Table 1. PCS stratification of radiotherapy facilities in Japan

Institution category	Description	Facilities (*n*)	New patients (*n*)	Average new patients/facility[a] (*n*)	Total patients (new + repeat) (*n*)	Comparison with data of 2007[b] (%)	Average total patients/facility[a] (*n*)	Comparison with data of 2007[b] (%)
A1	UH and CC (≥462 patients/y)	70	52 078	744.0	62 124	2.9	887.5	4.3
A2	UH and CC (<462 patients/y)	70	18 842	269.2	22 717	3.9	324.5	5.4
B1	Other (≥158 patients/y)	280	84 938	303.4	101 730	8.0	363.3	11.1
B2	Other (<158 patients/y)	280	26,532	94.8	31 258	9.2	111.6	13.5
Total		700	182 390[c]	260.6	217 829[c]	6.2	311.2	9.4
						7.3		5.9

PCS = Patterns of Care Study; UH = university hospital; CC = cancer center hospital; Other = other national, city, or public hospital.
[a]$P < 0.0001$.
[b]Rate of increase compared with the data of 2007. Calculating formula: $\frac{data\ of\ 2009\ (n) - data\ of\ 2007(n)}{data\ of\ 2007(n)} \times 100\ (\%)$
[c]Number of radiotherapy institutions was 770 in 2009, and the number of new patients was estimated at approximately 201 000; the corresponding number of total patients (new plus repeat) was 240 000.

therapy (IGRT) has been steadily expanding from A1 institutions (30.4% to 33.5%) to the other types of institutions (14.0% to 35.5%). The annual numbers of patients/Linac were 393.2 for A1, 244.3 for A2, 339.1 for B1 and 118 for B2 institutions and showed a 9.8 % increase compared with the data from 2007. The number of institutions with telecobalt in actual use showed a major decrease to 9 and became stable compared with 2007. Gamma Knife was installed more frequently in B1 and B2 institutions. A significant replacement of ^{60}Co RALS with ^{192}Ir RALS was observed especially in academic institutions, while the number of new ^{60}Co RALS-type systems in use did not increase. Six particle machines were registered in this survey, two with carbon-beam and five with proton-beam irradiation. One machine in Hyogo Prefecture can deliver either carbon or proton beams. Although the HIMAC in Chiba Prefecture has two synchrotrons, it was registered as one machine in the 2009 survey. The total number of new cancer patients treated at these six institutions was estimated at 2038 (1.19% of all new patients in Japan). Twenty-seven advanced institutions were included in the A1 category and treated more than 800 patients per year. They were equipped with Linacs with dual energy (75.3% of the institutions), 3DCRT (97.2%) and IMRT function (82.2%), as well as with ^{192}Ir RALS (92.6%) and a computed tomography (CT) simulator (96.3%).

Table 3 shows an overview of RT planning and other equipment. X-ray simulators were installed in 51.6% of all institutions, and CT simulators in 82.1%, with the latter exceeding the former for the first time in 2007. There was a significant difference in the rate of CT simulators installed by institutional stratification, from 95.7% in A1 to 69.3% in B2 institutions. Very few institutions (16 institutions) used magnetic resonance imaging (MRI) for RT only, while computers were widely used for RT recording.

Staffing patterns and patient loads

Table 4 shows the staffing patterns and patient loads by institutional stratification. 'Full-time or part-time' refers to the style of employment. Since even full-time ROs must share the diagnosis in a week at smaller institutions such as found in the B2 category, we felt that these numbers were not adequate for an accurate evaluation of man power. Therefore, data for full-time equivalent (FTE: 40 h/week for radiation oncology service only) were assessed in terms of the clinical working hours in RT of each individual. This is thus a method to determine actual man power at each institution. The total number of FTE ROs in Japan stood at 939.4, while the average numbers were 4.6 for A1, 1.6 for A2, 1.3 for B1 and 0.6 for B2 institutions. The number in B1 improved by 30% compared with 2007 [6]. The overall patient load per FTE RO in Japan was 231.9, and for A1, A2, B1 and B2 institutions the loads were 193.5, 205.2, 290.6 and 198.4, respectively, with the patient load for B1 institutions being by far the highest. The increase in the overall patient load per

Table 2. Equipment, its function and patient load per equipment by PCS institutional stratification

Radiotherapy equipment and its function	A1 ($n = 70$)		A2 ($n = 70$)		B1 ($n = 280$)		B2 ($n = 280$)		Total ($n = 700$)		Comparison with data of 2007 (%)
	n	%	*n*	%	*n*	%	*n*	%	*n*	%	
Linear accelerator	158		93		300		265		816		1.1[a]
with dual energy function	122	*77.2*[b]	70	*75.3*[b]	235	*78.3*[b]	159	*60.0*[b]	586	*71.8*[b]	5.0[c]
with 3DCRT function (MLC width ≥1.0 cm)	150	*94.9*[b]	81	*87.1*[b]	247	*82.3*[b]	185	*69.8*[b]	663	*81.3*[b]	12.5[c]
with IMRT function	116	*73.4*[b]	46	*49.5*[b]	127	*42.3*[b]	48	*18.1*[b]	337	*41.3*[b]	12.2[c]
with cone beam CT or CT on rail	48	*30.4*[b]	33	*35.5*[b]	73	*24.3*[b]	41	*15.5*[b]	195	*23.9*[b]	
with treatment position verification system (X-ray perspective image)	51	*32.3*[b]	31	*33.3*[b]	85	*28.3*[b]	37	*14.0*[b]	204	*25.0*[b]	
with treatment position verification system (other than those above)	53	*33.5*[b]	18	*19.4*[b]	77	*25.7*[b]	55	*20.8*[b]	203	*24.9*[b]	
Annual no. patients/Linac	393.2[d]		244.3[d]		339.1[a]		118.0[d]		266.9[d]		9.8[a]
Particle	3		0		3		0		6		
Microtoron	6		2		3		4		15		
Telecobalt (actual use)	2 (0)		2 (0)		3 (1)		8 (7)		15 (9)		
Gamma knife	3		2		32		9		46		
Other accelerator	2		1		1		1		5		
Other external irradiation device	4		2		1		0		6		
New type ^{60}Co RALS (actual use)	4 (4)	5.7[e] (5.7)	1 (1)	1.4[e] (1.4)	9 (9)	3.2[e] (3.2)	2 (1)	0.7[e] (0.4)	16 (15)	2.3[e] (2.1)	
Old type ^{60}Co RALS (actual use)	2 (2)	2.9[e] (2.9)	2 (1)	2.9[e] (1.4)	14 (11)	5.0[e] (3.9)	4 (0)	1.4[e] (0.0)	22 (14)	3.1[e] (2.0)	
^{192}Ir RALS (actual use)	60 (60)	85.7[e] (85.7)	32 (31)	45.7[e] (44.3)	37 (37)	13.2[e] (13.2)	4 (2)	1.4[e] (0.7)	133 (130)	19.0[e] (18.6)	
^{137}Cs RALS (actual use)	1 (0)		0 (0)		1 (1)		0 (0)		2 (2)		

PCS = Patterns of Care Study; RT = radiotherapy; 3D-CRT = three-dimensional conformal radiotherapy; MLC = multileaf collimator; IMRT = intensity-modulated radiotherapy; RALS = remote-controlled after-loading system.

[a]Rate of increase compared with the data of 2007. Calculating formula: $\frac{\text{data of } 2009\ (n) - \text{data of } 2007\ (n)}{\text{data of } 2007\ (n)} \times 100\ (\%)$

[b]Percentage calculated from the number of systems using this function and the total number of linear accelerator systems.

[c]Comparison with the data of 2007. Calculating formula: *data of* 2009 (%) − *data of* 2007 (%)

[d]The number of patients over the number of linear accelerators; institutions without linear accelerators excluded from calculation.

[e]Rate of institutions that have this equipment (≥2 pieces of equipment per institution).

Table 3. Radiotherapy planning and other equipments by PCS institutional stratification

RT planning and other equipment	A1 ($n = 70$)		A2 ($n = 70$)		B1 ($n = 280$)		B2 ($n = 280$)		Total ($n = 700$)		Comparison with data of 2007[b] (%)
	n	%[a]	*n*	%[a]	*n*	%[a]	*n*	%[a]	*n*	%[a]	
X-ray simulator	55	74.3	41	55.7	130	46.1	135	48.2	361	50.7	−10.2
CT simulator	74	95.7	61	84.3	235	78.6	205	69.3	575	77.1	11.5
RTP computer (two or more)	340 (63)	100 (90.0)	167 (35)	100 (50.0)	461 (99)	97.5 (35.4)	303 (37)	92.5 (13.2)	1271 (234)	96.0 (33.4)	0.7 (10.1)
MRI (two or more)	201 (60)	95.7 (85.7)	151 (56)	98.6 (80.0)	504 (184)	97.5 (65.7)	364 (86)	97.9 (30.7)	1220 (386)	97.6 (55.1)	1.8 (3.8)
for RT only	2	2.9	2	2.9	9	2.9	3	1.1	16	2.1	0.6
Computer use for RT recording	64	91.4	65	92.9	264	94.3	238	85.0	631	90.1	1.3

CT = computed tomography; RTP = radiotherapy planning; MRI = magnetic resonance imaging; other abbreviations as in Table 2.
[a]Ratio of institutions that have equipment (≥2 pieces of equipment per institution).
[b]Comparison with the data of 2007. Calculating formula: *data of 2009 (%) − data of 2007 (%)*.

FTE RO was 13.7% compared with 2007 (6). In Japan, 42.6 % of the institutions providing RT have their own designated beds, where ROs must also take care of their in-patients. The percentage distribution of institutions by patient load per FTE RO shown in Fig. 1a indicates that the largest number of facilities featured a patient/FTE staff level in the 101–150 range, and in the 151–200 range for the second largest number. The blue areas of the bars show that 47.7% of the institutions (334/700) had less than one FTE RO. Compared with 2007 [6], the patient load has increased even more.

A similar trend was observed for RT technologists and their patient load by institutional stratification with the percentage distribution of institutions by patient load per radiation technologist displayed in Fig. 1b. The largest number of facilities had a patient-per-radiotherapy technologist level in the 101–120 range, with the second largest number showing a range of 81–100 and the third largest a range of 121–140. There were 113.1 FTE medical physicists, 113.1FTE radiotherapy quality assurance (QA) staff and 1836FTE radiotherapists. For this survey, personnel numbers were checked for duplicate reporting by identification of individuals on staffing data and these data were analyzed in detail in another report [7]. Finally, there were 621.2 FTE nurses.

Distribution of primary sites, specific treatment and palliative treatment

Table 5 shows the distribution of primary sites by institutional stratification. The most common disease site was the breast, followed by the lung/bronchus/mediastinum and genito-urinary region. In Japan, the number of patients with prostate cancer undergoing RT was 17 919 in 2009, showing an increase of 10.4% over 2007 [6]. By disease site, the rate of increase compared with 2007 was the highest for prostate cancer at 10.4%, the second highest for breast cancer at 9.6% and the third highest for head and neck cancer at 9.3%. The stratification of institutions indicates that the rate of increase for lung cancer was notable for A1 institutions and the rates for prostate cancer were high for all categories, ranging from 8.0–20.3%. On the other hand, the rate for breast cancer was the lowest (–0.7%) for A2, while those for B1 and B2 ranged from 11.8–18.8%, and the rates for head and neck cancer were high for A2 (17.7%) and B1 (21.4%).

Table 6 shows the distribution of use of specific treatments and the number of patients treated with these modalities by PCS stratification of institutions. Use of interstitial irradiation, radioactive iodine therapy for prostate cancer, stereotactic body RT, IMRT and hyperthermia increased by 23.3%, 14.5%, 4.9%, 34.8% and 15%, respectively, compared with 2007 [6]. On the other hand, the use of intraoperative RT decreased significantly by –31.1%. Institutional stratification shows that there was a dramatic increase of 454.1% in the use of IMRT in B2 [5]. In 2009,

Table 4: Structure and personnel by PCS institutional stratification

	Structure and personnel					
	A1 (n = 70)	A2 (n = 70)	B1 (n = 280)	B2 (n = 280)	Total (n = 700)	Comparison with data of 2007 [a] (%)
Institutions/total institutions (%)	10.0	10.0	40.0	40.0	100	-
Institutions with RT bed (n)	59 (84.3)	37 (52.9)	124 (44.3)	78 (27.9)	298 (42.6)	6.0 (3.6 [b])
Average RT beds/institution (n)	11.2	3.3	3.1	1.5	3.3	6.5
Number of ROs (full time + part time)	369 + 64	151 + 35	372 + 216	193 + 245	1085 + 560	6.7
JASTRO-certified RO (full time)	214	73	192	52	531	11.3
Average JASTRO-certified RO/institution (n)	3.1	1.0	0.7	0.2	0.8	14.2
Total (full-time and part-time) RO FTE*	321.1	110.7	350.1	157.5	939.4	13.7
Average FTE ROs/institution	4.6	1.6	1.3	0.6	1.3	18.2
Patient load/FTE RO	193.5	205.2	290.6	198.4	231.9	-6.7
Number of RT technologists (full time + part time)	492 + 22	280 + 13	1133 + 33	825 + 2	2730 + 70	4.4
Total (full-time and part-time) RT technologist FTE	434.3	206.8	758.6	436.2	1836.0	12.4
Average FTE RT technologists/institution	6.2	3.0	2.7	1.6	2.6	13.0
Patient load/FTE RT technologist	143.0	109.9	134.1	71.7	118.6	-5.5
Number of full-time nurse (full time + part time)	114 + 26	74 + 13	270 + 82	125 + 50	583 + 171	-37.1
Total (full-time and part-time) nurse FTE	135.4	68.7	290.4	126.8	621.2	25.6
Number of medical physicists (full time + part time)	70 + 5	27 + 2	125 + 10	65 + 5	287 + 22	10.8
Total (full-time and part-time) medical physicist FTE	32.3	8.7	54.4	22.0	117.6	71.9
Number of RT QA staffs (full time + part time)	79 + 0	52 + 0	174 + 3	85 + 3	390 + 6	-26.1
Total (full-time and part-time) RT QA staff FTE	25.8	15.2	50.3	25.0	116.3	9.1

JASTRO = Japanese Society of Therapeutic Radiation Oncology; RO = radiation oncologist; FTE = full-time equivalent (40 h/wk only for RT practice); QA = quality assurance; other abbreviations as in Table 2. RT QA staff: Japanese Organization of RT Quality Management has certified RT quality managers from RT technologist since 2005 mainly by educational session.Data in parentheses are percentages.

[a]Rate of increase compared with the data of 2007. Calculating formula: $\frac{data\ of\ 2009\ (n) - data\ of\ 2007\ (n)}{data\ of\ 2007\ (n)} \times 100\ (\%)$

[b]Comparison with the data of 2007. Calculating formula: $data\ of\ 2009\ (\%) - data\ of\ 2007\ (\%)$

101 institutions (14.4%) actually utilized IMRT, which was significantly lower than the 337 Linacs with IMRT function (41.3%) as shown in Table 2. Figure 2 lists the numbers of patients treated with SRT and IMRT for each survey year. Approximately 12 000 patients were treated with SRT for the brain in each survey year and this number has remained stable. On the other hand, the number treated with SRT for the rest of the body has been increasing gradually and exceeded 2000 in 2009. The corresponding number of patients for IMRT has been increasing more rapidly and exceeds 4000, or about 2% of all RT-treated patients in 2009.

Table 7 shows the number of patients with brain or bone metastasis treated with radiation according to the same institutional stratification. More patients with brain metastasis (12.2% of all patients) were treated at B1 than at the other types of institutions, while use of radiation for bone

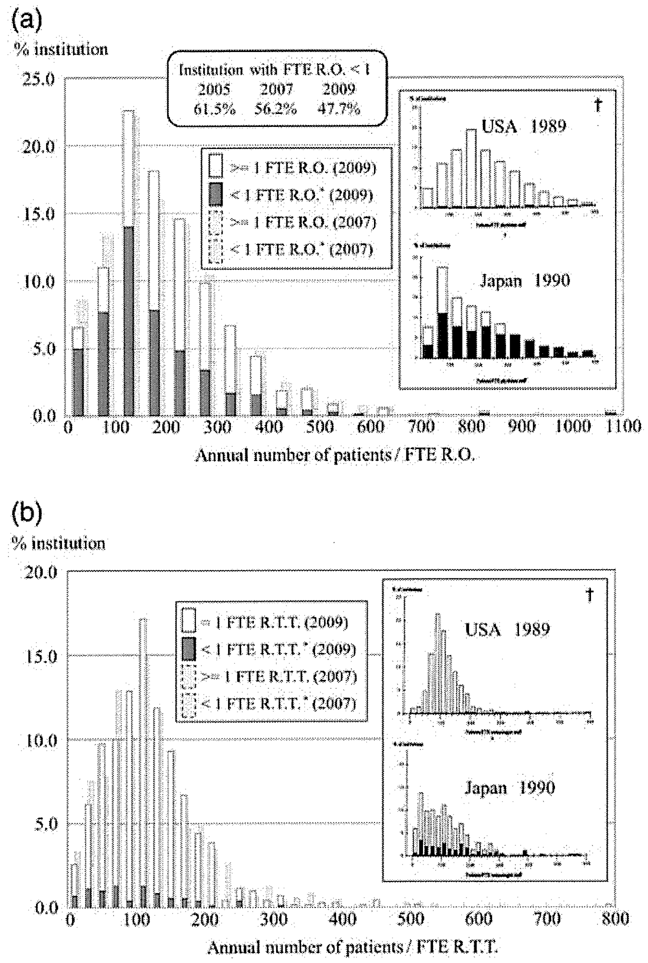

Fig. 1. (**a**) Percentage distribution by institution for patient load/full-time equivalent (FTE) radiation oncologists (ROs) in Japan; (**b**) corresponding percentage distribution for patient load/full-time equivalent (FTE) radiotherapy technologists in Japan (a) Spacing of the bars represents intervals of 50 patients/FTE radiation oncologist. Open bars represent institutions with one or more FTE staff member, and solid bars represent institutions with less than one FTE radiation oncologist. The number of FTEs for institutions with less than one FTE staff member was calculated as the equivalent of one FTE to avoid overestimating patient load per FTE RO or staff. (b) *Spacing of the bars represents intervals of 20 patients/FTE staff. †Corresponding data for the USA and Japan are shown for reference [3]. Originally published in Int. J. Radiat. Oncol. Biol. Phys. 34(1): 235–242.

metastasis ranged from 10.4% for A2 to 15.7% for B2. Overall, more patients with bone metastasis were treated with radiation at non-academic than at academic institutions. The number of patients with brain metastasis decreased slightly by –4.7% compared with 2007 [6].

Geographic patterns

Figure 3 shows the geographic distributions for 47 prefectures of the annual number of patients (new plus repeat) per 1000 population arranged in increasing order of the number of JASTRO-certified ROs per 1 000 000 population [20]. There were significant differences in the use of RT, from 1.1 patients per 1000 population (Saitama) to 2.3 (Tokyo). The average number of cancer patients per 1000 population per quarter ranged from 1.57 to 1.80 ($P = 0.1585$). The more JASTRO-certified physicians there were in a given area, the more RT tended to be used for cancer patients, although the correlation was of borderline significance. Similar trends were clearly observed in 2005 [5] and 2007 [6]. Compared with 2005 and 2007, the utilization rate of RT increased in every prefecture in 2009. However, the rates in 2007 and 2009 were not related to prefectural population density as was also observed in the data for 1990 [3].

DISCUSSION

In 1990, there were fewer facilities for radiation treatment and fewer patients treated with radiation in Japan than in the USA. Over the next 19 years, however, the number of patients in Japan increased significantly by a factor of 3.2 [3]. On the other hand, the utilization rate of radiation for new cancer patients remained at 27.6%, less than half that recorded in the USA and European countries, although the rate increased slightly by 0.75% per year between 2007 [6] and 2009. For implementation of the Cancer Control Act, comparative data of the structure of radiation oncology in Japan and in the USA as well as relevant PCS data proved to be very helpful.

Compared with 1990, the number of Linac systems increased significantly by a factor of 2.62 and increased by 1.1% over 2007 [6], while the number of systems using telecobalt decreased to only nine and remained stable. Furthermore, the use of various functions of Linac, such as dual energy, 3DCRT (MLC width <1 cm) and IMRT, improved significantly. The number of high dose rate (HDR) RALS in use has increased and ^{60}Co RALS has been largely replaced with ^{192}Ir RALS. In 2009, CT simulators had been installed in 82.1% of institutions throughout the country for a 15.7% increase over 2007 [6] and exceeded the number of X-ray simulators (51.6%). Radiotherapy planning systems (RTPs) were used at 96.0% of institutions for an increase in the number of RTPs of 6.59 times compared with 1990 [3]. Maturity of the functions of Linac and installation rates of CT simulators and systems using ^{192} Ir RALS also improved further compared with 2007 [6], but were still closely correlated with the PCS institutional stratification, which could therefore aid accurate differentiation between structural maturity and immaturity and the identification of structural targets for improvement.

The staffing patterns in Japan also improved in terms of numbers. However, institutions with less than one FTE radiation oncologist on their staff still account for 47.7% nationwide, although this represents an 8% decrease

Table 5. Primary sites of cancer treatment with RT in 2009 by PCS institutional stratification for new patients

Primary site	A1 ($n = 69$)		Comparison with data of 2007[a] (%)	A2 ($n = 66$)		Comparison with data of 2007[a] (%)	B1 ($n = 256$)		Comparison with data of 2007[a] (%)	B2 ($n = 253$)		Comparison with data of 2007[a] (%)	Total ($n = 644$)		Comparison with data of 2007[a] (%)
	n	%		n	%		n	%		n	%		n	%	
Cerebrospinal	1906	3.8	−5.7	994	5.4	38.1	4812	6.2	−13.6	1349	5.4	−3.4	9061	5.3	−6.6
Head and neck (including thyroid)	6444	12.8	−1.2	2500	13.6	17.7	7601	9.8	21.4	1560	6.3	−5.7	18 105	10.6	9.3
Esophagus	3247	6.5	−5.8	1196	6.5	1.4	3735	4.8	−8.2	1416	5.7	−3.9	9594	5.6	−5.7
Lung, trachea and mediastinum	7880	15.7	5.6	2771	15.0	−2.8	15 855	20.4	−5.7	5801	23.3	−0.7	32 307	18.9	−2.0
Lung	7335	14.6	8.0	2438	13.2	−0.6	14 358	18.5	−1.3	5060	20.4	−6.2	29 191	17.0	0.0
Breast	10 869	21.7	5.2	3637	19.7	−0.7	19 373	24.9	11.8	5955	24.0	18.8	39 834	23.3	9.6
Liver, biliary tract, pancreas	1948	3.9	1.0	806	4.4	19.6	2907	3.7	3.6	980	3.9	−4.2	6641	3.9	3.2
Gastric, small intestine, colorectal	2167	4.3	4.4	945	5.1	−6.9	3783	4.9	−6.2	1384	5.6	−7.6	8279	4.8	−4.0
Gynecologic	3430	6.8	3.5	1135	6.2	7.3	2914	3.7	−4.7	737	3.0	−5.6	8216	4.8	0.0
Urogenital	7167	14.3	5.8	2470	13.4	−1.1	10 019	12.9	2.8	3394	13.7	13.4	23 050	13.5	4.7
Prostate	5926	11.8	9.9	1888	10.2	8.0	7618	9.8	8.6	2487	10.0	20.3	17 919	10.5	10.4
Hematopoietic and lymphatic	2639	5.3	1.9	963	5.2	7.0	3264	4.2	−10.1	1083	4.4	15.8	7949	4.6	−1.3
Skin, bone and soft tissue	1269	2.5	−12.8	496	2.7	2.5	1590	2.0	−15.4	738	3.0	−1.7	4093	2.4	−10.4
Other (malignant)	541	1.1	−39.5	241	1.3	1.7	852	1.1	−5.0	307	1.2	5.1	1941	1.1	−16.3
Benign tumors	675	1.3	−31.7	278	1.5	4.5	1112	1.4	−13.7	155	0.6	−16.7	2220	1.3	−18.6
Pediatric <15 y (included in totals above)	461	0.9	4.8	145	0.8	25.0	349	0.4	−6.7	137	0.6	8.7	1092	0.6	3.4
Total	50 182	100	0.8	18 432	100	4.3	77 817	100	0.6	24 859	100.0	4.3	171 290	100	1.5

Abbreviations as in Table 2.

[a]Rate of increase compared with the data of 2007. Calculating formula: $\frac{\text{data of } 2009\ (n) - \text{data of } 2007\ (n)}{\text{data of } 2007\ (n)} \times 100\ (\%)$

[b]Total number of new patients different with these data, because no data on primary sites were reported by some institutions.

Table 6: Distribution of specific treatments and numbers of patients treated with these modalities by PCS stratification of institutions

Specific therapy	A1 ($n = 70$)		A2 ($n = 70$)		B1 ($n = 280$)		B2 ($n = 280$)		Total ($n = 700$)		Comparison with data of 2007[a] (%)
	n	%	*n*	%	*n*	%	*n*	%	*n*	%	
Intracavitary RT											
Treatment facilities	64	91.4	28	40.0	58	20.7	1	0.4	151	21.6	
Cases	1864		421		848		6		3139		–3.0
Interstitial RT											
Treatment facilities	55	78.6	20	28.6	32	11.4	2	0.7	109	15.6	
Cases	2482		550		993		45		4070		23.3
Radioactive iodine therapy for prostate											
Treatment facilities	50	71.4	16	22.9	29	10.4	1	0.4	96	13.7	
Cases	1842		360		856		22		3080		14.5
Total body RT											
Treatment facilities	63	90.0	31	44.3	65	23.2	21	7.5	180	25.7	
Cases	798		235		620		137		1790		4.9
Intraoperative RT											
Treatment facilities	15	21.4	6	8.6	4	1.4	3	1.1	28	4.0	
Cases	135		21		9		8		173		–31.1
Stereotactic brain RT											
Treatment facilities	43	61.4	26	37.1	94	33.6	39	13.9	202	25.8	
Cases	1660		658		9671		1866		13 855		10.4
Stereotactic body RT											
Treatment facilities	51	72.9	26	37.1	71	25.4	17	6.1	165	23.6	
Cases	1087		185		1125		140		2537		1.9
IMRT											
Treatment facilities	47	67.1	10	14.3	36	12.9	8	2.9	101	14.4	
Cases	1855		94		1961		386		4296		34.8
Thermoradiotherapy											
Treatment facilities	7	10.0	5	7.1	4	1.4	4	1.4	20	2.9	
Cases	185		38		137		31		391		15.0

PCS = Patterns of Care Study; RT = radiotherapy; IMRT = intensity-modulated radiotherapy.

[a]Rate of increase compared with the data of 2007. Calculating formula: $\frac{\textit{data of } 2009\ (n) - \textit{data of } 2007\ (n)}{\textit{data of } 2007\ (n)} \times 100\ (\%)$

compared with 2007 [6]. In other words, nearly half the institutions in Japan still rely on part-time radiation oncologists. There are two reasons for this. First, although the number of FTE radiation oncologists grew by 13.7 % over the last 2 years, the number of cancer patients who require radiation has also increased by 10% over the same period. Second, specialist fees for radiation oncologists in academic institutions are not covered by the Japanese medical care insurance system, which is strictly controlled by the government. Therefore, most radiation or other oncologists at academic institutions must work part-time at affiliated hospitals in the B1 and B2 groups to earn a living. To reduce the number of institutions that rely on part-time radiation oncologists and thus may encounter problems with their quality of care, a reform of Japan's current medical care system based on treatment outcome is required, especially as it applies to staff at academic institutions. However, great care is needed to ensure that the long-term success of radiation oncology in Japan and patient benefits are well balanced with costs. For this reason, personal identification of ROs in both A and B institutions was included and recorded in the 2007 and 2009 surveys for further detailed analysis of patient load and real cost [7]. There were significant differences in the average practice index for patients between ROs working mainly in main university hospitals and in affiliated hospitals (1.07 vs 0.71: $P < 0.0001$). Under the current Japanese national medical system, patterns of work by ROs at academic facilities appear to be problematic for fostering true specialization of ROs. On the other hand, according to the increase in the number of cancer patients who require RT, B1 institutions are gradually offering full-time positions for ROs. However, the speed of offers for second or third positions are slow in individual institutions due to tight budgets in most B1 institutions. Therefore, monitoring these structural data is necessary to convince local government to improve working environments for ROs. Even under these conditions, however, the number of FTE ROs increased by 2.57 times compared with 1990 [3], and by 13.7% over 2007 [6]. On the other hand, patient load per FTE RO also increased by 1.35 times to 231.9 during the same period 1990–2009, but registered a –0.67% decrease compared

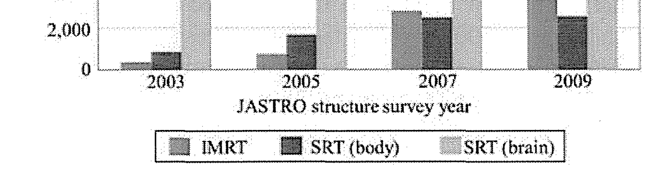

Fig. 2. Trends in numbers of patients treated with SRT for brain, SRT for body and IMRT by survey year

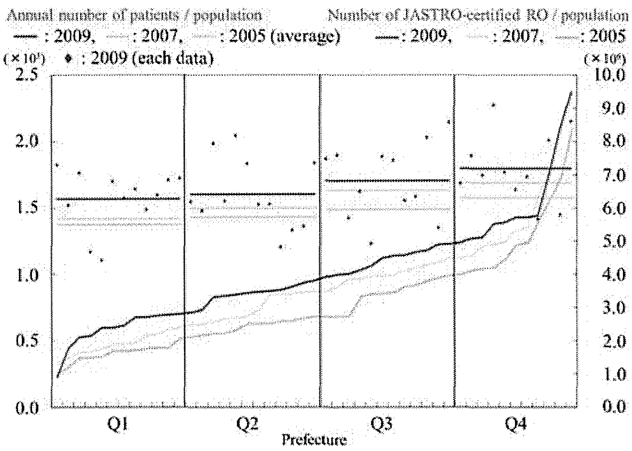

Fig. 3. Geographic distribution for 47 prefectures of annual numbers of patients (new plus repeat) per 1000 population in increasing order for JASTRO-certified radiation oncologists (RO)/ 1 000 000 population by prefecture Q1, 0–25%; Q2, 26–50%; Q3, 51–75%; and Q4, 76–100%. Horizontal lines show average annual number of patients (new plus repeat) per 1000 prefectural population per quarter.

Table 7: brain metastasis or bone metastasis patients treated with RT in 2007 by PCS institutional stratification

Metastasis	Patients										
	A1 ($n = 70$)		A2 ($n = 70$)		B1 ($n = 280$)		B2 ($n = 280$)		Total ($n = 700$)		Comparison with data of 2007[a] (%)
	n	%	n	%	n	%	n	%	n	%	
Brain	3534	5.2	1363	6.0	12 394	12.2	3043	9.7	20 334	9.3	–4.3
Bone	6948	11.2	2419	10.6	12 618	12.4	4921	15.7	26 906	12.4	–3.8

Data presented as number of patients, with percentages in parentheses.
[a]Rate of increase compared with the data of 2007. Calculating formula: $\frac{data\,of\,2009\,(n) - data\,of\,2007\,(n)}{data\,of\,2007\,(n)} \times 100\ (\%)$

with 2007 [6]. This may reflect the growing popularity of RT due to an increase in the elderly population and recent advances in technology and improvement in clinical results. The caseload ratio in Japan has therefore already exceeded the limit of the Blue Book guidelines of 200 patients per radiation oncologist and improved only slightly in 2009 [21, 22]. The percentage distribution of institutions by patient load per RO showed a slightly high percentage for smaller patient load/RO than that in the USA in 1989 [3], but also showed a major shift to a larger size in 2009 compared with 1990. In Japan, the patterns are now becoming similar to those of the USA in 1989 [3], indicating that Japanese radiation oncology is catching up quickly with western systems and growing steadily in spite of limited resources. Furthermore, additional recruiting and education of ROs continue to be top priorities for JASTRO. The distribution of patient load per RT technologist shows that only 17.3% of institutions met the narrow guideline range (100–120 patient per RT technologist) and the rest showed a dense distribution around the peak level. Compared with the distribution in the USA in 1989, nearly 18% of institutions in Japan had a relatively low caseload of 10–60, because there are still a large number of smaller B2-type institutions, which account for nearly 40% of institutions that do not attain the range specified by the guidelines. As for medical physicists, an analysis of patient load for FTE staff similar to that for RT technologists remains difficult, because the number of the former was very small and they were working mainly in metropolitan areas. However, RT technologists in Japan have been acting partly as medical physicists. Their training duration has changed from 3 to 4 years over the last decade, and graduate and postgraduate courses have been introduced. Currently, RT technologists who have obtained a master's degree or those with enough clinical experience can take the examination for qualification as a medical physicist, as can those with a master's degree in science or engineering like in the USA or Europe. A unique, hybrid education system for medical physicists has thus been developed in Japan since the Cancer Control Act actively started to support improvement in quality assurance and quality control (QA/QC) specialization for RT. However, the validity of this education and training system remains to be proven, not only for QA/QC but also for unique research and developmental activities. The discrepancy between FTE medical physicists and the number of registered medical physicists in Japan reflects the fact that their role in the clinic is not recognized as a full-time position only for medical physics services.

Analysis of the distribution of primary sites for RT showed that the number of lung cancer patients at A1-type institutions increased by 8% compared with 2007. On the other hand, more head and neck cancer patients were treated at A1-, A2- or B1-type institutions, but the rates of increase compared with 2007 were high for A2 and B1 institutions. The increase in the number of lung cancer patients at A1 institutions in 2009 was noteworthy and the same goes for that of prostate cancer patients or breast cancer patients at A1-, A2-, B1- and B2-type institutions. This suggests that stereotactic body RT (SBRT) for lung cancer at A1 and 3DCRT for prostate cancer or breast-conserving therapy for breast cancer (BCT) at A1, A2, B1 and B2 were used more frequently in 2009. Especially in B2-type institutions, breast cancer patients (18.8%) and prostate cancer patients (20.3%) increased at two of the highest rates. This indicates that treatments such as 3DCRT and BCT were disseminated widely to B2-type institutions as a standard. The number of patients with brain or bone metastasis did not increase compared with 2007 [6]. The use of specific treatments and the number of patients treated with these modalities were significantly affected by institutional stratification, with more specific treatments being performed at academic institutions. These findings indicate that significant differences in patterns of care, as reflected in structure, process and possibly outcome for cancer patients continued to be prevalent in Japan in 2009. However, these differences point to opportunities for improvement. The Japanese PCS group published structural guidelines based on PCS data [22] and we are using the structural data obtained in 2009 to revise the Japanese structural guidelines for radiation oncology in the near future. The use of intraoperative RT decreased significantly from 2005 to 2007 and showed a similar rate of decrease (35%) between 2007 and 2009, while that of thermoradiotherapy increased slightly by 15% compared with 2007 [6]. These two modalities are thus not considered mainstay treatments in Japan. The numbers of patients with bone metastasis or brain metastasis in 2009 decreased, compared with those in 2007. Within the limited resources of departments of radiation oncology, more efforts may be made, focusing on radical treatment than palliative ones. Also general treatments such as bisphosphonates or narcotic drugs such as opioids for bone metastasis may relatively reduce the candidates for RT. The reason for the reduction in use of RT for brain metastasis is unknown.

Geographic patterns showed that there were significant differences among prefectures in the use of RT, and the number of JASTRO-certified physicians per population was associated with the utilization of RT in 2005 [5], 2007 [6] and 2009, so that a shortage of radiation oncologists or medical physicists on a regional basis will remain a major concern in Japan. Compared with 2005 [5] and 2007 [6], however, the utilization rate of radiation for new cancer patients in 2009 showed further increase. JASTRO has been making every effort to recruit and educate radiation oncologists and medical physicists through public relations, to establish and conduct training courses at academic institutions, to become involved in the national examination for physicians and to seek an increase in the coverage of fees for ROs by the government-controlled insurance scheme.

In conclusion, the Japanese structure of radiation oncology has clearly and steadily improved over the past 19 years in terms of installation and use of equipment and its functions, but shortages of man power and differences in maturity depending on type of institution and caseload remain. Structural immaturity is an immediate target for improvement, while for improvements in process and outcome, the PCS or National Cancer Database (NCDB), which are currently operational and the subject of close examination, can be expected to perform an important function in the future of radiation oncology in Japan.

ACKNOWLEDGEMENTS

This study was supported by JASTRO. This study was also supported by Grants-in Aid for Cancer Research (H22-3rd Term Cancer Control-General-043, H23-3rd Term Cancer Control-General-007, H21-Cancer Clinic-General-008, and 20S-5) from the Ministry of Health, Labor and Welfare of Japan and by a Grant-in-Aid for Scientific Research from the Japan Society for the Promotion of Sciences (Nos 23390300, 23591838, 21249066 and 21591614). We wish to thank all radiation oncologists and technologists throughout Japan who participated in this survey for their efforts in providing us with information to make this study possible. We also appreciate the continual encouragement and support by Gerald E. Hanks, MD, former PI of PCS, J. Frank Wilson, MD, current PI of QRRO, Jean B. Owen, PhD, directorand all other PCS and QRRO members in the USA and Japan.

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Int J Clin Oncol
DOI 10.1007/s10147-012-0468-7

ORIGINAL ARTICLE

Japanese structure survey of radiation oncology in 2009 with special reference to designated cancer care hospitals

Hodaka Numasaki · Masamichi Nishio · Hiroshi Ikeda · Kenji Sekiguchi · Norihiko Kamikonya · Masahiko Koizumi · Masao Tago · Yutaka Ando · Nobuhiro Tsukamoto · Atsuro Terahara · Katsumasa Nakamura · Tetsuo Nishimura · Masao Murakami · Mitsuhiro Takahashi · Teruki Teshima · Japanese Society for Therapeutic Radiology and Oncology Database Committee

Received: 30 March 2012 / Accepted: 5 August 2012

Abstract
Background The structure of radiation oncology in designated cancer care hospitals in Japan was surveyed in terms of equipment, personnel, patient load, and geographic distribution, and compared with the structure in other radiotherapy facilities and the previous survey.

Methods The Japanese Society for Therapeutic Radiology and Oncology surveyed the national structure of radiation oncology in 2009. The structures of 365 designated cancer care hospitals and 335 other radiotherapy facilities were compared.

Results Designated cancer care hospitals accounted for 50.0 % of all the radiotherapy facilities in Japan. The patterns of equipment and personnel in designated cancer

H. Numasaki · T. Teshima (✉)
Department of Medical Physics and Engineering, Osaka University Graduate School of Medicine, 1-7, Yamadaoka, Suita, Osaka 565-0871, Japan
e-mail: teshima@sahs.med.osaka-u.ac.jp

M. Nishio
Department of Radiation Oncology, National Hospital Organization Hokkaido Cancer Center, Sapporo, Hokkaido, Japan

H. Ikeda
Department of Radiation Oncology, Sakai City Hospital, Sakai, Osaka, Japan

K. Sekiguchi
Department of Radiation Oncology, St. Luke's International Hospital, Tokyo, Japan

N. Kamikonya
Department of Radiology, Hyogo College of Medicine, Nishinomiya, Hyogo, Japan

M. Koizumi
Oncology Center, Osaka University Hospital, Suita, Osaka, Japan

M. Tago
Department of Radiology, Teikyo University School of Medicine University Hospital, Mizonokuchi, Kawasaki, Kanagawa, Japan

Y. Ando
Research Center Hospital for Charged Particle Therapy, National Institute of Radiological Sciences, Chiba, Japan

N. Tsukamoto
Department of Radiation Oncology, Saiseikai Yokohamashi Tobu Hospital, Yokohama, Kanagawa, Japan

A. Terahara
Department of Radiology, University of Tokyo Hospital, Tokyo, Japan

K. Nakamura
Department of Clinical Radiology, Kyushu University Graduate School of Medicine Sciences, Fukuoka, Japan

T. Nishimura
Division of Radiation Oncology, Shizuoka Cancer Center, Shizuoka, Japan

M. Murakami
Hyogo Ion Beam Medical Center, Tatsuno, Hyogo, Japan

M. Takahashi
Department of Radiology, Kiryu Kosei Hospital, Kiryu, Gunma, Japan

Published online: 28 September 2012

care hospitals and the other radiotherapy facilities were, respectively, as follows: linear accelerators per facility: 1.4 and 1.0; dual-energy function: 78.6 and 61.3 %; three-dimensional conformal radiotherapy function: 88.5 and 70.0 %; intensity-modulated radiotherapy function: 51.6 and 25.3 %; annual number of patients per linear accelerator: 301.3 and 185.2; Ir-192 remote-controlled after-loading systems: 31.8 and 4.2 %; and average number of full-time equivalent radiation oncologists per facility: 1.8 and 0.8. Compared with the previous survey, the ownership ratio of equipment and personnel improved in both designated cancer care hospitals and the other radiotherapy facilities. Annual patient loads per full-time equivalent radiation oncologist in the designated cancer care hospitals and the other radiotherapy facilities were 225.5 and 247.6, respectively. These values exceeded the standard guidelines level of 200.

Conclusions The structure of radiation oncology in designated Japanese cancer care hospitals was more mature than that in the other radiotherapy facilities. There is still a shortage of personnel. The serious understaffing problem in radiation oncology should be corrected in the future.

Keywords Radiotherapy · Medical engineering · Epidemiology

Introduction

In Japan, the current utilization rate of radiotherapy (RT) for new cancer patients in Japan is only 27.7 % and surgery remains predominant [1]. This rate is very low when compared to those for western developed countries. The main reason for this is that there is not enough personnel, such as radiation oncologists (ROs), medical physicists (MPs), and radiotherapy technologists (RTTs) [2, 3]. The Cancer Control Act was implemented in 2007 in response to patients' urgent petitions to the Japanese government [4]. This law strongly advocates the promotion of RT and an increase in the number of ROs and MPs. At the same time, the Ministry of Health, Labour and Welfare began the accreditation of "designated cancer care hospitals (DCCHs)" with the aim of correcting regional differences in the quality of cancer care and strengthening cooperation among regional cancer care hospitals [5, 6]. The Japanese Society for Therapeutic Radiology and Oncology (JASTRO) has conducted national structure surveys of RT facilities in Japan every 2 years since 1990 [7]. Findings of these surveys indicate that the structure of radiation oncology in Japan has improved in terms of equipment and functioning in response to the increasing numbers of cancer patients who require RT.

In the study presented here, the structure of radiation oncology in DCCHs in Japan was analyzed in terms of equipment, personnel, patient load, and geographic distribution, and compared with these features in other RT facilities in Japan. In addition, the recent structure of RT facilities was compared with that surveyed in 2007 [2] and the medical care situation in Japan was compared with that in European countries and the USA.

Methods and materials

A national survey in the form of a questionnaire on the structure of radiation oncology in Japan in 2009 was conducted by JASTRO from March 2010 to January 2011 [1]. The questionnaire consisted of items related to the number of treatment machines and type of modality, the number of personnel by job category, and the number of patients by type and disease site. The response rate was 90.9 % (700 out of 770) from all actual RT facilities in Japan. The number of DCCHs certified by the Ministry of Health, Labor and Welfare was 375 as of April 1, 2011 [8]. Of this total, 51 were designated prefectural and 324 were designated regional cancer care hospitals. The surveys were not returned by 20 facilities, and 3 facilities did not have departments of RT at the time of the survey, so that the structures of 365 DCCHs and 335 other RT facilities were analyzed. In this survey, full-time equivalent (FTE) (40 h/week for radiation oncology work only) data were surveyed in terms of the clinical working hours for RT of each staff member. SAS® 8.02 (SAS Institute Inc., Cary, NC, USA) [9] was used for the statistical analysis and statistical significance was determined by means of the χ^2 test and Student's t test.

The Japanese Blue Book Guidelines (JBBG) [10, 11] 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) [12, 13] data. The standard guidelines for annual patient load per external beam equipment were set at 250–300 (warning level 400), those for annual patient load per FTE RO at 200 (warning level 300), and those for annual patient load per FTE RT technologists at 120 (warning level 200).

Results

Current situation of radiation oncology

Table 1 shows the current situation of radiation oncology in Japan. DCCHs accounted for 50.0 % (385/770) of all the RT facilities in Japan. The numbers of new patients and total patients in all RT facilities in Japan were estimated at approximately 201,000 (182,390 × 770/700) and 240,000 (205,087 × 770/700), respectively. For DCCHs,

Table 1 Numbers of new patients and total patients (new plus repeat) requiring radiotherapy in designated cancer care hospitals and other radiotherapy hospitals

	DCCHs	Other RT facilities	p value (95 % CI)[a]	Total
Facilities	365	335	–	700
New patients	126,123[b]	56,267	–	182,390[c]
Average new patients/facility	345.5	168.0	<0.0001 (146.7, 208.4)	260.6
Total patients (new + repeat)	150,215[b]	67,614	–	217,829[c]
Average total patients per facility	411.5	201.8	<0.0001 (171.6, 247.8)	311.2

DCCH designated cancer care hospital, *RT* radiotherapy, *CI* confidence interval

[a] Student's t test

[b] The number of designated cancer care hospitals with RT was 385, and the number of new patients in DCCHs was estimated at approximately 134,000; the corresponding number of total patients (new plus repeat) was 159,000

[c] The number of radiotherapy facilities was 770 in 2009, and the number of new patients was estimated at approximately 201,000; the corresponding number of total patients (new plus repeat) was 240,000

the corresponding numbers were approximately 134,000 (126,123 × 385/365) and 159,000 (150,215 × 385/365). The number of new patients and total patients in DCCHs thus accounted for approximately 66.7 % (134,000/201,000) and 66.3 % (134,000/201,000 and 159,000/240,000) of the number of new patients and total patients in all RT facilities. The average numbers of new patients per facility were 345.5 for DCCHs and 168.0 for the other RT facilities, and for the average numbers of total patients per facility the corresponding figures were 411.5 and 201.8, respectively.

Facility and equipment patterns and patient load per linear accelerator

The RT equipment patterns and related functions in Japan are shown in Table 2. In DCCHs, 496 linear accelerators (linacs) and 116 ^{192}Ir remote-controlled after-loading systems (RALSs) were in current use, while the corresponding data for the other RT facilities were 320 and 14, respectively. The rate of equipment ownership at DCCHs was significantly higher than at the other RT facilities. As for the linac systems in DCCHs, the dual-energy function was used in 390 (78.6 %), the three-dimensional conformal radiotherapy (3D-CRT) function in 439 (88.5 %), and the IMRT function in 256 (51.6 %). For the other RT facilities, the corresponding figures were 196 (61.3 %), 224 (70.0 %), and 81 (25.3 %). The patient load per linac was 301.3 at DCCHs and 185.2 at the other RT facilities. Compared with the data for DCCHs in 2007 [2], the rate of linac ownership increased by 0.6 % while the rates of increase for installation of the various functions used with linacs were 3.8 % for dual-energy, 13.2 % for 3D-CRT, and 15.2 % for IMRT function. At the other RT facilities, the rate of linac ownership decreased by 0.4 %, while the rates of installation corresponding to those for DCCHs increased by 4.8, 9.5, and 5.5 %. The patterns for radiotherapy planning systems (RTPs) and other equipment are shown in Table 2. X-ray simulators were installed in 56.7 %, computed tomography (CT) simulators in 83.3 %, and RTPs in 97.3 % of the DCCHs, while the corresponding percentages for the other RT facilities were 44.2, 70.4, and 94.6 %. A noteworthy difference between the two types of facilities was found in the rates of X-ray simulator and CT simulator installation. Compared with the data for 2007 [3], X-ray simulator ownership at DCCHs decreased by 12.6 %, while CT simulator and RTP ownership increased by 8.2 and 0.5 %, respectively. At the other RT facilities, X-ray simulator ownership decreased by 8.8 % while CT simulator and RTP ownership increased by 13.7 and 0.8 %, respectively.

The distribution of annual patient load per linac in Japan is shown in Fig. 1. The patient load at 19.4 % of DCCHs and 4.6 % of the other RT hospitals exceeded the JBBG warning level of 400 patients per linac, but the average patient load per linac at the other facilities was below that level. Compared with the data for 2007 [2], the rate of facilities exceeding the JBBG warning level (400 patients per linac) decreased at both DCCHs (−0.8 %) and the other RT facilities (−0.7 %). However, the average number of total patients per facility increased at both DCCHs (1.6 %) and the other RT facilities (5.9 %).

Staffing patterns and patient loads

Staffing patterns and patient loads in Japan are detailed in Table 3. The figures for total FTE ROs were 666.3 for DCCHs and 273.1 for the other RT facilities, while the corresponding average numbers of FTE ROs per facility were 1.8 and 0.8 and for patient load per FTE RO 225.5 and 247.6. The distribution of annual patient load per FTE RO in Japan is illustrated in Fig. 2. More than 300 patients per RO (JBBG warning level) were treated in 23.3 % of DCCHs and in 10.7 % of the other facilities. Figure 3 shows the distribution of facilities by patient load per FTE RO, with the largest number featuring a patient per FTE RO level in the 100–149 range for DCCHs and the other

Table 2 Items of equipment, their function and patient load per unit of equipment in designated cancer care hospitals and other radiotherapy hospitals

	DCCHs (n = 365)		Comparison with 2007	Other RT facilities (n = 335)		Comparison with 2007	p value (95 % CI)	Total (n = 700)	
	n	%	%	n	%	%		n	%
Linac	496	98.6[a]	0.6[c]	320	90.4[a]	−0.4[c]	<0.0001[f]	816	94.7[a]
With dual energy function	390	78.6[b]	3.8[c]	196	61.3[b]	4.8[c]	<0.0001[f]	586	71.8[b]
With 3D-CRT function (MLC width ≤1.0 cm)	439	88.5[b]	13.2[c]	224	70.0[b]	9.5[c]	<0.0001[f]	663	81.3[b]
With IMRT function	256	51.6[b]	15.2[c]	81	25.3[b]	5.5[c]	<0.0001[f]	337	41.3[b]
Average no. linac per facility	1.4	–	4.7[e]	1.0	–	0.4[e]	<0.0001 (0.3, 0.4)[g]	1.2	–
Annual no. patients per linac	301.3[d]	–	1.6[e]	185.2[d]	–	5.9[e]	<0.0001 (86.8, 133.9)[g]	255.8[d]	–
^{192}Ir RALS (actual use)	116	31.8[a]	2.3[c]	14	4.2[a]	−1.2[c]	<0.0001[f]	130	18.6[a]
X-ray simulator	211	56.7[a]	−12.6[c]	150	44.2[a]	−8.8[c]	0.0009[f]	361	50.7[a]
CT simulator	324	83.3[a]	8.2[c]	251	70.4[a]	13.7[c]	<0.0001[f]	575	77.1[a]
RTP computer	854	97.3[a]	0.4[c]	417	94.6[a]	0.8[c]	0.0757[f]	1,271	96.0[a]

DCCH designated cancer care hospital, *RT* radiotherapy, *CI* confidence interval, *Linac* linear accelerator, *IMRT* intensity-modulated radiotherapy, *RALS* remote-controlled after-loading system, *CT* computed tomography, *3D-CRT* three-dimensional conformal radiotherapy, *RTP* radiotherapy planning

[a] Percentage of facilities which have this equipment

[b] Percentage calculated from the number of systems using this function and the total number of linac systems

[c] Comparison with the data of 2007, calculated using the formula: data of 2009 (%) – data of 2007 (%)

[d] Percentage calculated from the number of patients and the number of linac units. Facilities without linacs were excluded from the calculation

[e] Rate of increase compared with the data of 2007, calculated using the formula: $\frac{\text{data of 2009 }(n) - \text{data of 2007 }(n)}{\text{data of 2007 }(n)} \times 100\ (\%)$

[f] χ^2 test

[g] Student's t test

RT facilities. Facilities with less than 1 FTE RO still account for about 31.2 % of DCCHs and 65.7 % of the other RT facilities. The average numbers of FTE ROs per facility and full-time JASTRO-certified ROs per facility at DCCHs increased by 11.5 and 6.7 %, respectively, compared with 2007 data, and for the other RT facilities, those numbers increased by 18.9 and 22.3 %. The annual patient load per FTE RO, on the other hand, decreased by 4.9 % at DCCHs and 9.4 % at the other RT facilities.

The total numbers of FTE RTTs were 1175.7 for DCCHs and 660.2 for the other RT facilities, and the corresponding average numbers of RTTs per facility were 3.2 and 2.0, while the patient loads per FTE RTT were 127.8 and 102.4. The distribution of annual patient load per FTE RTT in Japan is shown in Fig. 4. More than 200 patients per RTT (JBBG warning level) were treated in 11.0 % of DCCHs and in 7.5 % of the other RT facilities, while Fig. 5 shows the distribution of facilities by patient load per FTE RTT. The largest number of facilities featured a patient per FTE RTT level in the 100–119 range for DCCHs and the other RT facilities. The total numbers of FTE MPs and FTE RT nurses were 74.6 and 392.8, respectively, for DCCHs and 43.0 and 228.4 for the other RT facilities.

Distribution of primary disease sites and palliative treatment

Table 4 shows the distribution of primary disease sites and palliative treatment at DCCHs and the other RT facilities. The most common disease site at DCCHs and the other RT facilities was the breast. Head/neck, esophagus, liver/biliary tract/pancreas, gynecologic, urogenital, prostate, hematopoietic/lymphatic, and skin/bone/soft tissue cancers were treated at higher rates at DCCHs than at the other RT facilities. The rates for other cancers were the reverse. Compared with the data for 2007, the percentage of breast cancers increased the most at DCCHs (1.4 %), and at the other RT facilities the percentage of head/neck and breast cancers increased significantly (2.4 and 2.3 %).

Brain metastasis was treated at higher rates at the other RT facilities (14.7 % of total patients) than at DCCHs (6.9 % of total patients), while the reverse was true for

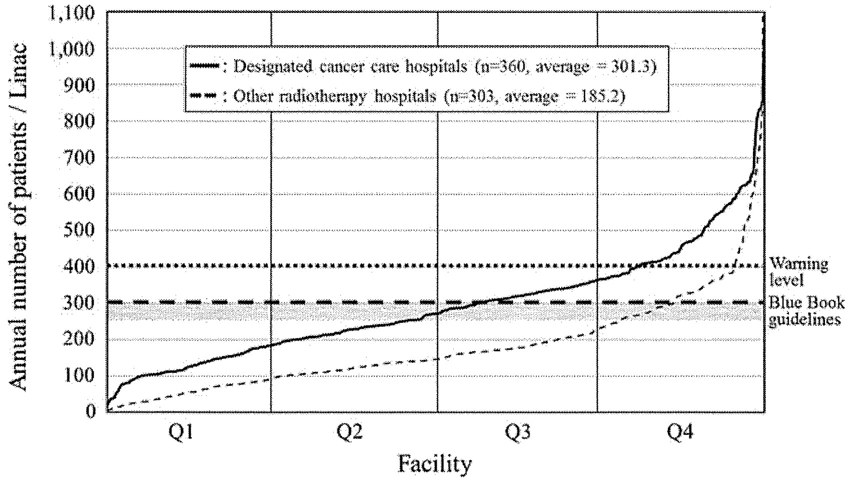

Fig. 1 Distribution of annual patient loads per linear accelerator in designated cancer care hospitals and the other radiotherapy facilities. *Horizontal axis* represents facilities arranged in order of increasing value of annual number of patients per treated equipment within facilities. *Q1* 0–25 %, *Q2* 26–50 %, *Q3* 51–75 %, *Q4* 76–100 %

Table 3 Structure and personnel of designated cancer care hospitals and other radiotherapy hospitals

	DCCHs ($n = 365$)	Comparison with 2007[a] (%)	Other RT facilities ($n = 335$)	Comparison with 2007[a] (%)	p value[b]	Total ($n = 700$)
Facilities with RT beds	190	–	108	–	–	298 (42.6)
Average no. RT beds per facility	4.2	−1.5	2.2	11.5	–	3.3
Total (full + part-time) RO FTE	666.3	–	273.1	–	–	939.4
Average no. FTE ROs per facility	1.8	11.5	0.8	18.9	<0.0001	1.3
JASTRO-certified RO (full-time)	422	–	109	–	–	531
Average no. JASTRO-certified ROs per facility	1.2	6.7	0.3	22.3	<0.0001	0.8
Annual no. patients per FTE RO	225.5	−4.9	247.6	−9.4	<0.0001	231.9
Total (full + part-time) RT technologist FTE	1175.7	–	660.2	–	–	1836.0
Average no. FTE RT technologists per facility	3.2	16.8	2.0	9.1	<0.0001	2.6
Annual no. patients per FTE RT technologist	127.8	−9.2	102.4	−1.3	<0.0001	118.7
Total (full + part-time) medical physicist FTE	74.6	77.7	43.0	62.9	–	117.6
Total (full + part-time) RT nurse FTE	392.8	29.1	228.4	20.1	–	621.2

DCCH designated cancer care hospital, *RT* radiotherapy, *RO* radiation oncologist, *FTE* full-time equivalent (40 h/week only for RT practise), *JASTRO* Japanese Society for Therapeutic Radiology and Oncology

[a] Rate of increase compared with the data of 2007, calculated using the formula: $\frac{\text{data of 2009 }(n)-\text{data of 2007 }(n)}{\text{data of 2007 }(n)} \times 100\ (\%)$

[b] Student's t test

bone metastasis (11.3 and 12.8 %, respectively). Compared with the data for 2007, the rate of brain and bone metastasis decreased in both DCCHs (−0.7 and −0.9 %) and the other RT facilities (−1.0 and −2.3 %).

Discussion

The utilization rate of RT for new cancer patients in Japan is less than half of that in developed countries in Europe and in the USA [14]. However, RT is expected to play an increasingly important role in Japan because the increase in the elderly population is the highest among developed countries. The distribution of facilities by patient load per RO for DCCHs proved to be largely similar to that of the USA in 1989 [15]. While the numbers of ROs in both DCCHs and the other RT hospitals in Japan has increased, the facilities which have less than one FTE RO still account for 31.2 % of DCCHs and 65.7 % of the other RT facilities. In Japan, the majority of facilities still rely on

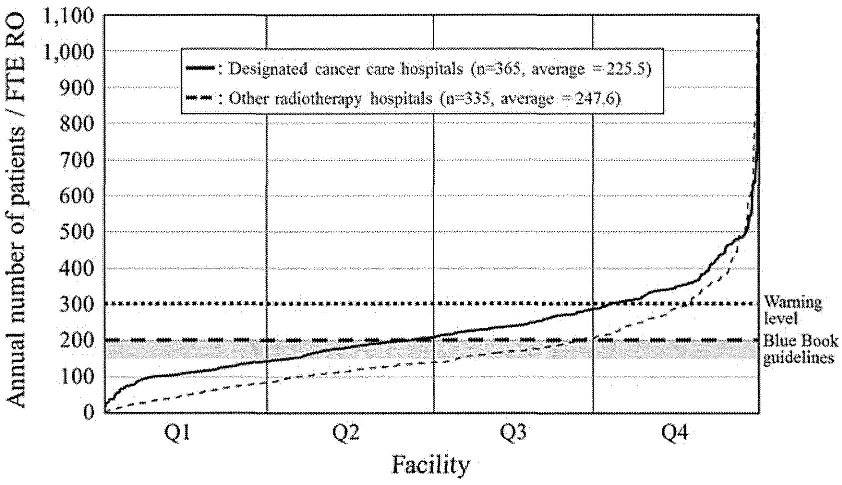

Fig. 2 Distribution of annual patient loads per FTE RO in designated cancer care hospitals and the other radiotherapy facilities. *Horizontal axis* represents facilities arranged in order of increasing value of annual number of patients per FTE RO within facilities. *Q1* 0–25 %, *Q2* 26–50 %, *Q3* 51–75 %, *Q4* 76–100 %. Number of FTE RO for facilities with FTE <1 was calculated as FTE = 1 to avoid overestimating patient loads per FTE RO

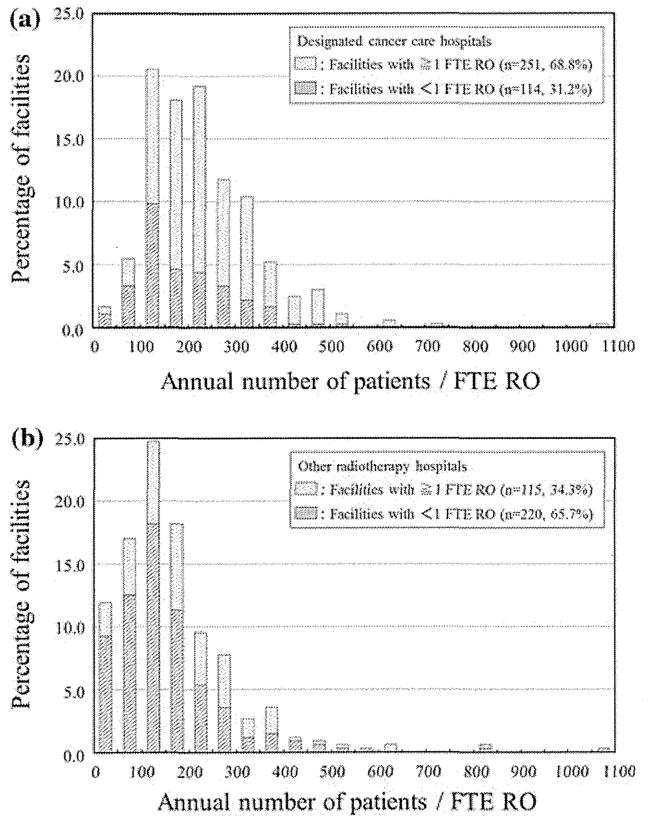

Fig. 3 Percentage of facilities by patient loads per FTE RO in designated cancer care hospitals (**a**) and in the other radiotherapy hospitals (**b**). *Each bar* represents an interval of 50 patients per FTE RO. Number of FTE RO for facilities with FTE <1 was calculated as FTE = 1 to avoid overestimating patient loads per FTE RO

part-time ROs, especially in facilities other than DCCHs, but in western developed countries, most facilities have at least 1 full-time RO. The distribution in Japan of facilities by patient load per RO for the other RT facilities in this study was similar to that in 1990 [15], so that a shortage of ROs has remained a major concern. More than 300 patients per RO (JBBG warning level) were treated in 17.6 % of all RT facilities. This is a matter of critical importance to the quality of radiotherapy.

A new educational system called "Cancer Professional Training Plan" by the Ministry of Education, Culture, Sports, Science and Technology, Japan is being developed in Japan to train specialists for cancer care, including ROs, MPs, medical oncologists, oncology nurses, and palliative care doctors. The average number of RT staff members at DCCHs was greater than that in the other RT hospitals. As noted above, there is still a shortage of Ros, although the numbers have increased. In Japan, many RT hospitals do not have an independent department for RT. One way to increase the number of ROs is to create an independent department for RT. The numbers of MPs in Japan are still smaller than those in western developed countries, and they work mainly in metropolitan areas or academic facilities, such as university hospitals or cancer centers. At present, no national license is available for MPs in Japan, but those with a master's degree in radiation technology or science and engineering can take the accreditation test for MPs administered by the Japanese Board of Medical Physics (JBMP). Compared with ROs and MPs, a sufficient number of RTTs is ensured in Japan. However, there is a significant number of hospitals with less than 1 FTE RTT in both DCCHs ($n = 13$) and the other RT hospitals ($n = 50$). In addition, many RTTs are extremely busy because they must also partially act as MPs. As for equipment, the ownership of equipment for advanced high-precision radiation therapy machines increased compared with 2007 at all RT facilities, especially DCCHs, indicating that the accreditation of DCCHs closely correlates with the maturity of the radiation oncology structure. Further accreditation of DCCHs by the Ministry of Health, Labor, and Welfare would be a move in the right direction towards a more balanced geographic consolidation of RT facilities in Japan.

The findings of this study show that, on a regional basis, DCCHs were located in the most suitable areas. There were

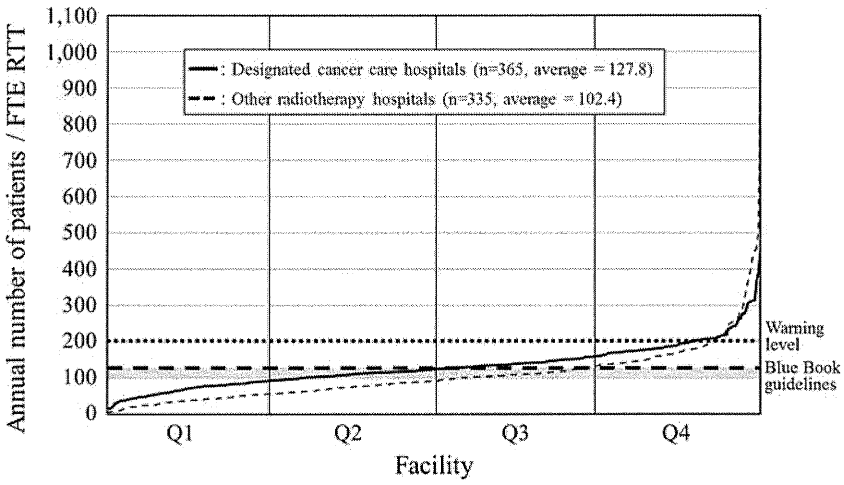

Fig. 4 Distribution of annual patient loads per FTE RTT in designated cancer care hospitals and the other radiotherapy facilities. *Horizontal axis* represents facilities arranged in order of increasing value of annual number of patients per FTE RTT within facilities. *Q1* 0–25 %, *Q2* 26–50 %, *Q3* 51–75 %, *Q4* 76–100 %. Number of FTE RTT for facilities with FTE <1 was calculated as FTE = 1 to avoid overestimating patient loads per FTE RTT

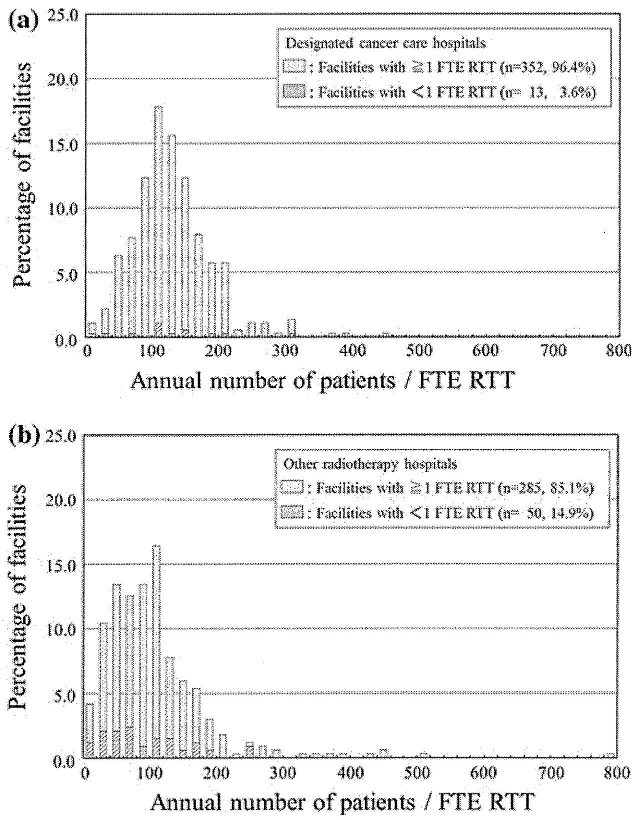

Fig. 5 Percentage of facilities by patient loads per FTE RTT in designated cancer care hospitals (**a**) and in the other radiotherapy hospitals (**b**). *Each bar* represents an interval of 20 patients per FTE RTT. Number of FTE RTT for facilities with FTE <1 was calculated as FTE = 1 to avoid overestimating patient loads per FTE RTT

388 DCCH facilities by the end of fiscal year 2011 because some further university facilities with many patients undergoing RT had been certified as DCCHs since the previous survey, while some small-scale facilities were not certified as DCCHs by the Ministry of Health, Labor, and Welfare. In terms of nationwide distribution, there seem to be enough RT facilities in Japan. On the other hand, the RT potential of RT facilities other than DCCHs in Japan remains unrealized because of personnel shortages. The most frequent primary disease site treated with RT at the other RT facilities changed from lung/trachea/mediastinum to breast, compared with the data for 2007, while at DCCHs, the most frequently treated primary disease site, the breast, remained unchanged from 2007. Finally, the number of patients with brain and bone metastasis did not increase since 2007.

To evaluate medical care systems for cancer at regular intervals, it is very important to collect detailed information on all cancer care facilities. In Japan, the structural data for all RT facilities is regularly surveyed by JASTRO. In addition, the procedures and the outcome data of cancer care for patients undergoing RT have been conducted by PCS every 4 years, but insufficient outcome data is collected. In the USA, a National Cancer Data Base was established in 1989 and since then has been collecting comprehensive data on cancer care, and this database is used as the quality indicator for improvements in the processes and outcomes of cancer care [16, 17]. We have established a Japanese National Cancer Database based on the RT data in Japan and we are preparing to use this system for the collection of cancer care data.

In conclusion, the RT structure of DCCHs in Japan showed more maturity than that of other RT facilities in terms of equipment, functions, and staff. However, there is still a shortage of personnel (ROs, RTTs, MPs, RT nurses, and so on) in radiation oncology in Japan. The structure survey data presented and discussed here seemed to be both fundamental and important for a clear and accurate understanding of the medical care system for radiation oncology in Japan. As this survey data makes clear, a

Table 4 Primary sites of cancer, brain metastasis, and bone metastasis treated with RT in designated cancer care hospitals and the other radiotherapy hospitals

Primary site	DCCHs (n = 344)		Comparison with 2007[a]	Others (n = 300)		Comparison with 2007[a]	p value[b]	Total (n = 644)	
	n	%	%	n	%	%		n	%
Cerebrospinal	4,719	3.9	0.2	4,342	8.5	−1.1	<0.0001	9,061	5.8
Head and neck (including thyroid)	13,084	10.9	−0.2	5,021	9.8	2.4	<0.0001	18,105	9.8
Esophagus	7,306	6.1	−0.4	2,288	4.5	−0.6	<0.0001	9,594	6.0
Lung, trachea, and mediastinum	21,600	18.0	−0.6	10,707	21.0	−0.5	<0.0001	32,307	19.5
Lung	19,532	16.2	−0.6	9,659	18.9	0.7	<0.0001	29,191	17.3
Breast	27,706	23.0	1.4	12,128	23.8	2.3	0.0008	39,834	21.5
Liver, biliary, tract, and pancreas	4,733	3.9	−0.1	1,908	3.7	0.3	0.0577	6,641	3.8
Gastric, small intestine, and colorectal	5,693	4.7	−0.2	2,586	5.1	−0.4	0.0029	8,279	5.1
Gynecologic	6,851	5.7	0.0	1,365	2.7	−0.6	<0.0001	8,216	4.9
Urogenital	16,641	13.8	0.7	6,409	12.6	−0.2	<0.0001	23,050	13.0
Prostate	12,830	10.7	0.9	5,089	10.0	0.6	<0.0001	17,919	9.6
Hematopoietic and lymphatic	6,176	5.1	−0.3	1,773	3.5	−0.1	<0.0001	7,949	4.8
Skin, bone, and soft tissue	3,014	2.5	−0.1	1,079	2.1	−0.7	<0.0001	4,093	2.7
Other (malignant)	1,359	1.1	−0.2	582	1.1	−0.3	0.8388	1,941	1.4
Benign tumors	1,407	1.2	−0.3	813	1.6	−0.4	<0.0001	2,220	1.6
Pediatric < 15 years (included in totals above)	900	0.7	0.0	192	0.4	−0.1	<0.0001	1,092	0.6
Total	120,289	100.0	0.0	51,001	100.0	0.0		171,290[c]	100.0
Metastasis	(n = 365)			(n = 335)				(n = 700)	
Brain	10,361	6.9	−0.7	9,973	14.7	−1.0	<0.0001	20,334	10.4
Bone	19,293	12.8	−0.9	7,613	11.3	−2.3	<0.0001	26,906	13.6

[a] Comparison with the data of 2007, calculated using the formula: data of 2009 (%) − data of 2007 (%)

[b] χ^2 test

[c] Number of total new patients is different with these data, because no data on primary sites were reported by some facilities

national policy is needed to improve the establishment of DCCHs and overcome the shortage of personnel for cancer care.

Acknowledgments This study was supported by the Japanese Society for Therapeutic Radiology and Oncology and Grants-in-Aid for Cancer Research (H22-3rd Term Cancer Control-General-043 and H23-3rd Term Cancer Control-General-007) from the Ministry of Health, Labor and Welfare of Japan and by Grants-in-Aid for Scientific Research from the Japan Society for the Promotion of Sciences (No. 23591838). We would like to express our appreciation to all ROs and radiotherapy technologists throughout Japan who participated in this survey, for providing us with valuable information to make this study possible. This study was supported by JASTRO.

Conflict of interest The authors declare that they have no conflict of interest.

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Int. J. Radiation Oncology Biol. Phys., Vol. 82, No. 1, pp. e111–e117, 2012

0360-3016/$ - see front matter

doi:10.1016/j.ijrobp.2011.01.029

CLINICAL INVESTIGATION **Education and Training**

NATIONAL MEDICAL CARE SYSTEM MAY IMPEDE FOSTERING OF TRUE SPECIALIZATION OF RADIATION ONCOLOGISTS: STUDY BASED ON STRUCTURE SURVEY IN JAPAN

HODAKA NUMASAKI, PH.D.,[*] HITOSHI SHIBUYA, M.D.,[†] MASAMICHI NISHIO, M.D.,[‡] HIROSHI IKEDA, M.D.,[§] KENJI SEKIGUCHI, M.D.,[||] NORIHIKO KAMIKONYA, M.D.,[¶] MASAHIKO KOIZUMI, M.D.,[#] MASAO TAGO, M.D.,[**] YUTAKA ANDO, M.D.,[††] NOBUHIRO TSUKAMOTO, M.D.,[‡‡] ATSURO TERAHARA, M.D.,[§§] KATSUMASA NAKAMURA, M.D.,[||||] MICHIHIDE MITSUMORI, M.D.,[¶¶] TETSUO NISHIMURA, M.D.,[##] MASATO HAREYAMA, M.D.,[***] TERUKI TESHIMA, M.D.[*], AND JAPANESE SOCIETY OF THERAPEUTIC RADIOLOGY AND ONCOLOGY DATABASE COMMITTEE

[*]Department of Medical Physics and Engineering, Osaka University Graduate School of Medicine, Suita, Osaka, Japan; [†]Department of Radiology, Tokyo Medical and Dental University, Tokyo, Japan; [‡]Department of Radiology, National Hospital Organization Hokkaido Cancer Center, Sapporo, Hokkaido, Japan; [§]Department of Radiology, Sakai Municipal Hospital, Sakai, Osaka, Japan; [||]Department of Radiation Oncology, St. Luke's International Hospital, Tokyo, Japan; [¶]Department of Radiology, Hyogo College of Medicine, Nishinomiya, Hyogo, Japan; [#]Oncology Center, Osaka University Hospital, Suita, Osaka, Japan; [**]Department of Radiology, Teikyo University School of Medicine University Hospital, Mizonokuchi, Kawasaki, Kanagawa, Japan; [††]Department of Medical Informatics, Heavy Ion Medical Center, National Institute of Radiological Sciences, Chiba, Japan; [‡‡]Department of Radiation Oncology, Saitama Medical University International Medical Center, Saitama, Japan; [§§]Department of Radiology, Toho University Omori Medical Center, Tokyo, Japan; [||||]Department of Radiology, Kyushu University Hospital at Beppu, Oita, Japan; [¶¶]Department of Radiation Oncology and Image-applied Therapy, Graduate School of Medicine Kyoto University, Kyoto, Japan; [##]Division of Radiation Oncology, Shizuoka Cancer Center, Shizuoka, Japan; and [***]Department of Radiology, Sapporo Medical University, Hokkaido, Japan

Purpose: To evaluate the actual work environment of radiation oncologists (ROs) in Japan in terms of working pattern, patient load, and quality of cancer care based on the relative time spent on patient care.

Methods and Materials: In 2008, the Japanese Society of Therapeutic Radiology and Oncology produced a questionnaire for a national structure survey of radiation oncology in 2007. Data for full-time ROs were crosschecked with data for part-time ROs by using their identification data. Data of 954 ROs were analyzed. The relative practice index for patients was calculated as the relative value of care time per patient on the basis of Japanese Blue Book guidelines (200 patients per RO).

Results: The working patterns of RO varied widely among facility categories. ROs working mainly at university hospitals treated 189.2 patients per year on average, with those working in university hospitals and their affiliated facilities treating 249.1 and those working in university hospitals only treating 144.0 patients per year on average. The corresponding data were 256.6 for cancer centers and 176.6 for other facilities. Geographically, the mean annual number of patients per RO per quarter was significantly associated with population size, varying from 143.1 to 203.4 ($p < 0.0001$). There were also significant differences in the average practice index for patients by ROs working mainly in university hospitals between those in main and affiliated facilities (1.07 vs 0.71: $p < 0.0001$).

Conclusions: ROs working in university hospitals and their affiliated facilities treated more patients than the other ROs. In terms of patient care time only, the quality of cancer care in affiliated facilities might be worse than that in university hospitals. Under the current national medical system, working patterns of ROs of academic facilities in Japan appear to be problematic for fostering true specialization of radiation oncologists. **© 2012 Elsevier Inc.**

Structure survey, Working pattern, Patient load, Quality of cancer care, Medical care system.

Reprint requests to: Teruki Teshima, M.D., Department of Medical Physics and Engineering, Osaka University Graduate School of Medicine 1-7, Yamadaoka, Suita, Osaka, 565-0871, Japan. Tel: +81-6-6879-2570; Fax: +81-6-6879-2570. E-mail: teshima@sahs.med.osaka-u.ac.jp

Supported by the Japanese Society of Therapeutic Radiology and Oncology (JASTRO) and Grants-in-Aid for Cancer Research (No. 18-4, 20S-5, and H19-3rd Term Cancer Control General-038) from the Ministry of Health, Labor and Welfare of Japan and by a Grant-in-Aid for Scientific Research from the Japan Society for the Promotion of Sciences (No. 19390320 and 20591495).

Conflict of interest: none

Acknowledgments—We thank all radiation oncologists throughout Japan who participated in this survey for their efforts in providing us with valuable information to make this study possible.

Received Oct 15, 2010, and in revised form Dec 8, 2010. Accepted for publication Jan 12, 2011.