Journal of Radiation Research, Vol. 61, No. 1, 2020, pp. 146–160
doi: 10.1093/jrr/rrz077
Advance Access Publication: 11 December 2019

Japanese structure survey of radiation oncology in 2012

Hodaka Numasaki[1,*], Teruki Teshima[2], Yutaka Ando[3], Keizo Akuta[4], Hiroshi Ikeda[5], Kaoru Okajima[6], Tomoyasu Kumano[7], Tomonari Sasaki[8], Kenji Sekiguchi[9], Masao Tago[10], Atsuro Terahara[11], Katsumasa Nakamura[12], Tetsuo Nishimura[13] and Kazuhiko Ogawa[14] for Society Japanese Radiation Oncology Database Committee

[1]Department of Functional Diagnostic Science, Osaka University Graduate School of Medicine, 1-7 Yamadaoka, Suita-shi, Osaka, 565-0871, Japan
[2]Department of Radiation Oncology, Osaka International Cancer Institute, 3-1-69 Otemae, Chuo-ku, Osaka-shi, Osaka, 541-8567, Japan
[3]Department of Radiation Oncology, Saitama Medical Center, 4-9-3 Kitaurawa, Urawa-ku, Saitama-shi, Saitama, 330-0074, Japan
[4]Department of Radiology, Japanese Red Cross Otsu Hospital, 1-1-35 Nagara, Otsu-shi, Siga, 520-0000, Japan
[5]Department of Radiation Oncology, Sakai City Medical Center, 1-1-1 Ebaraji-cho, Nishi-ku, Sakai-shi, Osaka, 593-8304, Japan
[6]Department of Radiology, Kindai University Nara Hospital, 1248-1 Otoda-cho, Ikoma-shi, Nara, 630-0293, Japan
[7]Department of Radiology, Gifu University School of Medicine, 1-1 Yanagido, Gifu-shi, Gifu, 501-1194, Japan.
[8]Division of Medical Quantum Science, Department of Health Sciences, Kyushu University Faculty of Medical Sciences, 3-1-1 Maidashi, Higashi-ku, Fukuoka-shi, Fukuoka, 812-8582, Japan
[9]Sonoda-kai Radiation Oncology Clinic, 3-4-19 Hokima, Adachi-ku, Tokyo, 121-0064, Japan
[10]Department of Radiology, Teikyo University Mizonokuchi Hospital, 5-1-1 Futako, Takatsu, Kawasaki-shi, Kanagawa, 213-8507, Japan
[11]Department of Radiology, Toho University Omori Medical Center, 6-11-1 Omori-nishi, Ota-ku, Tokyo, 143-8541, Japan
[12]Department of Radiation Oncology, Hamamatsu University Hospital, 1-20-1 Handayama, Higashi-ku, Hamamatsu-shi, Shizuoka, 431-3192, Japan
[13]Division of Radiation Oncology, Shizuoka Cancer Center Hospital, 1007 Shimonagakubo, Nagaizumi-cho, Sunto-gun, Shizuoka, 411-8777, Japan
[14]Department of Radiation Oncology, Osaka University Graduate School of Medicine, 2-2 Yamadaoka, Suita-shi, Osaka, 565-0871, Japan
*Corresponding author. Department of Functional Diagnostic Science, Osaka University Graduate School of Medicine 1-7 Yamadaoka, Suita-shi, Osaka 565-0871, JAPAN. Tel/Fax: +81-668792575; Email: numasaki@sahs.med.osaka-u.ac.jp
(Received 27 August 2019; revised 30 September 2019; editorial decision 6 October 2019)

ABSTRACT

This paper 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 March 2013 to August 2016, the Japanese Society for Radiation Oncology conducted a questionnaire based on the Japanese national structure survey of radiation oncology in 2012. 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 213 000 and 251 000, respectively. Additionally, the estimated cancer incidence was 865 238 cases with ~24.6% of all newly diagnosed patients being treated with radiation. The types and numbers of treatment devices actually used included linear accelerator (LINAC; $n = 864$), telecobalt ($n = 0$), Gamma Knife ($n = 44$), ^{60}Co remote afterloading system (RALS; $n = 23$) and ^{192}Ir RALS ($n = 130$). The LINAC system used dual-energy functions in 651 units, 3D conformal radiotherapy functions in 759 and intensity-modulated radiotherapy (IMRT) functions in 466. There were 792 Japan Radiological Society/Japanese Society for Radiation Oncology-certified radiation oncologists, 1061.6 full-time equivalent (FTE) radiation oncologists, 2124.2 FTE radiotherapy technologists, 181.3 FTE medical physicists, 170.9 FTE radiotherapy quality managers and 841.5 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 2012.

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 2 years since 1991 [2–22]. 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 2012 is now available.

MATERIALS AND METHODS

From March 2013 to August 2016, a questionnaire regarding the 2012 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 2012 were also considered. In total, 709 of 788 active institutions attempted the survey; the response rate was 90.0%.

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 h per week for radiation oncology work only) data. The Japanese Blue Book Guidelines (JBBG) [23, 24] 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) [25, 26] 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 patient load per FTE radiation oncologist (RO), and at 120 (warning level, 200) for annual patient load per FTE radiotherapy technologist.

Furthermore, we analyzed data from the designated cancer care hospital accredited by the Ministry of Health, Labor and Welfare. As on 1 October 2016, Japan had 427 designated cancer care hospitals [27]. A total of 44 institutions did not return the survey; therefore, the structure data for these 383 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, preliminary results have been presented as tables and figures (Tables 1–18 and Figs 1–6). We have briefly summarized the Japanese national structure survey of radiation oncology for 2012. The values obtained by dividing the real numbers of new patients (190 910) and total (new plus repeat) patients (225 818) by the response rate were 212 182.1 and 250 979.7, respectively. In addition, there may be radiotherapy institutions unknown by JASTRO. Therefore, the estimated number of new patients was ~213 000, obtained by rounding up 212 182.1 to the nearest 1000. In the same way, the estimated number of total patients was ~251 000 (Fig. 1).

DISCUSSION

In this report, the estimated numbers of new patients and total patients were ~213 000 and 251 000 by a simple calculation using the response rate. However, 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 method used as follows. If all non-responding institutions were in category A ($\leq$99), the estimated numbers of new patients and total patients were 195 901 and 231 727 by calculation using the average number of new patients in category A. On the other hand, the estimated numbers of new patients and total patients were 249 192 and 293 709 if all non-responding institutions were in category F ($\geq$500).

In 2012, based on Japanese cancer registries, the cancer incidence was estimated at 865 238 cases [28] with approximately 24.6% (213 000 of 865 238) of all newly diagnosed patients being treated with radiation.

Regarding the case scale of institution, ~50.5% of all radiotherapy institutions had >200 new radiotherapy patients per year, whereas 31.3% of the institutions had >300. Additionally, 41.5% of all radiotherapy institutions had <1.0 FTE ROs. Compared with the findings of a similar survey conducted 5 years ago, the percentage of institutions that have >= 1.0 FTE ROs had improved a little, but was not yet sufficient.

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

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)	6	1	15	46	39	25	132	18.6
B (100–199)	12	3	28	71	62	43	219	30.9
C (200–299)	11	4	9	43	44	25	136	19.2
D (300–399)	18	2	4	19	27	12	82	11.6
E (400–499)	17	1	3	12	4	11	48	6.8
F (≥500)	49	18	1	8	5	11	92	13.0
Total	113	29	60	199	181	127	709	
Institution ratio [%]	15.9	4.1	8.5	28.1	25.5	17.9		100.0

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

Scale category (number of institutions)	Institution category (number of institutions)						Total (709)	Average
	U (113)	G (29)	N (60)	P (199)	O (181)	H (127)		
A (132)	247	74	950	2795	2690	1584	8340	63.2
B (219)	1752	369	4220	10 160	9015	5909	31 425	143.5
C (136)	2824	1132	2227	10 434	10 568	6154	33 339	245.1
D (82)	6450	771	1450	6398	9175	4199	28,443	346.9
E (48)	7643	416	1274	5313	1896	4948	21 490	447.7
F (92)	36 020	16 337	698	4574	3334	6910	67 873	737.8
Total (709)	54 936	19 099	10 819	39 674	36 678	29 704	190 910	269.3
Average	486.2	658.6	180.3	199.4	202.6	233.9	269.3	
Median	449	641	156	168	173	186	201	

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 (709)	Average
	U (113)	G (29)	N (60)	P (199)	O (181)	H (127)		
A (132)	265	126	1037	3238	3070	2137	9873	74.8
B (219)	2077	409	4995	11 681	10 442	7329	36 933	168.6
C (136)	3125	1474	2524	12 481	12 141	7313	39 058	287.2
D (82)	7704	1007	1639	7645	11 145	5224	34 364	419.1
E (48)	9214	495	1461	6438	2280	6639	26 527	552.6
F (92)	40 577	19 933	860	5364	3812	8517	79 063	859.4
Total (709)	62 962	23 444	12 516	46 847	42 890	37 159	225 818	318.5
Average	557.2	808.4	208.6	235.4	237.0	292.6	318.5	
Median	525	697	184	185	202	225	236	

When viewed from the perspective of geographic distribution, radiotherapy institutions cover each region in Japan, although there are considerable differences in the number of radiotherapy institutions in prefectures. Concerning equipment, much of theequipment 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, radiotherapy technologists, medical physicists, radiotherapy quality managers and nurses) steadily increased. Annual total patient load per FTE RO was 212.7, which was lower than the 248.2 of the 2007 survey [16]. However, this patient load exceeds the 200.0 given as the standard value by the JBBG [23, 24]. With regard to other staff, the numbers of medical physicists and radiotherapy quality managers are absolutely insufficient. In most cases, radiotherapy technologists partially act as medical physicists and radiotherapy quality managers. Compared with the other types of staff mentioned above, a sufficient number of radiotherapy technologists is ensured

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

Treatment devices and their functions	Scale category (number of institutions)						Total (709)
	A (132)	B (219)	C (136)	D (82)	E (48)	F (92)	
LINAC	127	215	139	109	76	198	864
With dual energy function	75	157	111	89	61	158	651
With 3DCRT function (MLC width $\leq$ 1.0 cm)	93	177	125	102	70	192	759
With IMRT function	28	79	72	78	51	158	466
With cone beam CT or CT on rail	24	65	65	59	37	99	349
With treatment position verification system (X-ray perspective image)	29	54	60	54	38	88	323
With treatment position verification system (other than those above)	26	61	38	42	18	72	257
Annual no. patients/LINAC	77.7	171.8	281.0	315.3	349.0	399.3	261.4
CyberKnife®	2	6	0	2	3	6	19
Novalis®	2	1	5	10	8	9	35
Tomotherapy®	2	6	1	5	5	3	22
Particle	0	0	1	1	1	6	9
Microtoron	1	2	0	2	1	2	8
Telecobalt (actual use)	0 (0)	2 (0)	1 (0)	0 (0)	0 (0)	0 (0)	3 (0)
Gamma Knife®	4	11	7	8	6	8	44
Other accelerator	0	1	1	2	0	3	7
Other external irradiation device	0	0	2	0	0	4	6
New type ^{60}Co RALS (actual use)	0 (0)	4 (3)	6 (6)	3 (2)	5 (5)	4 (4)	22 (20)
Old type ^{60}Co RALS (actual use)	0 (0)	4 (1)	3 (1)	0 (0)	2 (1)	0 (0)	9 (3)
^{192}Ir RALS (actual use)	1 (0)	7 (7)	13 (13)	25 (23)	19 (19)	69 (68)	134 (130)
^{137}Cs RALS (actual use)	0 (0)	1 (1)	0 (0)	0 (0)	0 (0)	0 (0)	1 (1)

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.

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

Treatment planning equipment and accessories	Scale category (number of institutions)						Total (709)
	A (132)	B (219)	C (136)	D (82)	E (48)	F (92)	
X-ray simulator ($\geq$1*)	59 (59)	77 (77)	43 (43)	35 (33)	26 (26)	65 (60)	305 (298)
CT simulator ($\geq$1*)	110 (108)	195 (186)	135 (124)	86 (77)	44 (42)	107 (91)	677 (628)
RTP computer ($\geq$2 *)	163 (22)	300 (57)	233 (51)	219 (52)	165 (35)	531 (87)	1,611 (304)
X-ray CT ($\geq$2 *)	232 (86)	520 (178)	386 (121)	276 (76)	196 (45)	470 (89)	2,080 (595)
for RT only	52	119	98	69	38	102	478
MRI ($\geq$2*)	160 (33)	328 (106)	234 (90)	180 (69)	124 (44)	276 (80)	1,302 (422)
for RT only	2	5	4	4	3	4	22
Computer use for RT recording*	64	102	89	53	23	57	388
Water phantom ($\geq$2*)	144 (27)	246 (52)	185 (48)	108 (27)	76 (20)	193 (55)	952 (229)
Film densitometer ($\geq$2*)	43 (2)	92 (2)	72 (3)	67 (3)	44 (5)	100 (13)	418 (28)
Dosemeter ($\geq$3*)	335 (57)	694 (128)	552 (88)	331 (56)	258 (36)	658 (78)	2828 (443)

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

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

	Scale category (number of institutions)						Total (709)
	A (132)	B (219)	C (136)	D (82)	E (48)	F (92)	
Scale (annual no. of new patients)	≤99	100–199	200–299	300–399	400–499	≥500	
Institution ratio [%]	18.6	30.9	19.2	11.6	6.8	13.0	100
New patients	8340	31 425	33 339	28 443	21 490	67 873	190 910
New patients/institution	63.2	143.5	245.1	346.9	447.7	737.8	269.3
Total patients	9873	36 933	39 058	34 364	26 527	79 063	225 818
Total patients/institution	74.8	168.6	287.2	419.1	552.6	859.4	318.5
Beds	45 130	93 715	65 714	45 765	31 042	69 701	351 067
Institutions with RT beds (%)	25 (18.9)	51 (23.3)	31 (22.8)	32 (39)	25 (52.1)	58 (63)	222 (31.3)
RT beds	107.5	244.0	149.0	175.5	281.0	897.7	1 854.7
RT beds/total beds [%]	0.2	0.3	0.2	0.4	0.9	1.3	0.5
RT beds/institution	0.8	1.1	1.1	2.1	5.9	9.8	2.6
RT beds/institution with RT beds	4.3	4.8	4.8	5.5	11.2	15.5	8.4
JRS-certified institutions (%)	5 (3.8)	26 (11.9)	37 (27.2)	43 (52.4)	32 (66.7)	81 (88)	224 (31.6)
JRS-cooperation institutions (%)	45 (34.1)	104 (47.5)	66 (48.5)	25 (30.5)	9 (18.8)	20 (21.7)	269 (37.9)
JASTRO-certified institutions (%)	2 (1.5)	41 (18.7)	57 (41.9)	57 (69.5)	35 (72.9)	84 (91.3)	276 (38.9)
JRS membership (full-time)	59	161	136	134	119	450	1059
JASTRO membership (full-time)	50	142	133	130	111	449	1015
JRS/JASTRO-certified ROs (full-time)	31	115	120	114	85	327	792
Institutions with full-time RO (%)	54 (40.9)	137 (62.6)	111 (81.6)	77 (93.9)	46 (95.8)	85 (92.4)	510 (71.9)
ROs (full-time)	71	178	143	142	125	463	1,122
ROs (full-time)/institution	0.5	0.8	1.1	1.7	2.6	5.0	1.6
FTE RO (full-time)	24.4	145.0	125.3	121.9	103.1	359.4	878.9
FTE RO (full-time)/institution	0.29	0.62	0.92	1.51	2.10	4.16	1.28
ROs (part-time)	119	217	120	74	47	117	694
ROs (part-time)/institution	0.90	0.99	0.88	0.90	0.98	1.27	0.98
FTE RO (part-time)	23.4	38.1	20.8	16.3	16.2	39.2	153.9
FTE RO (part-time)/institution	0.2	0.2	0.2	0.2	0.3	0.4	0.2
FTE RO (full- plus part-time)	61.3	174.6	146.5	139.9	117.1	422.3	1,061.6
FTE RO (full- plus part-time)/institution	0.46	0.80	1.08	1.71	2.44	4.59	1.50
Radiologists (full-time)	150.0	405.0	358.8	355.0	286.0	962.0	2516.8
Radiologists (part-time)	170.5	345.2	247.1	194.5	70.4	219.0	1246.7
Radiologists (full-time)/institution	1.1	1.8	2.6	4.3	6.0	10.5	3.5
RTTs (full-time)*	396	783	570	443	292	791	3275
FTE RTT	198.6	442.1	354.0	292.3	215.6	621.6	2124.2
Medical physicists (full-time)*	21	64	69	64	42	128	388
FTE Medical physicist	8.3	20.9	32.5	27.6	19.1	73.0	181.3
RT quality manager (full-time)*	48	120	103	85	51	128	535
FTE RT quality manager	15.9	36.4	33.6	27.9	16.1	41.2	170.9
Dosimetrists (full-time)*	17	29	18	29	10	66	169
FTE Dosimetrist	4.6	7.1	4.5	9.4	3.3	12.8	41.5
Craftworkers (full-time)*	48	93	55	33	38	72	339
FTE Craftworker	11.4	17.3	11.7	6.6	4.0	9.9	60.7
Nurses (full-time)	137	318	234	192	107	302	1,290
FTE Nurse	66.55	177.94	159.89	121.81	80.25	235.1	841.5
Nursing assistants	5.2	4.8	12.4	10.2	10.8	26.44	69.8
Clerks	26.6	56.9	66.7	59.55	53.4	128.4	391.6

*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 ($\times 10^3$) [29]	Institutions	New patients	New patients/ institution	Total patients	Total patients/ institution
Hokkaido	5460	30	9431	314.4	11 642	388.1
Aomori	1350	10	2265	226.5	2470	247.0
Iwate	1303	8	1839	229.9	2412	301.5
Miyagi	2325	12	4447	370.6	5355	446.3
Akita	1063	10	1757	175.7	2095	209.5
Yamagata	1152	6	1381	230.2	1543	257.2
Fukushima	1962	10	2832	283.2	3136	313.6
Ibaraki	2943	14	3530	252.1	4275	305.4
Tochigi	1992	9	2767	307.4	3221	357.9
Gunma	1992	14	3944	281.7	4312	308.0
Saitama	7212	20	7180	359.0	8356	417.8
Chiba	6195	24	8038	334.9	9559	398.3
Tokyo	13,230	66	23 900	362.1	29 110	441.1
Kanagawa	9067	40	12 390	309.8	13 801	345.0
Niigata	2347	14	3671	262.2	4269	304.9
Toyama	1082	8	1578	197.3	1814	226.8
Ishikawa	1163	7	1963	280.4	2222	317.4
Fukui	799	6	1105	184.2	1291	215.2
Yamanashi	852	4	1361	340.3	1636	409.0
Nagano	2132	15	3248	216.5	3678	245.2
Gifu	2061	13	2908	223.7	3648	280.6
Shizuoka	3735	23	6129	266.5	7986	347.2
Aichi	7427	39	10 024	257.0	12 325	316.0
Mie	1840	12	2020	168.3	2227	185.6
Shiga	1415	10	1753	175.3	2199	219.9
Kyoto	2625	12	3744	312.0	4625	385.4
Osaka	8856	52	13 736	264.2	16 083	309.3
Hyogo	5571	32	8510	265.9	9742	304.4
Nara	1390	9	2251	250.1	2634	292.7
Wakayama	988	9	1397	155.2	1636	181.8
Tottori	582	7	1064	152.0	1265	180.7
Shimane	707	5	1016	203.2	1154	230.8
Okayama	1936	11	2859	259.9	3403	309.4
Hiroshima	2848	19	4762	250.6	5770	303.7
Yamaguchi	1431	14	1981	141.5	2291	163.6
Tokushima	776	5	1366	273.2	1459	291.8
Kagawa	989	6	1334	222.3	1531	255.2
Ehime	1415	10	2154	215.4	2550	255.0
Kochi	752	5	1224	244.8	1345	269.0
Fukuoka	5085	26	8416	323.7	9834	378.2
Saga	843	4	867	216.8	979	244.8
Nagasaki	1408	9	2324	258.2	2762	306.9
Kumamoto	1807	13	2971	228.5	3472	267.1
Oita	1185	11	1598	145.3	1970	179.1
Miyazaki	1126	8	1942	242.8	2312	289.0
Kagoshima	1690	11	2315	210.5	2567	233.4
Okinawa	1409	7	1618	231.1	1852	264.6
Total	127 518	709	190 910	269.3	225 818	318.5

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	11 642	42	53.3	218.4
Aomori	2 ,470	10	11.8	209.3
Iwate	2 ,412	7	10.5	229.7
Miyagi	5 ,355	14	19.6	273.9
Akita	2 ,095	3	6.0	349.2
Yamagata	1543	5	8.3	185.9
Fukushima	3136	14	16.7	187.8
Ibaraki	4275	11	18.4	232.3
Tochigi	3221	14	13.8	233.4
Gunma	4312	28	31.8	135.6
Saitama	8356	21	29.4	283.9
Chiba	9559	37	49.3	193.9
Tokyo	29 110	96	135.5	214.8
Kanagawa	13 801	48	63.5	217.3
Niigata	4269	14	19.9	214.5
Toyama	1814	4	6.8	266.8
Ishikawa	2222	8	8.7	255.4
Fukui	1291	12	11.6	111.3
Yamanashi	1636	6	7.0	233.7
Nagano	3678	8	12.5	295.4
Gifu	3648	9	12.1	301.5
Shizuoka	7986	26	31.7	251.9
Aichi	12 325	39	57.9	212.9
Mie	2227	6	10.1	220.5
Shiga	2199	7	14.3	153.8
Kyoto	4625	20	28.8	160.6
Osaka	16 083	63	84.3	190.8
Hyogo	9742	34	46.6	209.1
Nara	2634	11	16.8	156.8
Wakayama	1636	7	7.9	207.1
Tottori	1265	6	5.6	225.9
Shimane	1154	6	8.0	144.3
Okayama	3403	12	18.9	180.5
Hiroshima	5770	20	24.7	233.6
Yamaguchi	2291	7	12.0	190.9
Tokushima	1459	7	6.4	228.0
Kagawa	1531	6	6.3	243.0
Ehime	2550	9	13.3	191.7
Kochi	1345	5	4.4	305.7
Fukuoka	9834	36	46.7	210.6
Saga	979	5	5.6	174.8
Nagasaki	2762	9	9.8	281.8
Kumamoto	3472	13	19.2	180.8
Oita	1970	2	6.8	289.7
Miyazaki	2312	12	11.5	201.0
Kagoshima	2567	7	10.1	254.2
Okinawa	1852	6	7.5	246.9
Total	225 818	792	1061.6	212.7

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	11 642	76.1	153.0	17.3	6.3
Aomori	2470	25.7	96.1	3.4	3.4
Iwate	2412	25.0	96.5	2.2	1.2
Miyagi	5355	40.3	132.9	2.9	3.5
Akita	2095	18.9	110.9	1.2	2.3
Yamagata	1543	17.1	90.2	0.6	1.2
Fukushima	3136	37.0	84.9	3.3	0.4
Ibaraki	4275	47.2	90.6	2.1	2.7
Tochigi	3221	30.7	104.9	1.2	2.6
Gunma	4312	47.3	91.2	4.0	2.7
Saitama	8356	62.4	133.9	3.9	6.4
Chiba	9559	92.6	103.3	8.2	2.9
Tokyo	29 110	253.6	114.8	25.5	12.5
Kanagawa	13 801	142.2	97.1	8.0	11.1
Niigata	4269	41.1	103.9	1.9	1.3
Toyama	1814	19.1	95.2	0.7	2.5
Ishikawa	2222	25.2	88.2	1.0	1.5
Fukui	1291	22.8	56.6	2.7	1.0
Yamanashi	1636	6.7	246.0	0.6	1.7
Nagano	3678	33.6	109.5	2.5	1.0
Gifu	3648	31.5	115.8	1.6	3.2
Shizuoka	7986	84.5	94.6	7.8	7.9
Aichi	12 325	117.5	104.9	8.5	9.6
Mie	2227	25.7	86.7	1.6	2.8
Shiga	2199	30.4	72.3	1.0	4.1
Kyoto	4625	37.7	122.7	5.1	5.7
Osaka	16 083	161.0	99.9	23.0	14.3
Hyogo	9742	100.9	96.5	6.9	7.1
Nara	2634	25.9	101.7	1.9	3.9
Wakayama	1636	25.2	64.9	1.1	1.2
Tottori	1265	14.0	90.4	0.3	1.6
Shimane	1154	12.7	90.9	0.2	2.0
Okayama	3403	33.6	101.2	2.4	3.4
Hiroshima	5770	45.6	126.6	3.9	4.2
Yamaguchi	2291	27.1	84.5	0.6	2.9
Tokushima	1459	15.9	91.8	0.3	1.0
Kagawa	1531	11.7	130.9	0.9	1.2
Ehime	2550	22.8	111.8	3.4	4.4
Kochi	1345	9.8	137.2	1.1	0.8
Fukuoka	9834	80.1	122.8	6.1	9.7
Saga	979	10.0	97.9	0.2	0.3
Nagasaki	2762	18.8	146.9	2.7	2.7
Kumamoto	3472	34.9	99.5	2.6	3.3
Oita	1970	19.8	99.5	1.5	1.6
Miyazaki	2312	19.9	116.2	1.0	2.2
Kagoshima	2567	26.4	97.2	2.2	1.3
Okinawa	1852	16.5	112.2	0.5	0.6
Total	225 818	2124.2	106.3	181.3	170.9

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

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

	2012				2011			
Specific therapy	A (132)	B (219)	C (136)	D (82)	E (48)	F (92)	Total (709)	Total (694)
Intracavitary radiotherapy								
Treatment institutions	0	7	19	26	24	70	146	142
Patients	0	72	263	365	395	1941	3036	3008
Interstitial radiotherapy								
Treatment institutions	3	9	9	21	20	55	117	105
Patients	49	206	241	538	653	2447	4134	4071
^{125}I seed implantation therapy for prostate								
Treatment institutions	3	6	8	17	16	53	103	93
Patients	49	169	240	443	438	1985	3324	3273
Radioactive iodine therapy for thyroid cancer								
Treatment institutions	1	9	5	10	11	29	65	54
Patients	4	157	47	539	301	1240	2288	1879
Total body radiotherapy								
Treatment institutions	8	15	30	29	23	70	175	162
Patients	71	136	337	285	293	1126	2248	1957
Intraoperative radiotherapy								
Treatment institutions	1	2	3	1	3	13	23	20
Patients	2	2	5	1	10	78	98	102
Stereotactic brain radiotherapy								
Treatment institutions	12	44	42	52	31	52	233	214
Patients	663	2332	1673	3192	2162	4428	14 450	13 768
Stereotactic body radiotherapy								
Treatment institutions	5	38	51	57	31	73	255	222
Patients	14	588	536	777	767	2331	5013	3552
IMRT								
Treatment institutions	8	21	31	40	27	71	198	164
Patients	451	1097	1519	2000	2079	4801	11 947	8887
Thermoradiotherapy								
Treatment institutions	2	7	2	4	3	3	21	19
Patients	33	54	6	19	209	45	366	327
^{90}Sr radiotherapy for pterygia								
Treatment institutions	0	2	3	0	0	2	7	8
Patients	0	21	11	0	0	30	62	45
Internal ^{89}Sr radiotherapy								
Treatment institutions	10	35	39	35	23	53	195	169
Patients	62	138	239	157	124	425	1145	969
Internal ^{90}Y radiotherapy								
Treatment institutions	0	3	4	6	1	15	29	31
Patients	0	14	14	12	1	30	71	106

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

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

Primary site	*n*	%
Cerebrospinal	8484	4.7
Head and neck (including thyroid)	16 641	9.2
Esophagus	9386	5.2
Lung, trachea, and mediastinum	34 364	18.9
Lung	30 926	17.0
Breast	42 589	23.5
Liver, biliary tract, pancreas	7024	3.9
Gastric, small intestine, colorectal	8816	4.9
Gynecologic	9011	5.0
Urogenital	28 250	15.6
Prostate	22 320	12.3
Hematopoietic and lymphatic	8175	4.5
Skin, bone and soft tissue	3882	2.1
Other (malignant)	2253	1.2
Benign disease	2665	1.5
Pediatric ≤15 years (included in totals above)	912	0.5
Pediatric 16–19 years (included in totals above)	218	0.1
Total	181 540	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 (709)	
	A (132)		B (219)		C (136)		D (82)		E (48)		F (92)			
	n	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%
Brain	985	10.0	4254	11.5	3088	7.9	3507	10.2	2634	9.9	6975	8.8	21 443	9.5
Bone	1614	16.3	5651	15.3	5376	13.8	4421	12.9	2869	10.8	8735	11.0	28 666	12.7

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)	415
RH-B	All radiotherapy hospitals (FTE RO <1.0)	294
Total		709
DCCH-A	Designated cancer care hospitals (FTE RO ≥1.0)	287
DCCH-B	Designated cancer care hospitals (FTE RO <1.0)	96
Total		383

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 in Table 14; all radiotherapy hospitals.

	RH-A (415)		RH-B (294)		Total (709)	
	Average per hospital	Total number	Average per hospital	Total number	Average per hospital	Total number
Total patients	432.1	179 339	158.1	46 479	318.5	225 818
New patients	363.8	150 989	135.8	39 921	269.3	190 910
LINAC	1.4	585	0.9	279	1.2	864
Annual no. of total patients/LINAC	306.6		166.6		261.4	
Annual no. of new patients/LINAC	258.1		143.1		221.0	
FTE RO	2.3	948.2	0.4	113.4	1.5	1061.6
JRS/JASTRO-certified RO (full-time)	1.7	722	0.2	70	1.1	792
Annual no. of total patients/FTE RO	189.1		410.0		212.7	
Annual no. of new patients/FTE RO	159.2		352.2		179.8	
FTE RT technologist	3.9	1604.7	1.8	519.5	3.0	2124.2
Annual no. of total patients/FTE RTT	111.8		89.5		106.3	
Annual no. of new patients/FTE RTT	94.1		76.8		89.9	
FTE RT technologist/LINAC	2.7		1.9		2.5	
FTE medical physicist	0.37	155.2	0.09	26.1	0.26	181.3
Annual no. of total patients/FTE MP	1155.3		1784.2		1245.7	
Annual no. of new patients/FTE MP	972.6		1,532.5		1053.1	
FTE RT quality manager	0.33	136.2	0.12	34.7	0.24	170.9
Annual no. of total patients/FTE RTQM	1317.2		1339.5		1321.7	
Annual no. of new patients/FTE RTQM	1109.0		1150.5		1117.4	
FTE RT quality manager/LINAC	0.23		0.12		0.20	

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.

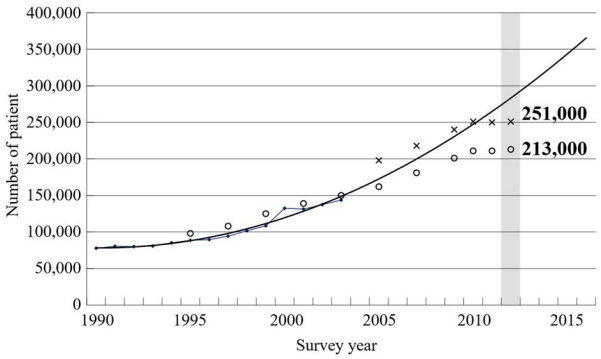

Fig. 1. Estimate of increase in demand for radiotherapy in Japan and estimated annual number of new and total patients, based on statistical correction of annual change in the number of new patients per year at Patterns of Care Study survey facilities [23]. x and o denote the estimated number of total (new plus repeat) and new patients from the results in structure surveys by the JASTRO.

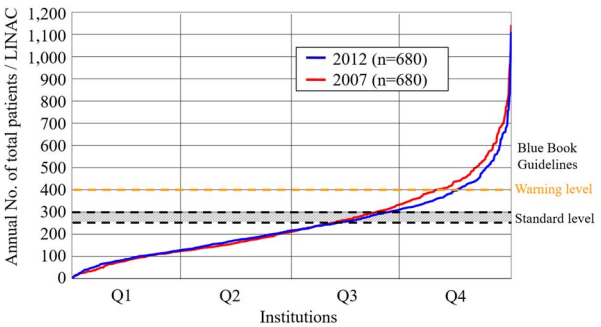

Fig. 2. Distribution of annual total (new plus repeat) patient load per LINAC in radiotherapy institutions. Horizontal axis represents institutions arranged in order of increasing value of annual number of total patients per LINAC within the institution. Q1: 0–25%, Q2: 26–50%, Q3: 51–75%, Q4: 76–100%.

in Japan. 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, but annual patient load per FTE RO and annual patient load per FTE radiotherapy technologist were almost the same as the national average. On the other hand, 25.1% of designated cancer care hospitals had <1.0 FTE radiation oncologist. Compared with the findings of a similar survey conducted 5 years ago [17], the above percentage had improved to 12.3%, but it was not yet sufficient.

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 (287)		DCCH-B (96)		Total (383)	
	Average per hospital	Total number	Average per hospital	Total number	Average per hospital	Total number
Total patients	495.3	142 145	196.1	18 828	420.3	160 973
New patients	418.9	120 223	171.9	16 498	357.0	136 721
LINAC	1.6	449	1.0	98	1.4	547
Annual no. of total patients/LINAC	316.6		192.1		294.3	
Annual no. of new patients/LINAC	267.8		168.3		249.9	
FTE RO	2.5	708.2	0.5	47.4	2.0	755.6
JRS/JASTRO-certified RO (full-time)	1.9	557	0.3	33	1.5	590
Annual No. of total patients/FTE RO	200.7		397.6		213.1	
Annual no. of new patients/FTE RO	169.8		348.4		181.0	
FTE RT technologist	4.2	1198.7	2.0	196.0	3.6	1394.6
Annual no. of total patients/FTE RTT	118.6		96.1		115.4	
Annual no. of new patients/FTE RTT	100.3		84.2		98.0	
FTE RT technologist/LINAC	2.7		2.0		2.5	
FTE medical physicist	0.41	118.0	0.11	10.5	0.34	128.4
Annual no. of total patients/FTE MP	1205.0		1,801.7		1,253.6	
Annual No. of new patients/FTE MP	1019.2		1,578.8		1,064.7	
FTE RT quality manager	0.36	102.9	0.15	14.3	0.31	117.2
Annual no. of total patients/FTE RTQM	1382.1		1316.6		1374.1	
Annual no. of new patients/FTE RTQM	1168.9		1153.7		1167.1	
FTE RT quality manager/LINAC	0.23		0.15		0.21	

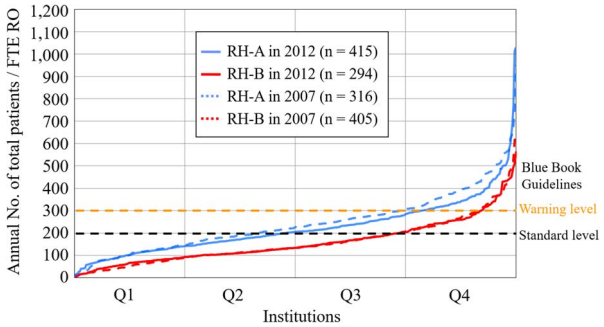

Fig. 3. Distribution of annual total (new plus repeat) patient load per FTE RO in all radiotherapy institutions. Horizontal axis represents institutions arranged in order of increasing value of annual number of total patients per FTE RO within the institution. Q1: 0–25%, Q2: 26–50%, Q3: 51–75%, Q4: 76–100%.

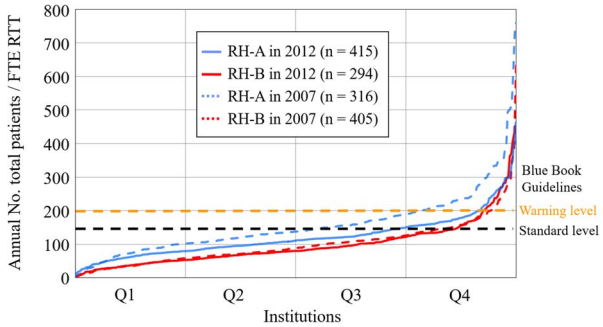

Fig. 4. Distribution of annual total (new plus repeat) patient load per FTE radiotherapy technologist (RTT) in all radiotherapy institutions. Horizontal axis represents institutions arranged in order of increasing value of annual number of total patients per FTE RTT within the institution. Q1: 0–25%,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

In conclusion, the Japanese structure of radiation oncology has clearly and steadily improved over the past 20 years in terms of installation and use of equipment and its functions, but 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 2012 will aid the continuous improvement of all aspects of radiation oncology in Japan.

FUNDING

This study was supported by the JASTRO and Grants-in-Aid for Scientific Research from the Japan Society for the Promotion of Science [JSPS KAKENHI Grant No. JP17K10475].

CONFLICT OF INTEREST

None declared.

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

	RH-A (n = 415)		RH-B (n = 294)		Total (n = 709)	
	n	%	n	%	n	%
LINAC	585	97.1	279	94.2	864	95.9
With dual energy function	460	85.3	191	64.6	651	76.7
With 3DCRT function (MLC width ≤ 1.0 cm)	544	91.3	215	72.8	759	83.6
With IMRT function	392	66.7	74	24.8	466	49.4
With cone beam CT or CT on rail	290	56.9	59	19.7	349	41.5
with treatment position verification system (X-ray perspective image)	260	49.2	63	21.1	323	37.5
With treatment position verification system (other than those above)	199	39.5	58	19.7	257	31.3
CT simulator	424	92.5	253	83.0	677	88.6
	DCCH-A (n = 287)		DCCH-B (n = 96)		Total (n = 383)	
	n	%	n	%	n	n
LINAC	449	100.0	98	100.0	547	100.0
With dual energy function	363	92.7	75	77.1	438	88.8
With 3DCRT function (MLC width ≤ 1.0 cm)	428	96.5	83	85.4	511	93.7
With IMRT function	310	73.5	38	38.5	348	64.8
With cone beam CT or CT on rail	227	62.4	28	28.1	255	53.8
With treatment position verification system (X-ray perspective image)	206	55.1	29	29.2	235	48.6
With treatment position verification system (other than those above)	147	40.1	26	27.1	173	36.8
CT simulator	303	96.5	90	87.5	393	94.3

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

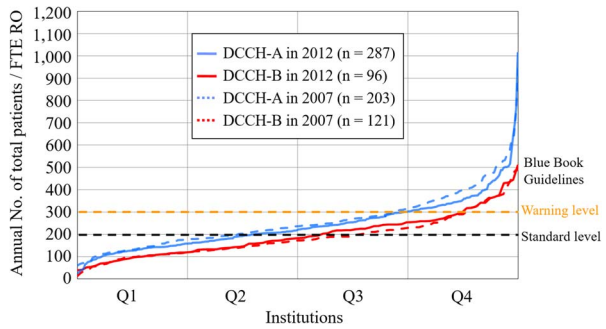

Fig. 5. Distribution of annual total (new plus repeat) patient load per FTE RO in designated cancer care hospitals. Horizontal axis represents institutions arranged in order of increasing value of annual number of total patients per FTE radiation oncologist within the institution. Q1: 0–25%, Q2: 26–50%,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

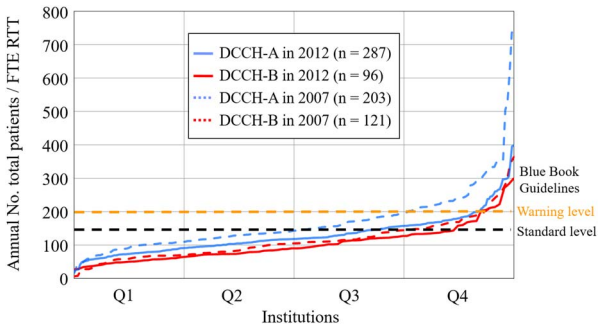

Fig. 6. Distribution of annual total (new plus repeat) patient load per FTE radiotherapy technologist (RTT) in designated cancer care hospitals. Horizontal axis represents institutions arranged in order of increasing value of annual number of total patients per FTE RTT within the institution. Q1: 0–25%,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

Table 18. Number of radiotherapy institutions, treatment devices, patient load and personnel: trend 1990–2012.

	1990	1993	1995	1997	1999	2001	Survey year 2003	2005	2007	2009	2010	2011	2012
Institutions	378	629	504	568	636	603	726	712	721	700	705	694	709
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
New patients	62 829	—	71 696	84 379	107 150	118 016	149 793	156 318	170 229	182 390	190 322	185 455	190 910
Total patients	—	—	—	—	—	—	—	191 173	205 087	217 829	226 851	220 092	225 818
Average no. of new patients	166	—	142	149	168	196	206	220	236	261	270	267	269
Treatment devices (actual use) LINAC	311	508	407	475	626	626	744	765	807	816	829	836	864
Telecobalt	170	213	127	98	83	45	42	11	15	11	9	3	0
^{192}Ir RALS	—	—	29	50	73	93	117	119	123	130	131	125	130
Full- time ROs	547	748	821	889	925	878	921	1003	1007	1085	1123	1102	1122
FTE RO	—	—	—	—	—	—	—	774	826	939	959	1019	1062
Full-time JRS/JASTRO-certified ROs	—	—	—	—	—	308	369	426	477	529	564	756	792
FTE RT technologist	592	877	665	733	771	918	1555	1635	1,634	1836	1841	2027	2124
Treatment planning equipment X-ray simulators	295	430	394	452	512	464	532	502	445	361	348	320	305
CT simulators	30	75	55	96	164	247	329	407	497	575	633	654	677
RTP computers	238	468	374	453	682	680	874	940	1070	1271	1381	1484	1611

ACKNOWLEDGMENTS

We wish to thank all radiation oncologists, radiation technologists and other staff throughout Japan who participated in this survey for their efforts in providing us with valuable information to make this study possible.

REFERENCES

1. Tsunemoto H. Present status of Japanese radiation oncology: National survey of structure in 1990 (in Japanese). *J Jpn Soc Ther Radiol Oncol (Special Report)* 1992;1–30.
2. Sato S, Nakamura Y, Kawashima K et al. Present status of radiotherapy in Japan –a census in 1990- finding on radiotherapy facilities (in Japanese with an English abstract). *J Jpn Soc Ther Radiol Oncol* 1994;6:83–9.
3. Morita K, Uchiyama Y. Present status of radiotherapy in Japan – the second census in 1993- (in Japanese with an English abstract). *J Jpn Soc Ther Radiol Oncol* 1995;7:251–61.
4. JASTRO Database Committee. Present status of radiotherapy in Japan –the regular census in 1995- (in Japanese with an English abstract). *J Jpn Soc Ther Radiol Oncol* 1997;9:231–53.
5. JASTRO Database Committee. Present status of radiotherapy in Japan –the regular census in 1997- (in Japanese with an English abstract). *J Jpn Soc Ther Radiol Oncol* 2001;13:175–82.
6. JASTRO Database Committee. Present status of radiotherapy in Japan –the regular structure survey in 1999- (in Japanese with an English abstract). *J Jpn Soc Ther Radiol Oncol* 2001;13: 227–35.
7. JASTRO Database Committee. Present status of radiotherapy in Japan –the regular structure survey in 2001- (in Japanese with an English abstract). *J Jpn Soc Ther Radiol Oncol* 2003;15:51–9.
8. JASTRO Database Committee. Present status of radiotherapy in Japan –the regular structure survey in 2003- (in Japanese with an English abstract). *J Jpn Soc Ther Radiol Oncol* 2005;17:115–21.
9. Shibuya H, Tsujii H. The structural characteristics of radiation oncology in Japan in 2003. *Int J Radiat Oncol Biol Phys* 2005;62:1472–6.
10. Teshima T, Numasaki H, Shibuya H et al. Japanese structure survey of radiation oncology in 2005 (first report) (in Japanese with an English abstract). *J Jpn Soc Ther Radiol Oncol* 2007;19:181–92.
11. Teshima T, Numasaki H, Shibuya H et al. Japanese structure survey of radiation oncology in 2005 (second report) (in Japanese with an English abstract). *J Jpn Soc Ther Radiol Oncol* 2007;19:193–205.
12. Teshima T, Numasaki H, Shibuya H et al. Japanese structure survey of radiation oncology in 2005 based on institutional stratification of patterns of care study. *Int J Radiat Oncol Biol Phys* 2008;72:144–52.
13. Numasaki H, Teshima T, Shibuya H et al. National structure of radiation oncology in Japan with special reference to designated cancer care hospital. *Int J Clin Oncol* 2009;14:237–44.
14. Teshima T, Numasaki H, Shibuya H et al. Japanese structure survey of radiation oncology in 2007 (first report) (in Japanese with an English abstract). *J Jpn Soc Ther Radiol Oncol* 2009;21:113–25.
15. Teshima T, Numasaki H, Shibuya H et al. Japanese structure survey of radiation oncology in 2007 (second report)

(in Japanese with an English abstract). *J Jpn Soc Ther Radiol Oncol* 2009;21:126–38.
16. Teshima T, Numasaki H, Shibuya H et al. Japanese structure survey of radiation oncology in 2007 based on institutional stratification of patterns of care study. *Int J Radiat Oncol Biol Phys* 2010;72:144–52.
17. Numasaki H, Teshima T, Shibuya H et al. Japanese structure survey of radiation oncology in 2007 with special reference to designated cancer care hospitals. *Strahlenther Onkol* 2011;187:167–74.
18. Numasaki H, Shibuya H, Nishio M et al. National medical care system may impede fostering of true specialization of radiation oncologists: Study based on structure survey in Japan. *Int J Radiat Oncol Biol Phys* 2012;82:e111–7.
19. Teshima T, Numasaki H, Nishio M et al. Japanese structure survey of radiation oncology in 2009 based on institutional stratification of patterns of care study. *J Radiat Res* 2012;53:710–2.
20. Numasaki H, Nishio M, Ikeda H et al. Japanese structure survey of radiation oncology in 2009 with special reference to designated cancer care hospitals. *Int J Clin Oncol* 2013;18:775–83.
21. Numasaki H, Teshima T, Nishimura T et al. Japanese structure survey of radiation oncology in 2010. *J Radiat Res* 2019;60:80–97.
22. Numasaki H, Teshima T, Nishimura T et al. Japanese structure survey of radiation oncology in 2011. *J Radiat Res* 2019; in press.
23. Japanese PCS Working Group. Radiation oncology in multidisciplinary cancer therapy -basic structure requirement for quality assurance of radiotherapy based on patterns of care study in Japan. Ministry of Health. *Labor, and Welfare Cancer Research Grant Planned Research Study* 2005;14–6.
24. Japanese PCS Working Group. Radiation oncology in multidisciplinary cancer therapy -basic structure requirement for quality assurance of radiotherapy based on patterns of care study in Japan. Ministry of Health. *Labor, and Welfare Cancer Research Grant Planned Research Study* 2010;18–4.
25. Tanisada K, Teshima T, Ohno Y et al. Patterns of care study quantitative evaluation of the quality of radiotherapy in Japan. *Cancer* 2002;95:164–71.
26. Teshima T. Japanese PCS working group. Patterns of care study in Japan. *Jpn J Clin Oncol* 2005;35:497–506.
27. Ministry of Health, Labor and welfare. A list of designated cancer hospitals. http://www.mhlw.go.jp/ (1 December 2016, date last accessed).
28. Cancer Information Service, National Cancer Center. Cancer registry and statistics. http://ganjoho.jp/reg_stat/statistics/dl/index.html (1 August 2016, date last accessed).
29. Statistics Bureau, Ministry of Internal Affairs and Communications. 2012 population census. http://www.stat.go.jp/data/jinsui/2012np/index.htm (1 January 2017, date last accessed).