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Original Article

Oncology Section

Questionnaire-based Survey on Radiation Treatment Planning using Multimodality Facilities in Radiotherapy Centres across India: A Cross-sectional Study

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ABSTRACT

Introduction: India is a low-middle-income country, and there is an increase in the burden of cancer under Non Communicable Diseases (NCD) in past decades. Around 60% of cancer patients require Radiotherapy (RT), either definitive or palliative in conjunction with other modalities. Considering the present requirements in the field of RT, data has been presented about centres providing both basic and advanced RT facilities.

Aim: To give an overview of current facilities available and to identify the multimodality-based planning in RT centres across India.

Materials and Methods: A cross-sectional questionnaire-based survey was conducted in centres having RT facilities in India, from March 2021 to April 2022. A systemic list of the current existing RT centres was taken from the Atomic Energy Regulatory Board (AERB) website. From the database list, 100 participants were selected randomly, with their contact information such as E-mail and WhatsApp. A Google survey form with a questionnaire was created for the study. The survey link forms were circulated across the RT centres in India.

Results: A total of 65 centres participated in the study. The percentage of responses found to be from North India 17 (26%), South India 24 (36.9%), West India 7 (10.8%), East India 9 (13.8%) and central India 7 (10.8%) with one centre (1.5%) not disclosed. The number of government, semi-private, private and not disclosed types of hospitals participated in the survey were 19 (29.2%), 5 (7.7%), 38 (58.5%) and 3 (4.6%), respectively. The average number of functional teletherapy machines, telecobalt and linear accelerators per centre was found to be 1.24±1.33, 0.34±0.54, and 1.11±1.06, respectively. The multimodality imaging facility for RT planning was found to be 36 (55.4%) MRI and 23 (35.4%) Positron Emission Tomography-Computed Tomography (PET-CT). The median cost of Intensity Modulated Radiotherapy (IMRT), Intensity Guided Radiotherapy (IGRT), 4-Dimensional IMRT (4-D IMRT), and 4-Dimensional IGRT (4-D IGRT) in Lakhs (L) was found to be 1.20 L (0.00-3.00), 1.50 L (0.00-3.30), 1.50 L (0.00-4.00), 1.50 L (0.00-4.00), respectively. For advance PET-CT based RT planning the median cost was found to be, for IMRT treatment 1.20 L (0.00-3.50) and for IGRT treatment 1.60 L (0.00-4.00).

Conclusion: There is a significant increase in radiation facilities in the recent millennium, especially in the private sector. The latest RT centres are equipped with multiple imaging modalities to accommodate the advanced RT planning features.

Keywords: Computed tomography, Intensity guided radiotherapy, Intensity modulated radiotherapy, Positron emission tomography

INTRODUCTION

As life expectancy increases and control of infectious disease reduces mortality, cancer and other Non Communicable Diseases (NCD) are significantly increasing the burden of mortality in Low and Middle-income Countries (LMIC) like India [1,2]. NCDs kill 41 million people each year, equivalent to 71% of all deaths globally. Malignancy is the second most important cause of mortality (9.3 million) among NCD, and its occurrence is expected to increase in the coming decades [3,4]. According to the World Health Organisation (WHO), the incidence of cancer between 2008 and 2030 is expected to increase by 82%, 70% and 58% in low, low-middle, and upper-middle-income countries, respectively, in comparison with a 40% rise in affluent countries [5]. Around 45% to 55% of newly diagnosed cases of cancer require radiation therapy as one of the treatment modalities [6]. Of those cured, 40% are by radiation therapy alone or by combination with other modalities [7]. Barton MB et al., noted about half of all cancer patients would benefit from atleast one course of RT. People with cancer in many countries of low and middle income do not have any access to RT and for most individuals RT services are limited. Improvements will come only with careful planning, investment in staff and equipment, and better access to information and education about cancer [8]. Rosenblatt E et al., identified that the average number of teletherapy machines per Radiotherapy (RT) centre ranged from 1.2 to 7.0 in different countries [9]. The fragmentation in RT services that prevails in many European countries might affect the economic burden of RT and its quality. Eastern and southeastern European countries need to expand and modernise their RT equipment [9]. The present study surveyed multimodality RT treatment and imaging equipment used from radiation therapy centres all over India.This is the first national survey in India on the trend of increased RT and multimodality facility centres in recent years.

MATERIALS AND METHODS

A cross-sectional questionnaire-based survey was was conducted among the radiation facility centers across India, from March 2021 to April 2022 with internet-based online Google forms. The participants' information was kept anonymous.

There are 524 centres in India as of 2021 [10]. A total of 100 participants' contact information such as E-mail and WhatsApp were randomly collected from the database [10]. The survey form was circulated to them either through mail or through WhatsApp form with a direct Google link to the institutions having RT centres. General reminders were sent to the participant to duly fill out the

form by short messages service to their WhatsApp numbers and mail reminders.

Study Procedure

The survey form was created using 30 questions in English on the recent addition of rapidly growing imaging modalities in RT practices. A Portable Document Format (PDF) of the questionnaire is attached [Appendix]. The questions in the survey form consisted of mainly radiation therapy infrastructure such as its establishment, teletherapy machine, and vendors of teletherapy, Positron Emission Tomography-Computed Tomography (PET-CT) and Magnetic Resonance Imaging (MRI) machines existing in their facility. As in India, the cost of treatment is always in a total package form, rather than individual sections, so, the total cost of treatment involved in normal RT planning and multimodality-based planning was collected, and the average number of patients planned and treated was collected.

STATISTICAL ANALYSIS

The survey results were analysed by using statistical software R version 4.0.0 (R Core Team, Vienna, Austria, 2021) for mean, standard deviation, and frequency. Skewness and kurtosis and Shapiro-Wilk testwere carried out for the number of physicists and functional teletherapy machinesand Fisher's exact testwas used for the association between type of hospitals, establishment years, teletherapymachines, PET-CT and MRI facilities. A p-value <0.05 was considered statistically significant.

RESULTS

The online survey form was sent to 100 centres, from which authors received a 65% response.

The responses were received from North India 17 (26%), South India 24 (36.9%), West India 7 (10.8%), East India 9 (13.8%) and from central India 7 (10.8%) with one centre (1.5%) not disclosed. Ninenteen (29.2%) government, five (7.7%) semi-private, 38 (58.5%) private and three (4.6%) not disclosed types of hospitals participated in the survey [Table/Fig-1].

Basic details	n (%)
Zone	
Not disclosed*	1 (1.5)
North	17 (26.2)
South	24 (36.9)
West	7 (10.8)
East	9 (13.8)
Central	7 (10.8)
State/UT	
Not Disclosed*	3 (4.6)
Andaman and Nicobar (UT)	0
Andhra Pradesh	5 (7.7)
Arunachal Pradesh	1 (1.5)
Assam	0
Bihar	1 (1.5)
Chandigarh (UT)	1 (1.5)
Chhattisgarh	3 (4.6)
Dadra and Nagar Haveli (UT)	0
Daman and Diu (UT)	0
Delhi	5 (7.7)
Goa	0
Gujarat	2 (3.1)
Haryana	2 (3.1)
Himachal Pradesh	2 (3.1)
Jammu and Kashmir	1 (1.5)
Jharkhand	1 (1.5)
Karnataka	9 (13.8)
Kerala	0
Ladakh	0
Lakshadweep (UT)	0
Madhya Pradesh	2 (3.1)
Maharashtra	6 (9.2)
Manipur	1 (1.5)
Meghalaya	0
Mizoram	0
Nagaland	2 (3.1)
Orissa	1 (1.5)
Puducherry (UT)	0
Punjab	5 (7.7)
Rajasthan	2 (3.1)
Sikkim	0
Tamil Nadu	5 (7.7)
Telangana	3 (4.6)
Tripura	0
Uttar Pradesh	1 (1.5)
Uttarakhand	0
West Bengal	1 (1.5)
Type of hospital	
Government	19 (29.2)
Semi-private	5 (7.7)
Private	38 (58.5)
Not disclosed*	3 (4.6)
Organisation establishment year	
Not disclosed*	9 (14)
1896-1920	1 (2)
1921-1945	0
1946-1970	5 (8)
1971-1995	9 (14)
1996-2020	40 (62)
2021 - Current Year	1 (2)
Month of survey	
Mar-21	39 (60)
Apr-21	2 (3.1)
May-21	0
Jun-21	0
Jul-21	0
Aug-21	6 (9.2)
Sep-21	5 (7.7)
Oct-21	0
Nov-21	0
Dec-21	4 (6.2)
Jan-22	0
Feb-22	5 (7.7)
Mar-22	4 (6.2)

[Table/Fig-1]: Summary of demographics details of the survey participants (N=65). *indicates not disclosed includes the participants not answered, blank, do not know, and not disclosing

In terms of the availability of telecobalt and linear accelerator, they were found to be 21 (32.3%) with 95% Confidence Interval (CI); 21.5%-45.2% and n=51 (78.5%) 95% CI; 66.2%-87.3%, respectively among the participants. None of the participants were equipped with the proton accelerators in the survey. The average number of functional teletherapy

machines, telecobalt, and linear accelerators per centre found to be 1.24±1.33, 0.34±0.54, and 1.11±1.06, respectively [Table/Fig-2].

Centre details	Mean±SD || Median (IQR) || Min-Max || Frequency (%)
Radiotherapy department present (Yes)	64 (98.5)
Initial phase	1 (1.5)
Number of physicists	2.62±1.99 || 2.00 (1.00-3.00) || 1.00 - 12.00
Functional teletherapy machines	1.24±1.33 || 1.00 (1.00-2.00) || 0.00 - 8.00
Telecobalt	0.34±0.54 || 0.00 (0.00-1.00) || 0.00 - 2.00
Gamma knife	
Not Disclosed	1 (1.5)
Yes	1 (1.5)
No	63 (96.9)
Number of functional linac machines	1.11±1.06 || 1.00 (1.00-1.00) || 0.00 - 7.00
Average number of patients receiving treatment in a day	
Not Disclosed	2 (3.1)
Initial Stage	1 (1.5)
<30	13 (20)
30-50	13 (20)
50-100	30 (46.2)
100-150	2 (3.1)
150-200	1 (1.5)
200-300	1 (1.5)
300-400	2 (3.1)
Multi-modality based planning	
Not Disclosed	2 (3.1)
Initial Stage	1 (1.5)
Yes	41 (63.1)
No	21 (32.3)
MRI facility	
Yes	36 (55.4)
No	28 (43.1)
Initial Stage	1 (1.5)
PET-CT facility	
Yes	23 (35.4)
No	41 (63.1)
Initial stage	1 (1.5)
Cyclotron facility (Yes)	3 (4.6)

[Table/Fig-2]: Summary of centre details participated in the survey (N=65).

From [Table/Fig-3] the distribution of the number of physicists, and functional teletherapy machines in each centre participating in the study were positively skewness and kurtosis. Shapiro-Wilk test for the data was significant (p-value ≤0.001), suggesting that the data was not normally distributed, and there appeared to be more than one mode/peak in the data, thus making it multimodal. There was a moderate positive correlation between the number of physicist and functional teletherapy machines, and this correlation was statistically significant (rho= 0.54, p-value ≤0.001). It was found that for every 1 unit increase in functional teletherapy machines, the number of physicist increases by 1.14 units. From [Table/Fig-4], in terms of the machine availability the government sector has the higher % of telecobalt machine {N=6(54.5%)} and the private sector has a higher percentage of Linac machines {N=29 (69.0%)}. [Table/Fig-5] indicates Eclipse is the most common treatment planning system used among the RT centres across India. From [Table/Fig-6], 32 (49%) participants did not disclose the existence of MRI machine in their centres. Within the remaining population in the survey, the most common MRI company was found to be GE (n=11, 18%) followed by Philips (n=10, 15%) and Siemens (n=9, 14%). From the [Table/Fig-7], 41 (63.1%) participants did not disclose the existence of PET-CT in their institutions. The most common PET-CT machine vendor was found to be GE (n=11, 16.9%) followed by Siemens (n=7, 10.8%) and one (1.5%) institution has Siemens as well as GE PET-CT machines. There was a significant difference between the various groups in terms of distribution of PET-CT facility (p-value ≤0.001) and the strength of association between the two variables (Cramer's V= 0.75) was found to be high. Eighteen (50%) had the largest proportion of MRI facility and PET-CT facility [Table/Fig-8].

From [Table/Fig-9], the government sector treated 124.21±113.94 patients in a day. Cost of IMRT and IGRT was found to be 1.25±0.69 Lakhs (L) and 1.72±0.93 L, respectively higher in private sector. The median cost (Min-Max) of IMRT, IGRT, 4-D IMRT and 4-D IGRTin Lakhs (L) was found to be 1.20L (0.00-3.00), 1.50L (0.00-3.30), 1.50L (0.00-4.00), 1.50L (0.00-4.0), respectively [Table/Fig-10]. From the [Table/Fig-11], 23 (38.3%) of the participants not disclosed the average number of MRI based RT planning in a month (95%CI: 26.4% - 51.8%). From [Table/Fig-11] we can infer, 20 (33.3%) of the participants and 12 (20%) had an average number of MRI based RT planning in a month ranged from 1-10 (95% CI: 22.0%-46.8%) and 11-50 (95% CI: 11.2%-32.7%), respectively.

From [Table/Fig-12], it was observed that 24 (42.9%) of the participants had an average number of PET-CT based RT planning (month) in the range 1-10 (95% CI: 30.0%-56.7%) and 22 (39.3%) of the participants did not disclose the average number of PET-CT based RT planning in a month (95% CI: 26.8%-53.2%).

Parameters	Number of physicist	Functional teletherapy machines	Number of functional telecobalt	Number of functional linac machines
Mean±SD	2.62±1.99	1.24±1.33	0.34±0.54	1.11±1.06
Median (IQR)	2 (1-3)	1 (1-2)	0 (0-1)	1 (1-1)
Range	1-12	0-8	0-2	0-7
Skewness and kurtosis	2.33 and 7.35 (*p-value ≤**0.001**)	2.78 and 10.62 (*p-value ≤**0.001**)	1.25 and 0.53 (*p-value ≤**0.001**)	2.87 and 12.88 (*p-value ≤**0.001**)

[Table/Fig-3]: Range, mean and median Inter Quartile Range (IQR) for number of physicist and functional teletherapy machines.
*Shapiro-Wilk test

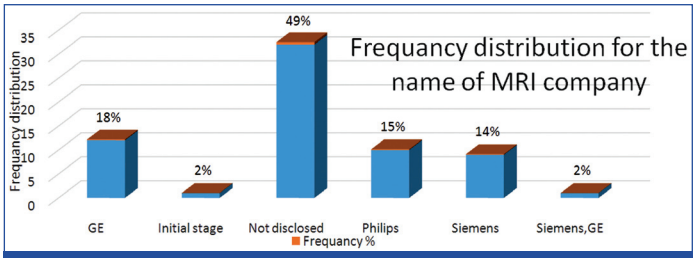
Type of hospital	Machines available, n (%)						Fisher's-exact test	
	None	Linac	Telecobalt	Telecobalt+Linac	Telecobalt+Gamma knife+Linac	Total	χ^2	p-value
Government	0	7 (16.7%)	6 (54.5%)	5 (62.5%)	1 (100%)	19 (29.2%)	19.162	**0.039**
Semi-private	0	3 (7.1%)	2 (18.2%)	0	0	5 (7.7%)		
Private	3 (100%)	29 (69%)	3 (27.3%)	3 (37.5%)	0	38 (58.5%)		
Not disclosed	0	3 (7.1%)	0	0	0	3 (4.6%)		
Total	3 (100%)	42 (100%)	11 (100%)	8 (100%)	1 (100%)	65 (100%)		

[Table/Fig-4]: Association between machines available and type of hospital (N=65).
Bold p-value indicates statistically significant value

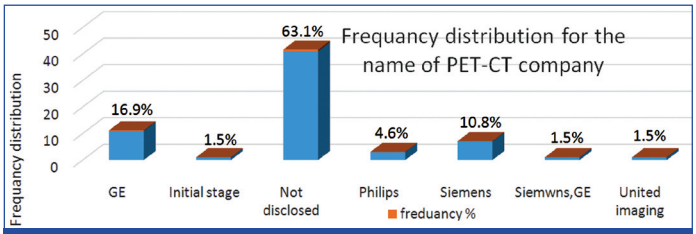
Treatment planning system	n (%)
Not disclosed	10 (13%)
Eclipse	32 (41%)
Monaco	17 (22%)
Pinnacle	2 (3%)
Gamma plan	1 (1%)
Oncentra	5 (6%)
Plato sunrise	1 (1%)
Thera plan plus	1 (1%)
Accuray	1 (1%)
XIO CMS	5 (6%)
Sagiplan	1 (1%)
Asha 3D	1 (1%)
Manual planning	1 (1%)
Initial stage+	1 (1%)

[Table/Fig-5]: Summary of treatment planning system N=79*.
*The author concluded that the RT centres having single, dual or multiple treatment planning systems were found to be 58(89.23%),6(9.23%) and 1(1.54%) respectively.
Initial stage+ indicates the RT centre currently in the RT facility designing and machine procurement stage. Some of the radiotherapy centres are having two or multiple treatment planning systems

The establishment years, in the range 1896-1920 and 1946-1970, the largest proportion of types of hospital found to be semi private (n=1; 100%) and government (n=3; 60%). From the year range, 1971-1995 the Government (n=4; 44.4%) and private (n=4; 44.4%) shared the same proportion increase as per the data collected. Near to the millennium from 1996-2020 and 2021 to the current year the increase in the proportion of hospital were



[Table/Fig-6]: Summary of name of MRI company (N=65).



[Table/Fig-7]: Summary of name of PET-CT company (N=65).

PET-CT facility	MRI facility				Fisher's-exact test	
	Yes n (%)	No n (%)	Initial stage n (%)	Total n (%)	χ^2	p-value
Yes	18 (50)	5 (17.9)	0	23 (35.4)	72.178	**<0.001**
No	18 (50)	23 (82.1)	0	41 (63.1)		
Initial stage	0	0	1 (100)	1 (1.5)		
Total	36 (100)	28 (100)	1 (100)	65 (100)		

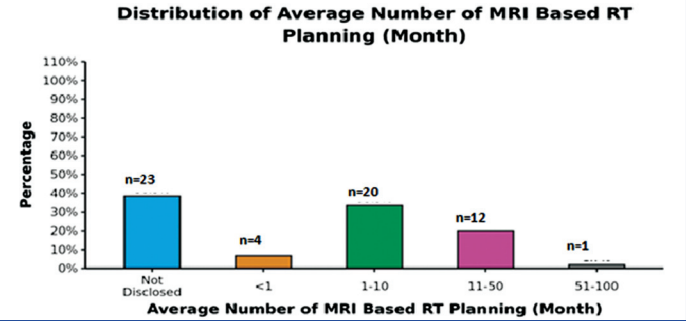
[Table/Fig-8]: Association between MRI facility and PET-CT facility (N=65).

Parameters	Type of hospital				p-value
	Government (n=19)	Semi-private (n=5)	Private (n=38)	Not disclosed (n=3)	
Average number of patients receiving treatment in a day	124.21±113.94	44.00±31.30	74.47±42.60	76.67±40.41	0.081[2]
Cost of Treatment: IMRT (Lakhs)	1.19±0.22	0.75±0.61	1.25±0.69	0.60±0.85	0.287[2]
Cost of Treatment: IGRT (Lakhs)	1.42±0.35	0.82±0.85	1.72±0.93	0.75±1.06	0.160[2]
Cost of Treatment: 4D IMRT (Lakhs)	2.00±0.71	0.98±1.12	1.69±1.49	0.00±0	0.442[2]
Cost of Treatment: 4D IGRT (Lakhs)	2.15±0.92	1.08±1.28	1.89±1.47	0.00±0	0.382[2]
Cost of Treatment: PET-CT Based IMRT (Lakhs)	1.35±0.21	0.82±0.85	1.43±0.96	0.00±0	0.306[2]
Cost of Treatment: PET-CT Based IGRT (Lakhs)	1.35±0.21	1.00±1.41	1.84±1.29	0.00±0	0.376[2]
Cost of Treatment: PET-CT Based 4D IMRT (Lakhs)	1.50±0	0.98±1.12	1.83±1.60	0.00±0	0.511[2]
Cost of Treatment: PET-CT Based 4D IGRT (Lakhs)	1.50±0	1.08±1.28	1.89±1.65	0.00±0	0.536[2]
Cyclotron Facility (Yes)	3 (15.8)	0	0	0	0.982[1]
Name of the PET-CT source procurement centre					
Not disclosed	11 (64.7)	4 (100)	18 (58.1)	3 (100)	0.091[1]
Apollo Hyderabad	1 (5.9)	0	0	0	
Atulyahealthcare	1 (5.9)	0	2 (6.5)	0	
Bangalore HCG	0	0	2 (6.5)	0	
BIACI&RC	0	0	2 (6.5)	0	
BRIT	0	0	1 (3.2)	0	
HCG Chennai	0	0	1 (3.2)	0	
IBA Noida	1 (5.9)	0	2 (6.5)	0	
NIMHANS	0	0	1 (3.2)	0	
Army Hospital	1 (5.9)	0	0	0	
Shreeji Imaging Pvt.Ltd. Delhi	1 (5.9)	0	0	0	
PGIMER	1 (5.9)	0	0	0	
VECC	0	0	1 (3.2)	0	
Others	0	0	1 (3.2)	0	
Average number of MRI based RT planning (month)	12.75±17.98	12.20±21.55	20.67±25.14	30.00±28.28	0.480[2]
Average number of PET-CTbased RT planning (month)	21.22±33.26	17.75±21.91	12.04±14.61	27.50±31.82	0.914[2]

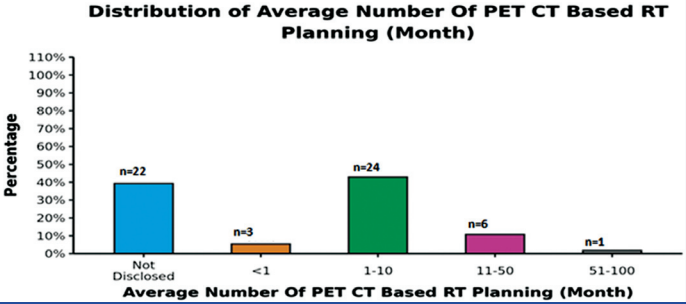
[Table/Fig-9]: Association between type of hospital versus cost of treatment, PET-CT source procurement and average number of RT planning, results presented as mean±SD and n (%).[1]Fisher's-exact test, [2]Kruskal Wallis test

All parameters	Mean±SD || Median (IQR) || Min-Max
Average number of patients receiving treatment in a day	86.77±73.93 || 100.00 (50.00-100.00) || 0.00-400.00
Cost of multi-modality based planning	
Cost of treatment: IMRT (Lakhs)	1.16±0.63 || 1.20 (0.90-1.50) || 0.00-3.00
Cost of treatment: IGRT (Lakhs)	1.52±0.87 || 1.50 (1.05-2.00) || 0.00-3.30
Cost of treatment: 4D IMRT (Lakhs)	1.50±1.35 || 1.50 (0.01-2.50) || 0.00-4.00
Cost of treatment: 4D IGRT (Lakhs)	1.68±1.39 || 1.50 (0.19-2.72) || 0.00-4.00
Cost of treatment: PET-CT based IMRT (Lakhs)	1.28±0.93 || 1.20 (0.79-1.94) || 0.00-3.50
Cost of treatment: PET-CT based IGRT (Lakhs)	1.61±1.24 || 1.60 (0.45-2.50) || 0.00-4.00
Cost of treatment: PET-CT based 4D IMRT (Lakhs)	1.50±1.44 || 1.50 (0.00-2.42) || 0.00-4.20
Cost of treatment: PET-CT based 4D IGRT (Lakhs)	1.55±1.50 || 1.50 (0.00-2.50) || 0.00-4.20

[Table/Fig-10]: Distribution of the participants with mean, median and maximum and minimum in terms of cost of treatment: IMRT, IGRT (Lakhs) (N=63).



[Table/Fig-11]: Distribution of the participants in terms of average number of MRI based RT planning (month) (n=60).



[Table/Fig-12]: Distribution of the participants in terms of average number ofPET-CTbased RT planning (month) (n=56).

DISCUSSION

The utilisation of radiation started right after the invention of X-rays and Radium in the early 20s. With the invention of X-rays by Roentgen in 1895, low, medium and high energy kilo voltage radiation treatment started for cancer along with gamma radiations [11-14]. In historical aspects of RT centres by Munshi A et al., the first RT was established in 1910 [13]. From the references published as 50 years of cancer control in India only, there were 186 RT centers according to Bhabha Atomic Research Centre which was updated till October 2002 [15]. In 2021 February there were 524 RT centres in India as updated by Atomic Energy Regulatory Board (AERB) [10]. From these historical data, a graph was plotted as shown in [Table/Fig-14]. Retrospectively, the present study compared the growth of the population in India over the last 110 years to the number of RT centres established from the historical data [14,16]. From this graph, the number of machines required as compared to the increase in the Indian population was found to be not satisfactory.

According to Ravichandran R there are 25 machines added per year although it is a good number, still, the Indian population needs atleast 1000 such machines for cancer treatment [17]. To fulfill such wide a gap, the government is implementing the strengthening of tertiary care centres under which more treatment machines will be added in government institutions [17]. However, government alone can not solve the cancer burden in India. So, there is a growing interest in setting up RT facilities from the private sector which will increase the number of machines. As per the projected incidence of cancer in India, every 1 in 9 Indians will develop cancer during their lifetime by Mathur P et al., [19].

To take care of this cancer burden, the Indian government under the universal health scheme on comprehensive cancer care, can now afford high-end treatment free of cost. This benefit is available to the low socio-economic group in government as well as in private sector 2 [20].

As per Grover S et al., and Tatsuzaki H and Levin CV the ratio of megavoltage units per institution was 1.66 and 1.55 in LMIC [2,21]. From the present study, authors found this ratio to be 1.26. The accelerator-to-cobalt ratio is 3.26 for India. This result could be due to the increase in the number of linear accelerators in private institutions recently in India.

Yong J et al., 2 have coated the cost by the activity-based for 3-Dimensional Conventional Radiotherapy (3DCRT) and IMRT for various sites and settings [22]. However, presently in India each and every RT centre offer packaged service charges for the entire course of RT treatment unlike break-up charges for different services in various other countries. In addition, some

Type of hospital	Organisation establishment year, n (%)							Fisher's-exact test*	
	Not disclosed	1896-1920	1946-1970	1971-1995	1996-2020	2021-current year	Total	χ^2	p-value
Government	2 (33.3)	0	3 (60)	4 (44.4)	8 (20)	0	17 (27.4)		
Semi-private	0	1 (100)	0	1 (11.1)	3 (7.5)	0	5 (8.1)		
Private	1 (16.7)	0	2 (40)	4 (44.4)	29 (72.5)	1 (100)	37 (59.7)	48.388	**0.002**
Not disclosed	3 (50)	0	0	0	0	0	3 (4.8)		
Total	6 (100)	1 (100)	5 (100)	9 (100)	40 (100)	1 (100)	62 (100)		

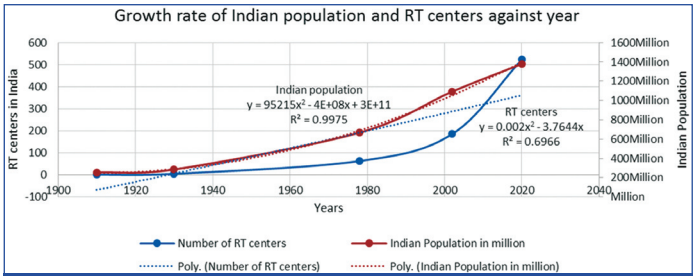
[Table/Fig-13]: Association betweenorganisation establishment year and type of hospital (n=62).
*Fisher's-exact test was used to explore the association between 'Organisation Establishment Year' and 'Type of Hospital' as more than 20% of the total number of cells had an expected count of less than 5

from private sectors with 29 (72.5%) and 1 (100%) hospitals, respectively [Table/Fig-13].

From [Table/Fig-14], the association between the Indian populations versus the years and the RT centre was found to be positive with R2=0.9 (very strong association) and R2=0.6 (strong association), respectively.

of the RT centres render free services for RT treatment. In addition, the package charges vary from type of hospital to interstate region.

Due to the high population density in the Asia Pacific, which requires a large number of RT facilities, Zubizarreta E et al., coated



[Table/Fig-14]: Growth rate of Indian population and RT centres versus the number of years from published references 16 and 19.

total treatment associated costs to be 1.66 lac(2126$) [23]. The Average cost of RT for IMRT and IGRT was found to be 1.16±0.63 L (1486$) and 1.52±0.87 L (1947$). This study shows the cost is lower by 30% and 8.4%, respectively against the Asia Pacific region.

Limitation(s)

An important limitation of this study is the number of participating centres. The overall survey response rate of participants was found to be 65% (65 centres out of 100). But the overall response is 12.4% compared with existing RT facilities in India (N=524), with the highest contribution (23%) from the central zone. There are centres that are not equipped with PET-CT and MRI imaging modalities. In spite of this, some RT centres do multimodality-based RT planning. The images used in this planning are either in Compact Disc (CD) or Digital Versatile Disc (DVD) format which is a passive way of RT planning. So this study does not provide whether the PET and MRI images utilised in the institutional RT planning are from the same institution. In this study, authors have included teletherapy machines in the RT centres excluding the brachytherapy machines.

CONCLUSION(S)

The present survey was carried out to assess radiation facility and multimodality image based treatment planning in RT departments in India. The present study findings showed a significant increase in radiation facilities in recent millennium particularly in private sectors. There is an increase in trend to utilise the multimodality imaging (MRI and PET-CT) based RT planning in RT facilities across India.

REFERENCES

[1] Kanavos P. The rising burden of cancer in the developing world. Annals of Oncology. 2006;17:viii15–viii23.
[2] Grover S, Xu MJ, Yeager A, Rosman L, Groen RS, Chackungal S, et al. A systematic review of radiotherapy capacity in low- and middle-income countries. Frontiers in Oncology. 2015;4:380.
[3] Non communicable Diseases Country Profiles 2018 [Internet]. World Health Organization. World Health Organization; 1970 [cited 2022Dec16]. Available from: https://apps.who.int/iris/handle/10665/274512
[4] Hunter DJ, Reddy KS. No communicable diseases. N Engl J Med. 2013;369:1336-43.
[5] World Health Organization. Global status report on no communicable diseases 2010. Geneva, Switzerland. Available at: http://www.who.int/ nmh/publications/ncd_report2010/en/. Accessed December 1, 2013.
[6] Slotman BJ, Cottier B, Bentzen SM, Heeren G, Lievens Y, van den Bogaert W. Overview of national guidelines for infrastructure and staffing of radiotherapy. ESTRO-QUARTS: work package. 1.RadiotherOncol. 2005 Jun;75(3):349-54. doi: 10.1016/j.radonc.2004.12.005. Epub 2004 Dec 23. PMID: 15893832.
[7] SBU-The Swedish Council on Technology Assessment in Health Care. Radiotherapy for cancer. ActaOncol. 1996;35(s6):09-23.
[8] Barton MB, Frommer M, Shafiq J. Role of radiotherapy in cancer control in low-income and middle-income countries. Lancet Oncol. 2006;7:584-95.
[9] Rosenblatt E, Izewska J, Anacak Y, Pynda Y, Scalliet P, Boniol M, Autier Pet al. Radiotherapy capacity in European countries: an analysis of the Directory of Radiotherapy Centres (DIRAC) database. Lancet Oncol. 2013 Feb;14(2):e79-86. doi: 10.1016/S1470-2045(12)70556-9. Epub 2013 Jan 24. PMID: 23352499.
[10] Cancer treatment centreslicenced by Atomic Energy Regulatory ... - aerb [Internet]. [cited 2022Dec16]. Available from: https://www.aerb.gov.in/images/PDF/Radiotheraphy/RSD3.pdf
[11] Case JT, Buschke F. History of radiation therapy. New York: Grune& Stratton; 1958:13-41.
[12] Lederman M. The early history of radiotherapy: 1895-1939. Int J RadiatOncolBiol Phys. 1981;7:639-48.
[13] Munshi A, Ganesh T, Mohanti BK. Radiotherapy in India: History, current scenario and proposed solutions. Indian J Cancer. 2019;56:359-63.
[14] Evolution of radiotherapy machines and changing scenario in India [Internet]. [cited 2022Dec16]. Available from: https://main.mohfw.gov.in/sites/default/files/Evolution%20Of%20Radiotherapy%20Machines%20And%20Changing%20Scenario%20In%20India.pdf
[15] Radiotherapy machine for cancer treatment [Internet]. Department of Atomic Energy. [cited 2022Dec16]. Available from: https://dae.gov.in/node/294
[16] https://www.statista.com/statistics/1066922/population-india-historical
[17] Ravichandran R. Has the time come for doing away with cobalt-60 teletherapy for cancer treatments. J Med Phys.2009;34(2):63-65.
[18] https://pib.gov.in/PressReleseDetailm.aspx?PRID=1697445
[19] Mathur P, Sathishkumar K, Chaturvedi M. Cancer Statistics, 2020: Report From National Cancer Registry Programme, India. JCO Global Oncology 2020;6:1063-75.
[20] Bhadelia A. Comprehensive value-based cancer care in India: Opportunities for systems strengthening. Indian J Med Res. 2021;154(2):329-37.
[21] Tatsuzaki H, Levin CV. Quantitative status of resources for radiation therapy in Asia and Pacific region. RadiotherOncol. 2001;60(1):81-89.
[22] Yong J, McGowan T, Redmond-Misner R,Beca J,Warde P, Gutierrez E,et al. Estimating the costs of intensity-modulated and 3-dimensional conformal radiotherapy in ontario. CurrOncol. 2016;23(3):228-38.https://doi.org/10.3747/co.23.2998.https://www.mdpi.com/1718-7729/23/3/2998.
[23] Zubizarreta E, Van Dyk J, Lievens Y. Analysis of global radiotherapy needs and costs by geographic region and income level. ClinOncol (R CollRadiol). 2017;29(2):84-92.

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