735	2034

linac = linear accelerator, Ir = iridium, RO = radiation oncologist, FTE = full-time equivalent, JRS = Japan Radiological Society, JASTRO = Japanese Society for Radiation Oncology, RT = radiotherapy, CT = computed tomography, RTP = radiotherapy planning.

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CONFLICT OF INTEREST

The authors declare they have no conflicts of interest.

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