located in metropolitan areas, so many cancer patients who lived in those areas might have received treatment in the hospitals in Tokyo. The number of JASTRO-certified physicians in radiotherapy facilities and designated cancer care hospitals were also strongly associated with the number of patients undergoing RT (correlation coefficient were 0.92 and 0.83). The JASTRO-certified physicians were properly in place. However, the absolute number of JASTRO-certified physicians was especially insufficient in regions where there were many patients undergoing RT. In figure 6 (b), there were five peaks in the number of JASTRO-certified physicians in the Q3 and Q4 regions. These peaks were Tokyo, Kanagawa, Chiba, Hiroshima, and Gunma in descending order. In the metropolitan area, the Keihanshin area, and the Chukyo area, the cancer patients can easily receive treatment in the hospitals of other regions, so figure 6 (b) has a jagged graph. In Japan, it is necessary to increase in the number of designated cancer care hospitals and the number of the JASTRO-certified physicians in regions where there is a large population and a lot of patients.

The utilization rate of radiotherapy for new cancer patients in Japan remains at about 25% (162,000/660,578[9]), less than a half the ratio of the United States and European countries. The anti-cancer law was enacted in Japan to promote radiotherapy and education for radiation oncologists, medical physicists and other staff members as of April 2007. In Japan, radiotherapy is expected to play an increasingly important role since the increase in the elderly population is the highest among other developed countries.

The ownership of all equipment was more firmly in place in designated cancer care hospitals than in the others.[10] The function of linac, in particular IMRT function, does not mean actual use of its function. In 2005, mainly due to severe shortage of manpower, only 6.0% of linac with its function was used for actual IMRT in the clinic. The average number of staff members for radiotherapy in designated cancer care hospitals was more than that of the others. So, the accreditation of designated cancer care hospitals is closely correlated with the maturity of the structures of radiation oncology.[10] However, it is problematic that there are designated cancer care hospitals without their own departments of radiotherapy. We consider that all of designated cancer care hospitals need to have their own departments of radiotherapy because number of cancer patients requiring RT is rapidly increasing and current RT in Japan is underutilized compared with those in Europe and the United States. Accreditation of designated cancer care hospitals by Ministry of Health, Labor and Welfare would be a good start to consolidate the RT facilities geographically in Japan.

The structural information of all radiotherapy facilities in Japan is regularly surveyed by JASTRO. Although the process and the outcome for cancer care undergoing RT have been investigated by PCS every four years, the collection of the outcome information is insufficient. In the United States, a National Cancer Database was established and has been collecting the data for cancer care. This database is used as the quality indicator for improvements in the processes and

outcomes of cancer care. It is necessary to establish an informational system in Japan that can collect national data for cancer care. We have currently established a Japanese National Cancer Database based on the RT data. We are preparing the collection of cancer care data by using this system.

In conclusion, the structure of radiation oncology in designated cancer care hospitals in Japan showed its maturity more so than that of other facilities in terms of equipment and their functions, although a shortage of manpower still exists. It is necessary as national policy to solve the problem of the arrangement of designated cancer care hospitals and the shortage of manpower for cancer care as clarified by this survey data.

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Figure legends

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

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

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

Figure 3(b). Percentage of facilities by patient loads / FTE RO in the other hospitals. Each bar represents an interval of 50 patients per FTE RO. Number of FTE RO for facilities with FTE < 1 was calculated as FTE = 1 to avoid overestimating patient loads / FTE RO.

Figure 4. Distribution of annual patient loads / RT technologist in designated cancer care hospitals and the others. Horizontal axis represents facilities arranged in order of increasing value of annual number of patients / RT technologist within facilities. Q1: 0-25%, Q2: 26-50%, Q3: 51-75%, Q4: 76-100%.

Figure 5(a). Percentage of facilities by patient loads / RT technologist in designated cancer care hospitals. Each bar represents an interval of 20 patients per FTE staff.

Figure 5(b). Percentage of facilities by patient loads / RT technologist in the other hospitals. Each bar represents an interval of 20 patients per FTE staff.

Figure 6(a). Geographic distribution for 47 prefectures of the number of facilities arranged in order of increasing population. Q1: 0-25%, Q2: 26-50%, Q3: 51-75%, Q4: 76-100%. Upper horizontal bar (-) shows average number of facilities of the prefectures per quarter in all radiotherapy hospitals and lower horizontal bar (-) shows that in designated cancer care hospitals.

Figure 6(b). Geographic distribution for 47 prefectures of the number of JASTRO-certified physicians arranged in order of the increasing number of patient undergoing RT by prefecture. Q1: 0-25%, Q2: 26-50%, Q3: 51-75%, Q4: 76-100%. Upper horizontal bar (-) shows average number of JASTRO-certified physicians of the prefectures per quarter in all radiotherapy hospitals and lower horizontal bar (-) shows that in designated cancer care hospitals.

Table 1. The numbers of new patients and total patients (new plus repeat) requiring RT in designated cancer care hospitals and the others

	Designated cancer care hospitals	Others	*p-value*	Total
Facilities	326	386		712
New patients	96558†	59,760		156,318††
Average no. new patients/facility	296.2	154.8	<.0001	219.5
Total patients (new + repeat)	118548†	72,625		191,173††
Average no. total patients/facility	363.6	188.1	<.0001	268.5

† The number of designated cancer care hospitals with RT was 333, and number of new patients in designated cancer care hospitals was estimated at approximately 99,000 (96,558*333/326); corresponding number of total patients (new plus repeat) was 121,000 (118,548*333/326).

†† The number of radiotherapy facilities was 735 in 2005, and number of new patients was estimated at approximately 162,000 (156,318*735/712); corresponding number of total patients (new plus repeat) was 198,000 (191,173*735/712).

Table 2. Equipment patterns and staffing patterns and patient load in designated prefectural cancer care hospitals and designated regional cancer care hospitals

	Designated prefectural cancer care hospitals (n =49)		Designated regional cancer care hospitals (n =277)		*p-value*
	n	%	n	%	
Linac	87	100.0*	310	95.7*	.1377
with IMRT function	46	52.9†	73	23.5†	<.0001
No. linacs/facility	1.8		1.1		<.0001
Annual no. patients/facility	722.3		300.2		<.0001
Annual no. patients/linac	406.8††		257.0††		<.0001
^{192}Ir RALS (actual use)	37	75.5	54	8.6	<.0001
CT simulator	47	83.7††	170	59.9††	.0015
Average no. FTE ROs/facility	3.1		1.2		<.0001
Average no. JASTRO-certified ROs/facility	2.1		0.7		<.0001

* Percentage calculated from the number of systems using this function and the total number of Linac systems.

† Percentage calculated from the number of patients and the number of Linac. The facilities without Linac were excluded from the calculation.

†† Percentage of facilities which have equipment

Linac: Linear accelerator, IMRT: intensity-modulated radiotherapy, RALS: remote-controlled afterloading system, CT: computed tomography, FTE: full-time equivalent (40h/wk only for RT practice), RO: radiation oncologist, JASTRO: Japanese Society of Therapeutic Radiology and Oncology.

Table 3. Equipment, its function and patient load per equipment in designated cancer care hospitals and the others

	Designated cancer care hospitals (n =326)		Others (n =386)		*p-value*	Total (n = 712)	
	n	%	n	%		n	%
Linac	397	96.3*	368	88.9*	.0002	765	92.3*
With dual energy function	291	73.1†	207	56.3†	<.0001	498	65.1†
With 3D-CRT function (MLC width =< 1.0cm)	268	67.5,	194	52.7†	<.0001	462	60.4†
With IMRT function	119	30.0†	51	13.9†	<.0001	170	22.2†
Average no. linac/facility	1.2		1.0		<.0001	1.1	
Annual no. patients/linac	289.7††		175.1††		<.0001	234.6††	
Telecobalt (actual use)	18 (7)		16 (4)			34 (11)	
Gamma Knife	17		31		.1400	48	
^{60}Co RALS (actual use)	51 (46)	15.6 (14.1)	23 (18)	7.1†† (5.5)	<.0001	74 (64)	10.4†† (9.0)
^{192} Ir RALS (actual use)	94 (91)	28.5†† (27.6)	29 (28)	8.9†† (8.6)	<.0001	123 (119)	17.1†† (16.6)

* Percentage of facilities which have this equipment (two or more pieces of equipment per facility).

† Percentage calculated from the number of systems using this function and the total number of linac systems.

†† Percentage calculated from the number of patients and the number of linac. The facilities without linac were excluded from the calculation.

3D-CRT: three-dimensional conformal radiotherapy, other abbreviations as in Table2.

Table 4. Radiotherapy planning and other equipments in designated cancer care hospitals and the others

	Designated cancer care hospitals (n = 326)		Others (n = 386)		*p-value*	Total (n = 712)	
	n	%	n	%		n	%
X-ray simulator	262	79.1*	240	61.7*	<.0001	502	69.7*
CT simulator	217	63.5*	190	48.4*	<.0001	407	55.3*
RTP computer (>=2)	510 (101)	96.3* (38.5)	430 (45)	90.4* (11.7)	.0019 (<.0001)	940 (146)	93.1* (20.5)
MRI (>=2)	588 (203)	97.5* (77.5)	524 (135)	92.2* (35.0)	.0017 (<.0001)	1,112 (338)	94.7* (47.5)
For RT only	6	1.8*	6	1.6*	-	12	1.7*
Computer use for RT recording	298	91.4*	328	85.0*	.0086	626	87.9*

* Percentage of institutions which have equipment (two or more pieces of equipment per institution).

RTP: radiotherapy planning, MRI: magnetic resonance imaging, RT: radiotherapy, other abbreviations as in Table2.

Table 5. Structure and personnel in designated cancer care hospitals and the others

	Designated cancer care hospitals (n =326)	Others (n =386)	*p-value*	Total (n = 712)
Facilities with RT bed	164 (50.3)	123 (31.9)		287 (40.3)
Average no. RT bed/facility	4.8	3.0	.0001	3.6
Total (full-time + part-time) RO FTE	471.3	303.2		774.5
Average no. FTE ROs/facility	1.4	0.9	<.0001	1.1
JASTRO-certified RO (full-time)	293	133		426
Average no.JASTRO-certified ROs/facility	0.9	0.4	<.0001	0.6
Patient load/FTE RO	251.5	239.6	.0641	246.8
Total RT technologists	889.9	744.6		1634.5
Average no. RT technologists/facility	2.7	2.3	<.0001	2.3
Patient load/RT technologist	133.2	97.5	<.0001	117.0
Full-time medical physicists + part-time	65.0 + 17.1	52.0 + 13.0		117.0 + 30.1
Full-time RT QA staffs + part-time	156.0 + 8.0	100.8 + 5.0		256.8 + 13.0
Total nurses/assistants/clerks	476.8	430.2		907.0

QA: quality assurance, other abbreviations as in Table 2. Data in parentheses are percentages.

Table 6. Primary sites of cancer, brain metastasis, and bone metastasis treated with RT in designated cancer care hospitals and the others

Primary site	Designated cancer care hospitals (n =321)		Others (n =380)		*p-value*	Total (n = 701)	
	n	%	n	%		n	%
Cerebrospinal	4,130	4.3	4,469	7.7	<.0001	8,599	5.6
Head and neck (including thyroid)	11,199	11.6	5,174	8.9	<.0001	16,373	10.6
Esophagus	6,647	6.9	3,566	6.1	<.0001	10,213	6.6
Lung, trachea, and mediastinum	18,097	18.8	11,943	20.5	<.0001	30,040	19.4
Lung	15,341	15.9	10,051	17.3	<.0001	25,392	16.4
Breast	18,733	19.4	11,528	19.8	.0458	30,261	19.6
Liver, biliary, tract, and pancreas	4,116	4.3	2,239	3.9	<.0001	6,355	4.1
Gastric, small intestine, and colorectal	4,868	5.0	2,976	5.1	.5193	7,844	5.1
Gynecologic	6,277	6.5	2,392	4.1	<.0001	8,669	5.6
Urogenital	11,380	11.8	7,180	12.4	.0011	18,560	12.0
Prostate	8,133	8.4	5,085	8.7	.0291	13,218	8.6
Hematopoietic and lymphatic	5,499	5.7	2,541	4.4	<.0001	8,040	5.2
Skin, bone, and soft tissue	3,326	3.4	1,878	3.2	.0223	5,204	3.4
Other (malignant)	1,165	1.2	910	1.6	<.0001	2,075	1.3
Benign tumors	1,033	1.1	1,323	2.3	<.0001	2,356	1.5
Pediatric <15y (included in totals above)	577	0.6	470	0.8	<.0001	1,047	0.7
Total	96,470	100.0	58,119	100.0	<.0001	154,589*	100.0
Metastasis	(n =326)		(n =386)		*p-value*	(n = 712)	
Brain	7,212	6.1	8,109	11.2	<.0001	15,321	8.0
Bone	16,968	14.3	10,508	14.5	.3464	27,476	14.4

* Number of total new patients different with these data, because no data on primary sites were reported by some facilities.

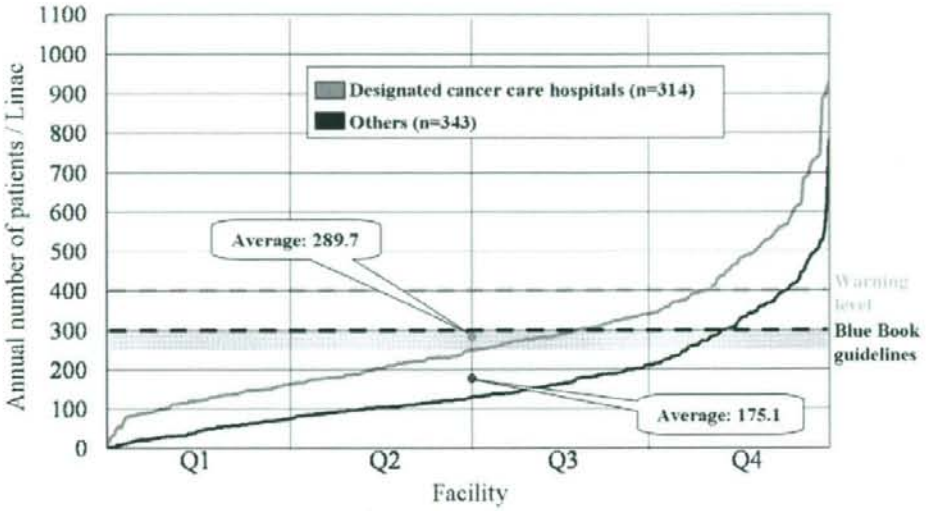
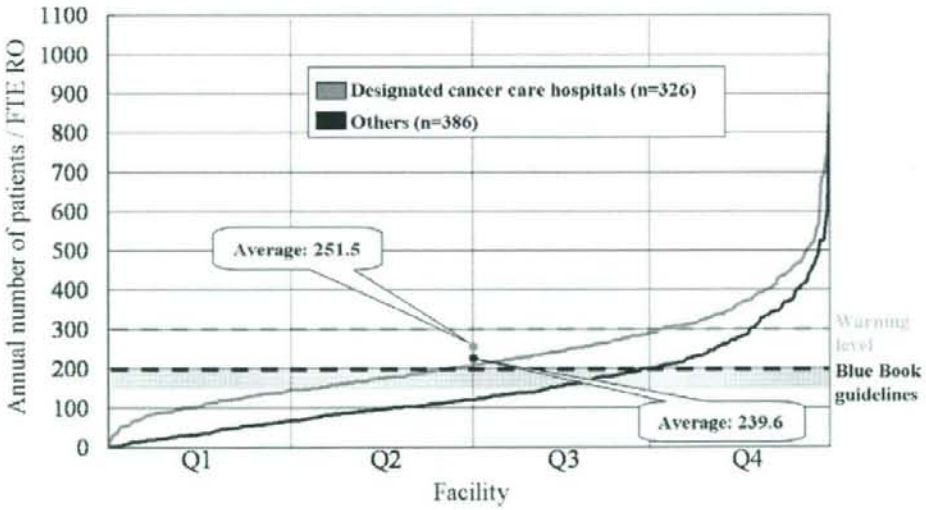


Figure 1



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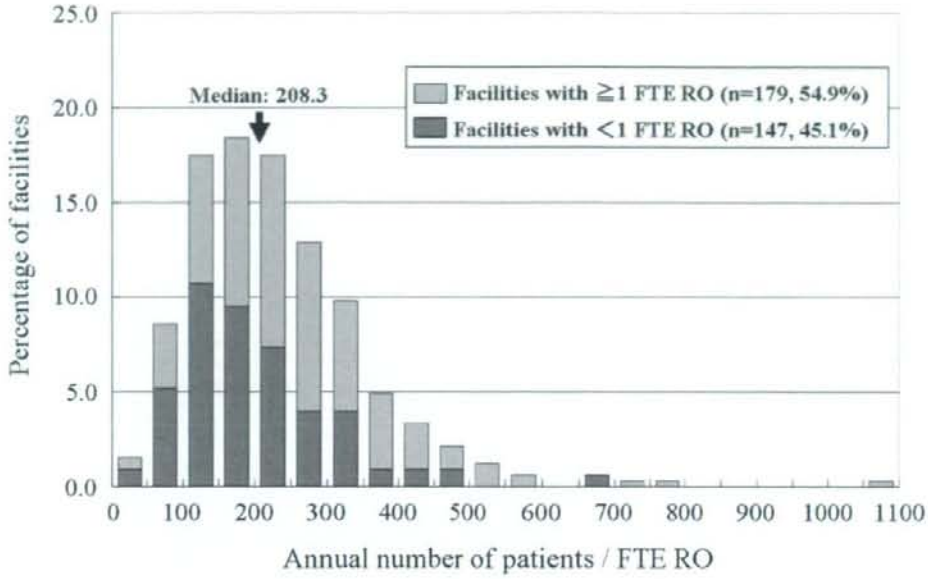
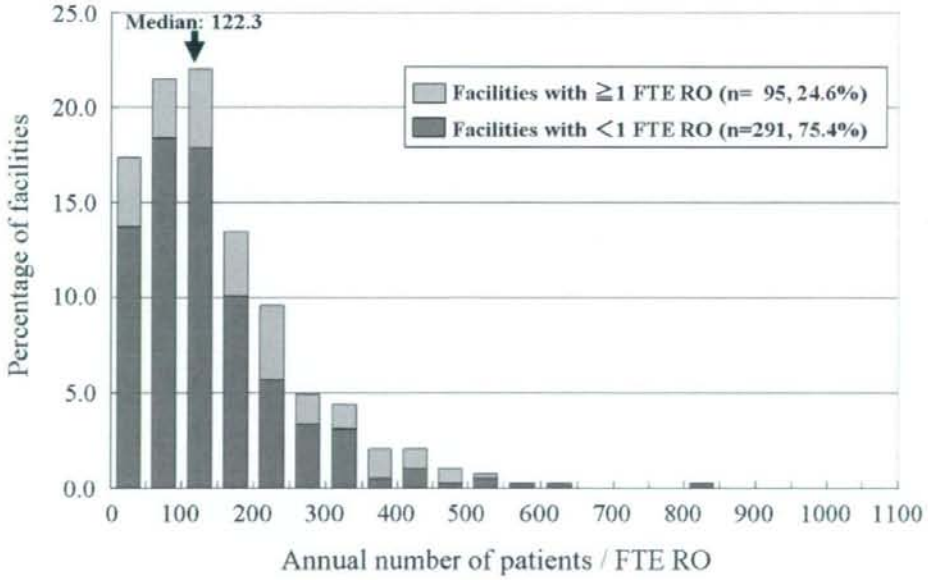


Figure 3(a)



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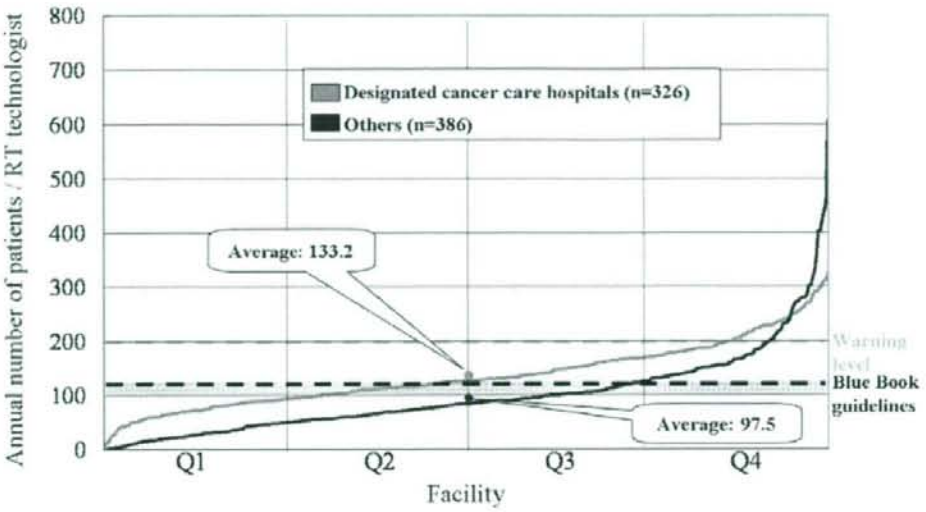
800
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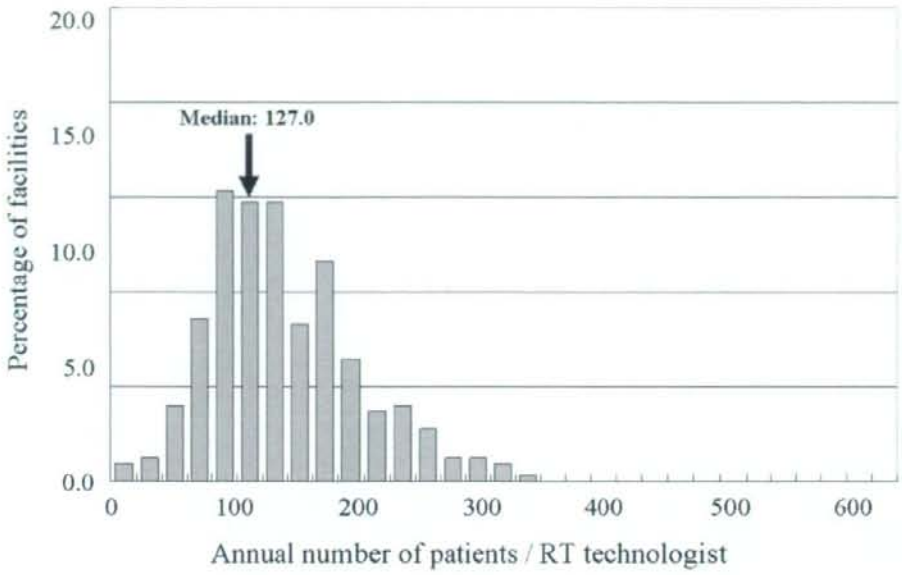
Annual number of patients / RT technologist
Designated cancer care hospitals (n=326)
Others (n=386)
Average: 133.2
Average: 97.5
Warning level
Blue Book guidelines
Q1
Q2
Q3
Q4
Facility

Figure 4



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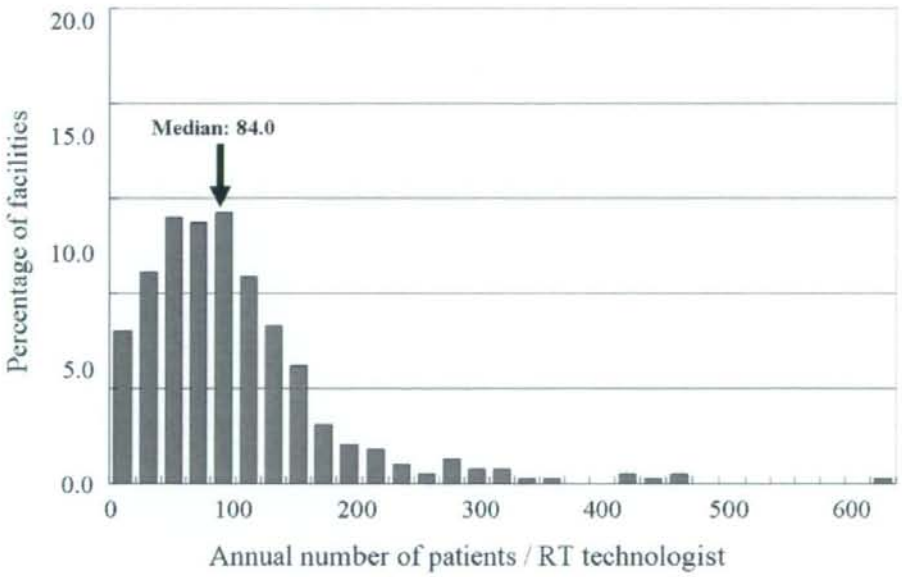

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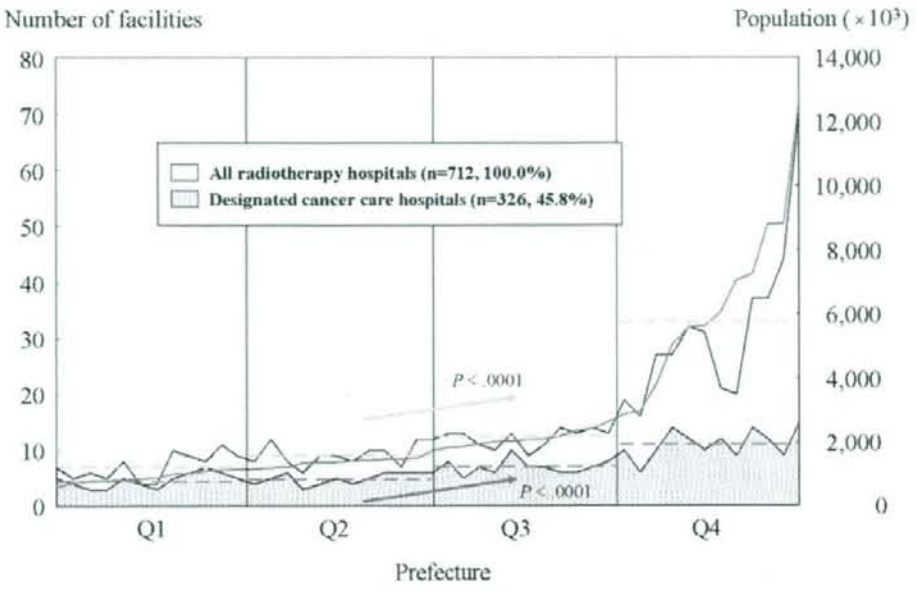

Figure 6(a)

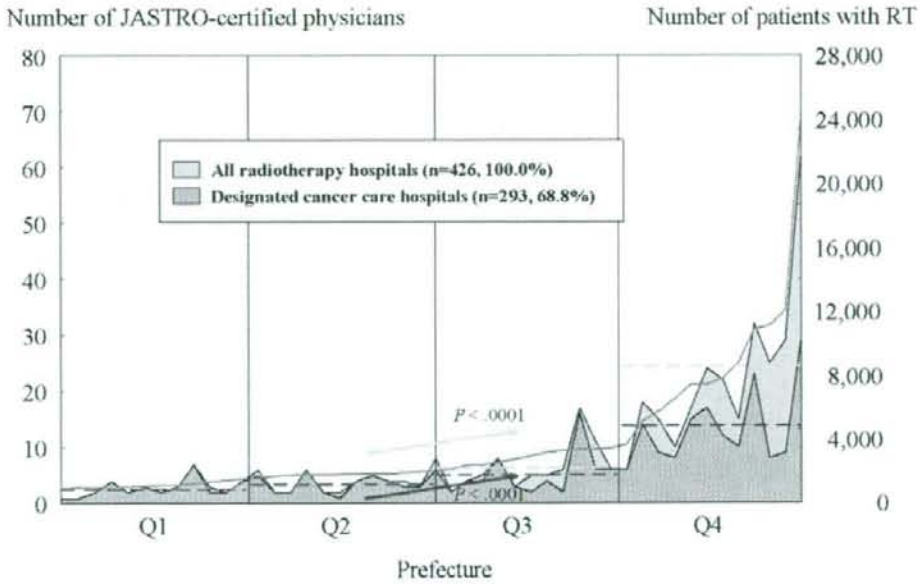

Figure 6(b)