Japanese structure survey of radiation oncology in 2012

Hodaka Numasaki1,*, Teruki Teshima2, Yutaka Ando3, Keizo Akuta4, Hiroshi Ikeda5, Kaoru Okajima6, Tomoyasu Kumano7, Tomonari Sasaki8, Kenji Sekiguchi9, Masao Tago10, Atsuro Terahara11, Katsumasa Nakamura12, Tetsuo Nishimura13 and Kazuhiko Ogawa14 for Society Japanese Radiation Oncology Database Committee

1Department of Functional Diagnostic Science, Osaka University Graduate School of Medicine, 1-7 Yamadaoka, Suita-shi, Osaka, 565-0871, Japan
2Department of Radiation Oncology, Osaka International Cancer Institute, 3-1-69 Otemae, Chuo-ku, Osaka-shi, Osaka, 541-8567, Japan
3Department of Radiation Oncology, Saitama Medical Center, 4-9-3 Kitaurawa, Urawa-ku, Saitama-shi, Saitama, 330-0074, Japan
4Department of Radiology, Japanese Red Cross Osaka Hospital, 1-1-35 Nagara, Higashinari-ku, Osaka, 520-8500, Japan
5Department of Radiation Oncology, Sapporo City Medical Center, 1-1-1 Ebaraji-cho, Nishi-ku, Sapporo-shi, Hokkaido, 060-8597, Japan
6Department of Radiology, Kindai University School of Medicine, 1-1 Yanagido, Higashi-ku, Osu-shi, Ibaraki, 305-0843, Japan
7Department of Radiology, Gunma University School of Medicine, 1-5-10 Showa-cho, Maebashi-shi, Gunma, 371-3808, Japan
8Department of Radiology, Kanazawa University School of Medicine, 7-1-1 Izumikawacho, Kanazawa-shi, Ishikawa, 920-8641, Japan
9Department of Radiology, Chiba University School of Medicine, 1-8-1 Inohana, Inage-ku, Chiba, 263-8522, Japan
10Department of Radiology, Teikyo University Mizonokuchi Hospital, 5-1-1 Futako, Takatsu, Kawasaki-shi, Kanagawa, 213-8507, Japan
11Department of Radiology, Toho University Omori Medical Center, 6-11-1 Omori-nishi, Ota-ku, Tokyo, 143-8541, Japan
12Department of Radiation Oncology, Hamamatsu University Hospital, 1-20-1 Handayama, Higashi-ku, Hamamatsu-shi, Shizuoka, 431-3192, Japan
13Division of Radiation Oncology, Sapporo Cancer Center Hospital, 1007 Shimonakakubo, Nagaizumi-cho, Sunto-gun, Shizuoka, 411-8777, Japan
14Department 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 patientstreated 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), Co remote afterloading system (RALS; n = 23) and 192Ir 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 patients (251 000) 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 (<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 (≥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 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 | 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    | 10160   | 9015    | 5909      | 31425   | 143.5  |
| C (136)                                | 2824                                          | 1132        | 2227    | 10434   | 10568   | 6154      | 33339   | 245.1  |
| D (82)                                 | 6450                                          | 771         | 1450    | 6398    | 9175    | 4199      | 28443   | 346.9  |
| E (48)                                 | 7643                                          | 416         | 1274    | 5313    | 1896    | 4948      | 21490   | 447.7  |
| F (92)                                 | 36020                                         | 16337       | 698     | 4574    | 3334    | 6910      | 67873   | 737.8  |
| Total (709)                            | 54936                                         | 19099       | 10819   | 39674   | 36678   | 29704     | 190910  | 269.3  |

### 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    | 11681   | 10442   | 7329      | 36933   | 168.6  |
| C (136)                                | 3125                                          | 1474        | 2524    | 12481   | 12141   | 7313      | 39058   | 278.7  |
| D (82)                                 | 7704                                          | 1007        | 1639    | 7645    | 11145   | 5224      | 33646   | 419.1  |
| E (48)                                 | 9214                                          | 495         | 1461    | 6438    | 2280    | 6639      | 26527   | 552.6  |
| F (92)                                 | 40577                                         | 19933       | 860     | 5364    | 3812    | 8517      | 79063   | 859.4  |
| Total (709)                            | 62962                                         | 23444       | 12516   | 46847   | 42890   | 37159     | 225818  | 318.5  |

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 the equipment had been rapidly replaced with ones with excellent functions, although there are differences depending on the scale of the institution. The numbers of staff (ROs, 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 ≤ 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   |
| Microtron                             | 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)  | 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 (≥ 1*)                      | 59 (59) | 77 (77) | 43 (43) | 35 (33) | 26 (26) | 65 (60) | 305 (298) |
| CT simulator (≥ 1*)                         | 110 (108) | 195 (186) | 135 (124) | 86 (77) | 44 (42) | 107 (91) | 677 (628) |
| RTP computer (≥ 2*)                         | 163 (22) | 300 (57) | 233 (51) | 219 (52) | 165 (35) | 531 (87) | 1,611 (304) |
| X-ray CT (≥ 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 (≥ 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 (≥ 2*)                        | 144 (27) | 246 (52) | 185 (48) | 108 (27) | 76 (20) | 193 (55) | 952 (229) |
| Film densitometer (≥ 2*)                    | 43 (2)  | 92 (2)  | 72 (3)  | 67 (3)  | 44 (5)  | 100 (13) | 418 (28) |
| Dosemeter (≥ 3*)                            | 335 (57) | 694 (128) | 552 (88) | 331 (56) | 258 (36) | 658 (78) | 2,828 (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) | A (132) | B (219) | C (136) | D (82) | E (48) | F (92) | Total (709) |
|----------------------------------------|---------|---------|---------|--------|--------|--------|-------------|
| 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    | 31425   | 33339   | 28443  | 21490  | 67873  | 190 910     |
| New patients/institution               | 63.2    | 143.5   | 245.1   | 346.9  | 474.7  | 737.8  | 269.3       |
| Total patients                         | 9873    | 36933   | 39058   | 34364  | 26527  | 79063  | 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)/instituion| 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         |
| RITs (full-time)*                      | 396     | 783     | 570     | 443    | 292    | 791    | 3275        |
| FTE RIT                                | 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 ($\times 10^3$) | 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                       |
| Fukushima       | 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      |
| Fukushima    | 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.

| Specific therapy                              | 2012 | 2011 |     |     |     |     |     |
|-----------------------------------------------|------|------|-----|-----|-----|-----|-----|
|                                               | 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  |
| ¹²⁵I 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 | 14450 | 13768 |
| 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 | 11947 | 8887  |
| Thermoradiotherapy                            |       |       |       |       |       |       |       |       |
| Treatment institutions                        | 2    | 7    | 2    | 4    | 3    | 3    | 21    | 19    |
| Patients                                      | 33   | 54   | 6    | 19   | 209  | 45   | 366   | 327   |
| ⁶⁰Sr radiotherapy for pterygia                 |       |       |       |       |       |       |       |       |
| Treatment institutions                        | 0    | 2    | 3    | 0    | 0    | 2    | 7     | 8     |
| Patients                                      | 0    | 21   | 11   | 0    | 0    | 30   | 62    | 45    |
| Internal ⁶⁰Sr radiotherapy                    |       |       |       |       |       |       |       |       |
| Treatment institutions                        | 10   | 35   | 39   | 35   | 23   | 53   | 195   | 169   |
| Patients                                      | 62   | 138  | 239  | 157  | 124  | 425  | 1145  | 969   |
| Internal ⁹⁰Y radiotherapy                     |       |       |       |       |       |       |       |       |
| Treatment institutions                        | 0    | 3    | 4    | 6    | 1    | 15   | 29    | 31    |
| Patients                                      | 0    | 14   | 14   | 11   | 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)                | 16641| 9.2 |
| Esophagus                                        | 9386| 5.2 |
| Lung, trachea, and mediastinum                   | 34364| 18.9|
| Lung                                             | 30926| 17.0|
| Breast                                           | 42589| 23.5|
| Liver, biliary tract, pancreas                   | 7024| 3.9 |
| Gastric, small intestine, colorectal             | 8816| 4.9 |
| Gynecologic                                      | 9011| 5.0 |
| Urogenital                                        | 28250| 15.6|
| Prostate                                         | 22320| 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                                            | 181540| 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.

| Scale category (number of institutions) | Total (709) |
|-----------------------------------------|-------------|
| Metastasis A (132)                      |             |
| n                                       | %           |
| Brain                                   | 985         | 10.0 |
| Bone                                    | 1614        | 16.3 |
| Metastasis B (219)                      |             |
| n                                       | %           |
| Brain                                   | 4254        | 11.5 |
| Bone                                    | 5651        | 15.3 |
| Metastasis C (136)                      |             |
| n                                       | %           |
| Brain                                   | 3088        | 7.9  |
| Bone                                    | 5376        | 13.8 |
| Metastasis D (82)                       |             |
| n                                       | %           |
| Brain                                   | 3507        | 10.2 |
| Bone                                    | 4421        | 12.9 |
| Metastasis E (48)                       |             |
| n                                       | %           |
| Brain                                   | 2634        | 9.9  |
| Bone                                    | 2869        | 10.8 |
| Metastasis F (92)                       |             |
| n                                       | %           |
| Brain                                   | 6975        | 8.8  |
| Bone                                    | 8735        | 11.0 |
| Total Metastasis                         | 21443       | 9.5  |
| Total                                   | 28666       | 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.

| Category                              | 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      | 1532.5  | 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  | Total number         | Average per  | Total number         | Average per  | Total number         |
|                      | hospital     |                      | hospital     |                      | hospital     |                      |
| 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.

| Equipment                              | 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 3D CRT 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)                       |     |       |     |       |     |       |
| LINAC                                  | 449 | 100.0 | 98  | 100.0 | 547 | 100.0 |
| With dual energy function              | 363 | 92.7  | 75  | 77.1  | 438 | 88.8  |
| With 3D CRT 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, 3D CRT = 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  |
| ^105Ir RALS              | —      | —   | 29   | 50   | 73   | 93   | 117                       | 119  | 123  | 130  | 125  | 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 |
| JRS/JASTRO-certified ROs | —      | —   | —    | —    | —    | —    | 308                       | 426  | 477  | 529  | 564  | 756  | 792  |
| FTE RT technologist      | 592    | 877  | 665  | 733  | 771  | 918  | 1555                      | 1635 | 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–acensus 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 –thefirstcensus 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 2007 (first report) (in Japanese with an English abstract). J Jpn Soc Ther Radiol Oncol 2009;21:113–25.
13. Teshima T, Numasaki H, Shibuya H et al. Japanese structure survey of radiation oncology in 2007 (second report)
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* 2013;60:80–97.

22. Numasaki H, Teshima T, Nishimura T et al. Japanese structure survey of radiation oncology in 2011. *J Radiat Res* 2013;60:80–97.

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. *Ipn 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/](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](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](http://www.stat.go.jp/data/jinsui/2012np/index.htm) (1 January 2017, date last accessed).