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Research Article

CAN INDIA WIN THE FIGHT IN NARROWING THE GAP BETWEEN METRO CENTRIC CANCER CARE AND RURAL OUTREACH?

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A B S T R A C T

Introduction: Radiotherapy forms an integral part of cancer treatment and defining a dedicated cancer Centre without radiotherapy facilities is unacceptable. India is a developing country, categorized under LMICs. Healthcare facilities at semi-urban and rural places in India are grimmer and so as the cancer care facilities.

Material and methods: Data collected through telephonic interviews from the radiotherapy centers listed by AERB, India released in May 2016. Data for state-wise population for 2016 and 2026 was taken from the registrar general and census commissioner, India, and projected. However, for projection of density, cancer incidence and prevalence for 2016 and 2026 was projected by exponential method. Also, we assumed that the state-level prevalence and incidence of cancer in 2015 will not change over time in 2016.

Results: Most of the cancer care facilities are present in developed cities and metros and the rest other places are devoid of such facilities in spite of higher incidence and prevalence of cancer. These types of uneven distribution of facilities also affect the treatment outcome.

Conclusion: Infrastructure for the treatment of cancer patients pertaining to radiotherapy treatment units should be upgraded, as per WHO guidelines to bridge the gap between metros and non-metro areas.

INTRODUCTION

Universal health coverage (UHC) is one of the major targets of the Sustainable Development Goals (SDGs) and current global health priority[1]. UHC ensures that all citizens of a country have access to quality health care and health services in need, without any disparity.World Health Organization definition (WHO) has defined a set of UHC targets that all the member countries need to achieve by 2030 as part of their progress towards health financing reform, and every UN member state has committed to these goals. As, every 6th human being is Indian, globally it is impossible to achieve SDGs without substantial contribution from India. Health policies of most of the nations across the globe still revolve around prevention and cure of communicable diseases and maternal and child health. Non-communicable diseases (NCD) inspite of its grave impact on healthcare system needs to strengthen its position. Policymakers need to primarily prioritize their attention towards the impact of non-communicable diseases (NCD) which is worsening the healthcare delivery resulting in 40 million deaths every year worldwide due to NCD, 70% of total global mortality[2]. The amount of global public funding for NCD program is very less as compared to the communicable diseases and it reveals that the level of commitment by nations and health organizations need to improve upon, proportionate to the increasing projections[3, 4].

The situation is even grimmer in lower and middle income countries (LMICs) sharing three quarters of global NCD mortality and a large proportion of that at 48% as avoidable premature adult mortality[5]. In 2015 Cancer alone contributed 8.7 million deaths worldwide and hence is second only to cardio-vascular disease in NCD mortality[6]. Also, there is an exponential rise in the number of cancer patients globally in the last decade, with estimated chances of every 4th healthy female and every 3rd healthy male of contracting this deadly disease during the age of 0-80 years. Moreover, two-thirds of the newly diagnosed cases of cancer are expected to occur in LMICs only by the year 2025[7]. Despite recent advances in the form of novel diagnostic modalities and multimodality treatment approach globally, a diagnosis of cancer is still perceived as a death knell especially in LMICs. Cancer

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incidence between 2008 and 2030 is projected to raise by 82%, 70%, and 58% in low, low-middle, and upper-middle income countries, respectively, compared with 40% in high-income countries[8]. By 2030, the number of cancer cases is projected to increase to 20 million and the number of cancer deaths to 13 million[9].

Around 0.68 million deaths per year were attributed to cancer in India in 2012 adding to the global death toll of cancer at around 8.2 million[7]. Five year survival for most common malignancy breast cancer of women in India is about 66% and in USA is 90%[10]. Major factors responsible being the late presentation of the patients with advanced disease, poor access to treatment and financial constraints. Radiation therapy plays an important role in cancer treatment with almost 50% of patients diagnosed with cancer receive radiotherapy during their course of treatment and it contributes approximately 40% of curative treatment[11,32]. Hence, radiotherapy is more scalable and multifunctional than any other treatment modality. But, there is a huge disparity in the distribution of radiation facilities across the globe between high, middle and low-income countries as evident by the fact that 56.4% of the world's total cancer patients had access to only 31.7% of the global teletherapy units for their treatment[12]. This facility shortfall in the number of radiotherapy machines is mostly due to the lack of policy and planning, competing demands and monetary viability, thus leading to further constraint on the limited resources and budget[13].

With an estimated 2.5 million population living with the diagnosis of cancer in India, similar to many low-income and middle-income countries, a majority of Indian population does not have agood access to organized and regulated public cancer care system[14]. Furthermore, cancer accounted for 6% of all adult deaths in India while 71% of patients were in their prime productive age i.e. between 30 and 69 years at the time of their death which results in loss of GDP to about 600 million USD per year[15].

LMICs have 0.71 teletherapy units/million population, in contrast to 7.62 teletherapy units/million population for high-income countries[16, 17]. In south-east Asia, India is the biggest nation with a reasonably huge number of patients suffering from cancer. In India, cancer care and treatment facilities are available only at tertiary level centers. There is no recent relevant study to assess the situation of radiotherapy treatment equipment availability and hence the current status of cancer care & treatment facilities in India and states. This study will attempt to fill the gap in the cancer care, policy and planning.

MATERIAL AND METHODS

Data for the number of radiotherapy machines at each center was collected by telephonic interview and data accumulation from records of the radiotherapy treatment centers listed by Atomic Energy Regulatory Board, India. Data for state-wise population for 2016 and 2026 was taken from the 'report of the technical group on population projections constituted by the National Commission on population, the office of the registrar general and census commissioner, India' and projected[29]. However, for projection of density, cancer incidence and prevalence for 2016 and 2026 was projected by exponential method[30], which describe in details as follow.

$P_t = P_0 (e^{rt})$

Where

P_t = Population (Density or Incidence or Prevalence) t years later

P_0 = Initial Population (Density or Incidence or Prevalence)

e = base of the natural logarithm

r = annual rate of growth

t = time interval in years

Here we assumed that state level population is closed for migration. For projection of cancer incidence and prevalence in 2016 and 2026, we assumed that the state-level prevalence and incidence of cancer in the year 2015 will not change over time in 2016. Further, we assumed few scenarios of cancer incidence and prevalence increase and projected state wise cancer burden in 2026. We performed all our analysis for undivided Andhra Pradesh due to lack of information for newly created Telangana state. District wise radiotherapy machines were also plotted on the map of India using Microsoft Paint software[31].

RESULTS

From **Table 1** it is evident that there were approximately 3.27 million cases of cancer in India in 2016 and 1.21 million new patients were diagnosed with cancer throughout the country in 2016. With the highest population in the country, the state Uttar Pradesh has highest cancer cases followed by Bihar and Maharashtra. There were total 494 radiotherapy machines throughout the country, and maximum radiotherapy machines were in Maharashtra followed by Andhra Pradesh, Karnataka and Tamil Nadu.

Table 1 Status of state-wise radiotherapy machines in India 2016

State	Population (x1000)	Estimated Cancer Incidence	Estimated Cancer Prevalence	No. of Radiotherapy Machines	Machine/ million population	Minimum machines required@
Andaman & Nicobar Islands*	556	347	939	0	0.00	1
Andhra Pradesh	88772	89300	241107	54	0.61	89
Arunachal Pradesh	1322	1271	3429	0	0.00	2
Assam	32673	26489	71520	7	0.21	33
Bihar	104600	109143	294690	5	0.05	105
Chandigarh*	1817	1032	2791	7	3.85	2
Chhattisgarh	26070	26598	71808	6	0.23	27
Dadra & Nagar Haveli*	427	420	1127	0	0.00	1
Daman & Diu*	338	396	1068	0	0.00	1
Delhi (NCT)*	21648	16171	43668	32	1.48	22
Goa	1991	1408	3799	2	1.00	2
Gujarat	63264	61105	164997	26	0.41	64
Haryana	27712	25276	68246	10	0.32	28
Himachal Pradesh	7129	6645	17945	1	0.14	8
Jammu & Kashmir	12496	13053	35238	4	0.32	13
Jharkhand	33916	34159	92233	6	0.18	34
Karnataka	62713	60877	164374	50	0.80	63
Kerala	35796	34688	93655	25	0.70	36
Lakshadweep*	82	73	194	0	0.00	1
Madhya Pradesh	78542	74298	200611	20	0.25	79
Maharashtra	120914	109064	294470	72	0.60	121
Manipur	2609	1989	5369	1	0.38	3
Meghalaya	2792	2653	7168	1	0.36	3
Mizoram	1070	957	2589	1	0.93	2
Nagaland	2395	1685	4547	1	0.42	3
Odisha	42679	41186	111201	8	0.19	43
Puducherry*	1694	1364	3689	4	2.36	2
Punjab	29267	26626	71891	21	0.72	30
Rajasthan	73523	68880	185979	17	0.23	74
Sikkim	651	679	1826	0	0.00	1
Tamil Nadu	69610	65986	178162	50	0.72	70
Tripura	3851	3639	9823	1	0.26	4
Uttar Pradesh	220106	204758	552846	38	0.17	221
Uttarakhand	10711	10351	27951	3	0.28	11
West Bengal	94035	91387	246738	21	0.22	95
Total	1277771	1213953	3277688	494	0.39	1294

On an average India has 0.39 radiotherapy machines per million populationand only four UT/states were following this standard of one machine per million population. As per our calculation in India, there should be 1294 radiotherapy machines to follow the WHO standard.

Table 2 gives state-wise projected population, cancer incidence and prevalence and number of radiotherapy units required to match WHO guidelines. It is evident that the country will behaving about 1406 million Indians with approximately 4.20 million cancer prevalence and 1.56 million cancer incidences by 2026. The total number of radiotherapy unit requirement will be about 1424 machines throughout the country. Out of 35 states and union territories, in 6 states there will be a requirement of 50 or more machines and 4 states will require more than hundred radiotherapy treatment units with the highest demand in Uttar Pradesh of 251 machines in 2026.

Table 2 Estimated populations, cancer cases and requirement of services in year 2026

State	Population (x1000)	Estimated Cancer Incidence	Estimated Cancer Prevalence	No. of Radiotherapy Machines
Andaman & Nicobar Islands*	654	386	1044	1
Andhra Pradesh	94329	122364	330373	95
Arunachal Pradesh	1444	1559	4194	2
Assam	35747	29061	78460	36
Bihar	114296	148823	401837	115
Chandigarh*	2535	1280	3471	3
Chhattisgarh	28727	35646	96208	29
Dadra & Nagar Haveli*	532	732	1932	1
Daman & Diu*	440	1026	2754	1
Delhi (NCT)*	28410	19578	52895	29
Goa	2261	1702	4572	3
Gujarat	69627	78936	213192	70
Haryana	31282	32040	86516	32
Himachal Pradesh	7597	8043	21732	8
Jammu & Kashmir	13482	17558	47389	14
Jharkhand	37538	45540	122974	38
Karnataka	67162	76657	206997	68
Kerala	37325	46653	125952	38
Lakshadweep*	76	113	281	1
Madhya Pradesh	88228	97402	263026	89
Maharashtra	134019	132615	358046	134
Manipur	2852	1772	4776	3
Meghalaya	3052	3135	8496	4
Mizoram	1169	1096	2978	2
Nagaland	2618	1856	5002	3
Odisha	45449	50791	137138	46
Puducherry*	2240	1958	5317	3
Punjab	31457	31990	86378	32
Rajasthan	81889	87869	237262	82
Sikkim	713	1137	3034	1
Tamil Nadu	71950	73487	198412	72
Tripura	4210	5055	13637	5
Uttar Pradesh	250250	269722	728238	251
Uttarakhand	11800	13550	36596	12
West Bengal	100854	116042	313287	101
Total	1406214	1557174	4204396	1424

Table 3 shows cancer incidence according to various projections in cancer growth rates in India and states. It is evident that if 50% incremental change in cancer occurrence rates is observed, about 2.33 million new cancer cases will be added in 2026.

Table 4 illustrates cancer prevalence in various scenarios, and with current pace, there will be about 42 million cancer patients in the country and if the prevalence changes with the rate of 10, 20, 30, 40 and 50% this number will grow by about 46.22, 50.45, 54.65, 58.86 and 63.06 million cancer patients in 2026.

Table 3 Projection of Cancer incidence considering different scenarios in 2026

State	No change	10% increase	20% increase	30% increase	40% increase	50% increase
Andaman & Nicobar Islands*	386	424.6	463.2	501.8	540.4	579
Andhra Pradesh	122364	134600.4	146836.8	159073.2	171309.6	183546
Arunachal Pradesh	1559	1714.9	1870.8	2026.7	2182.6	2338.5
Assam	29061	31967.1	34873.2	37779.3	40685.4	43591.5
Bihar	148823	163705.3	178587.6	193469.9	208352.2	223234.5
Chandigarh*	1280	1408	1536	1664	1792	1920
Chhattisgarh	35646	39210.6	42775.2	46339.8	49904.4	53469
Dadra & Nagar Haveli*	732	805.2	878.4	951.6	1024.8	1098
Daman & Diu*	1026	1128.6	1231.2	1333.8	1436.4	1539
Delhi (NCT)*	19578	21535.8	23493.6	25451.4	27409.2	29367
Goa	1702	1872.2	2042.4	2212.6	2382.8	2553
Gujarat	78936	86829.6	94723.2	102616.8	110510.4	118404
Haryana	32040	35244	38448	41652	44856	48060
Himachal Pradesh	8043	8847.3	9651.6	10455.9	11260.2	12064.5
Jammu & Kashmir	17558	19313.8	21069.6	22825.4	24581.2	26337
Jharkhand	45540	50094	54648	59202	63756	68310
Karnataka	76657	84322.7	91988.4	99654.1	107319.8	114985.5
Kerala	46653	51318.3	55983.6	60648.9	65314.2	69979.5
Lakshadweep*	113	124.3	135.6	146.9	158.2	169.5
Madhya Pradesh	97402	107142.2	116882.4	126622.6	136362.8	146103
Maharashtra	132615	145876.5	159138	172399.5	185661	198922.5
Manipur	1772	1949.2	2126.4	2303.6	2480.8	2658
Meghalaya	3135	3448.5	3762	4075.5	4389	4702.5
Mizoram	1096	1205.6	1315.2	1424.8	1534.4	1644
Nagaland	1856	2041.6	2227.2	2412.8	2598.4	2784
Odisha	50791	55870.1	60949.2	66028.3	71107.4	76186.5
Puducherry*	1958	2153.8	2349.6	2545.4	2741.2	2937
Punjab	31990	35189	38388	41587	44786	47985
Rajasthan	87869	96655.9	105442.8	114229.7	123016.6	131803.5
Sikkim	1137	1250.7	1364.4	1478.1	1591.8	1705.5
Tamil Nadu	73487	80835.7	88184.4	95533.1	102881.8	110230.5
Tripura	5055	5560.5	6066	6571.5	7077	7582.5
Uttar Pradesh	269722	296694.2	323666.4	350638.6	377610.8	404583
Uttarakhand	13550	14905	16260	17615	18970	20325
West Bengal	116042	127646.2	139250.4	150854.6	162458.8	174063
Total	1557174	1712891.4	1868608.8	2024326.2	2180043.6	2335761

Table 5 shows the concentration of radiotherapy treatment units in the metro cities and it is evident that all metro cities match WHO guidelines. 37% of total 494 radiotherapy machines were in 8 metro cities of India, while residence of these eight metro cities, constituting only 8.76% of Indians.

Table 6 shows the cross-sectional comparison around the globe, pertaining to radiotherapy machine density highlighting the vast divide between the lower-middle income country and the high-income countries. It is clear that higher income countries like United States of America, United Kingdom are way ahead of India and even some African and Latin American countries from upper-lower-middle income group have better radiotherapy machine density in comparison to India.

Table 7 shows the number of districts having projected population more than 1 million and the number of districts having radiotherapy machines. Out of 640 districts listed in Census 2011, 483 districts have a population of over a million in 2016, and only 157 districts have one or more radiotherapy machines.

Table 8 shows area covered by radiotherapy machines.

Table 4 Projection of cancer prevalence considering different scenario in 2026

State	No change	10% increase	20% increase	30% increase	40% increase	50% increase
ndaman & Nicobar Islands*	1044	1148.4	1252.8	1357.2	1461.6	1566
Andhra Pradesh	330373	363410.3	396447.6	429484.9	462522.2	495559.5
Arunachal Pradesh	4194	4613.4	5032.8	5452.2	5871.6	6291
Assam	78460	86306	94152	101998	109844	117690
Bihar	401837	442020.7	482204.4	522388.1	562571.8	602755.5
Chandigarh*	3471	3818.1	4165.2	4512.3	4859.4	5206.5
Chhattisgarh	96208	105828.8	115449.6	125070.4	134691.2	144312
Dadra & Nagar Haveli*	1932	2125.2	2318.4	2511.6	2704.8	2898
Daman & Diu*	2754	3029.4	3304.8	3580.2	3855.6	4131
Delhi (NCT)*	52895	58184.5	63474	68763.5	74053	79342.5
Goa	4572	5029.2	5486.4	5943.6	6400.8	6858
Gujarat	213192	234511.2	255830.4	277149.6	298468.8	319788
Haryana	86516	95167.6	103819.2	112470.8	121122.4	129774
Himachal Pradesh	21732	23905.2	26078.4	28251.6	30424.8	32598
Jammu & Kashmir	47389	52127.9	56866.8	61605.7	66344.6	71083.5
Jharkhand	122974	135271.4	147568.8	159866.2	172163.6	184461
Karnataka	206997	227696.7	248396.4	269096.1	289795.8	310495.5
Kerala	125952	138547.2	151142.4	163737.6	176332.8	188928
Lakshadweep*	281	309.1	337.2	365.3	393.4	421.5
Madhya Pradesh	263026	289328.6	315631.2	341933.8	368236.4	394539
Maharashtra	358046	393850.6	429655.2	465459.8	501264.4	537069
Manipur	4776	5253.6	5731.2	6208.8	6686.4	7164
Meghalaya	8496	9345.6	10195.2	11044.8	11894.4	12744
Mizoram	2978	3275.8	3573.6	3871.4	4169.2	4467
Nagaland	5002	5502.2	6002.4	6502.6	7002.8	7503
Odisha	137138	150851.8	164565.6	178279.4	191993.2	205707
Puducherry*	5317	5848.7	6380.4	6912.1	7443.8	7975.5
Punjab	86378	95015.8	103653.6	112291.4	120929.2	129567
Rajasthan	237262	260988.2	284714.4	308440.6	332166.8	355893
Sikkim	3034	3337.4	3640.8	3944.2	4247.6	4551
Tamil Nadu	198412	218253.2	238094.4	257935.6	277776.8	297618
Tripura	13637	15000.7	16364.4	17728.1	19091.8	20455.5
Uttar Pradesh	728238	801061.8	873885.6	946709.4	1019533	1092357
Uttarakhand	36596	40255.6	43915.2	47574.8	51234.4	54894
West Bengal	313287	344615.7	375944.4	407273.1	438601.8	469930.5
Total	4204396	4624835.6	5045275.2	5465714.8	5886154.2	6306594

Table 5 Radiotherapy Machines in major cities Vs Rest of India in 2016

State	City Names	No of Machines	Population (x1000)	Machine/million population
Andhra Pradesh	Hyderabad + Secunderabad	27	11723	2.30
Delhi (NCT)* + NCR	Delhi (NCT)* + Gurugram +Ghaziabad + NOIDA + Faridabad	43	26148	1.64
Karnataka	Bangalore	27	11557	2.34
Maharashtra	Mumbai +Thane	31	21690	1.42
Tamilnadu	Chennai	19	10108	1.88
West Bengal	Kolkata + Howrah	16	15622	1.02
Maharashtra	Pune	11	7276	1.51
Gujrat	Ahmedabad + Gandhinagar	10	7797	1.28
Total		184	111921	1.64
Rest of India		310	1165850	0.27

Table 6 Comparison of Radiotherapy units per million populations

Name Country/Region	Total	LIC	LMIC	ULMIC
United States of America	12.45			
Australia	10.12			
United Kingdom	5.04			
India	0.38			
Europe and Central Asia	1.951	0.24	1.636	2.228
Latin America	1.523	0	0.718	1.638
Asia and pacific	0.661	0.144	0.358	1.135
Africa	0.26	0.029	0.318	0.963

Table 7 States wise number of district of India having population above or equal one million in 2016 and number of districts having radiotherapy facilities

State	Total District	District population ≥ one million	Districts having radiotherapy machines
Andaman & Nicobar Islands*	3	0	0
Andhra Pradesh	23	23	14
Arunachal Pradesh	16	0	0
Assam	27	19	3
Bihar	38	35	1
Chandigarh*	1	1	1
Chhattisgarh	18	10	3
Dadra & Nagar Haveli*	1	0	0
Daman & Diu*	2	0	0
Delhi (NCT)*	9	6	6
Goa	2	0	1
Gujarat	26	22	9
Haryana	21	19	5
Himachal Pradesh	12	2	1
Jammu & Kashmir	22	4	2

Jharkhand	24	17	3
Karnataka	30	29	14
Kerala	14	13	8
Lakshadweep*	1	0	0
Madhya Pradesh	50	40	7
Maharashtra	35	34	19
Manipur	9	0	1
Meghalaya	7	0	1
Mizoram	8	0	1
Nagaland	11	0	1
Odisha	30	22	4
Puducherry*	4	1	1
Punjab	20	12	9
Rajasthan	33	31	7
Sikkim	4	0	0
Tamil Nadu	32	29	12
Tripura	4	1	1
Uttar Pradesh	71	71	14
Uttarakhand	13	4	2
West Bengal	19	19	6
Total	640	464	157

DISCUSSION

The mortality and morbidity due to cancer occurred synchronous to the increasing addictions amongst specially the young population of India, for tobacco, alcohol and lifestyle changes[14]. Also, importantly for this surge in cancer incidence an increased usage of canned food products, artificial food additives, pesticides, artificial colouring agents or dyes etc. has shown to take the toll[18, 19]. It is also worth mentioning that increasing lifespan over the past three-four decades resulted into substantial rise in the proportion of aged population and gradually good control on communicable diseases have also been a reason for establishing the non-communicable diseases like cancer in the fore front as the most important health threat [20].

Table 8 Area coverage by RT machines in 2016

State	Population (x1000)	Estimated Cancer Incidence	Estimated Cancer Prevalence	Total district	No of machine in district	Area (Sq. KM)	Density (per Sq. KM)	% Area covered
Andaman & Nicobar Islands*	556	347	939	3	0	8249	48	0.00%
Andhra Pradesh	88772	89300	241107	23	14	275045	326	60.87%
Arunachal Pradesh	1322	1271	3429	16	0	83743	19	0.00%
Assam	32673	26489	71520	27	3	78438	429	11.11%
Bihar	104600	109143	294690	38	1	94163	1233	2.63%
Chandigarh*	1817	1032	2791	1	1	114	10011	100.00%
Chhattisgarh	26070	26598	71808	18	3	135192	209	16.67%
Dadra & Nagar Haveli*	427	420	1127	1	0	491	513	0.00%
Daman & Diu*	338	396	1068	2	0	111	32	0.00%
Delhi (NCT)*	21648	16171	43668	9	6	1483	9363	66.67%
Goa	1991	1408	3799	2	1	3702	410	50.00%
Gujarat	63264	61105	164997	26	9	196244	337	34.62%
Haryana	27712	25276	68246	21	5	44212	628	23.81%
Himachal Pradesh	7129	6645	17945	12	1	55673	131	8.33%
Jammu & Kashmir	12496	13053	35238	22	2	222236	42	9.09%
Jharkhand	33916	34159	92233	24	3	79716	458	12.50%
Karnataka	62713	60877	164374	30	14	191791	344	46.67%
Kerala	35796	34688	93655	14	8	38852	880	57.14%
Lakshadweep*	82	73	194	1	0	30	2075	0.00%
Madhya Pradesh	78542	74298	200611	50	7	308252	259	14.00%
Maharashtra	120914	109064	294470	35	19	307713	394	54.29%
Manipur	2609	1989	5369	9	1	22327	130	11.11%
Meghalaya	2792	2653	7168	7	1	22429	149	14.29%
Mizoram	1070	957	2589	8	1	21081	58	12.50%
Nagaland	2395	1685	4547	11	1	16579	119	9.09%
Odisha	42679	41186	111201	30	4	155707	287	13.33%
Puducherry*	1694	1364	3689	4	1	490	2940	25.00%
Punjab	29267	26626	71891	20	9	50362	588	45.00%
Rajasthan	73523	68880	185979	33	7	342239	222	21.21%
Sikkim	651	679	1826	4	0	7096	91	0.00%
Tamil Nadu	69610	65986	178162	32	12	130060	598	37.50%
Tripura	3851	3639	9823	4	1	10486	376	25.00%
Uttar Pradesh	220106	204758	552846	71	14	240928	908	19.72%
Uttarakhand	10711	10351	27951	13	2	53483	206	15.38%
West Bengal	94035	91387	246738	19	6	88752	1099	31.58%
Total	1277771	1213953	3277688	640	157	3287469	415	24.53%

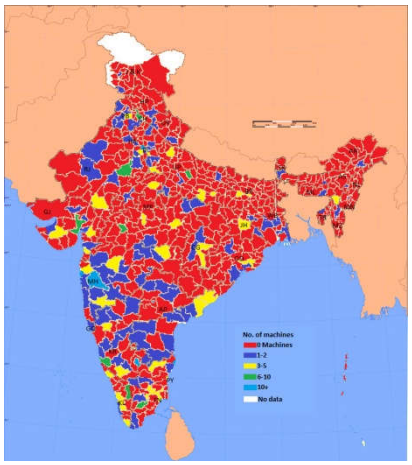

Figure 1 shows the distribution of radiotherapy treatment machines at the district level in the country. It was clear from the figures that most of the districts from North and North-East India are lagging behind with regards to cancer treatment facilities.

Of all the chronic illnesses spread over the globe, cancer is considered probably to be the most preventable disease[21]. While there is a wide disparity in the incidence rates of cancer across different geographical regions over the globe, the variation in the mortality rates is quite different. The incidence of cancer in India in 2012 was almost two-third at 1.01 million as compared to 1.60 million in the United States of America, but survival rates are way below with about 0.68 million cancer patients succumbing to the disease[10]. Hence, in developed countries, there is a consistent decrease in the death rates along with relatively favourable survival, even though the incidence of cancer is rising steadily.

In the developing countries we can presume that ignorance to the basic knowledge of cancer is a biggest killer than the disease itself[22]. Factors responsible for existing catastrophic situation pertaining to cancer and mortality in India are late presentation of cancer patients in advanced stages. Lack of awareness and health, illiteracy, myths widespread in the

society, conservative attitude of patients, social stigma attached to the disease, delayed referrals to the specialized healthcare are few of them[23]. This is also associated with high defaulter rates while on treatment. The consequence is poor survival of patients irrespective of the best and latest multimodality available treatment. There has been a metro-centric bias in this relation. The high concentration of good facilities of cancer treatment in metro regions have indirectly been not reachable to the majority of Indian population who are suburb and rural centric as more than70% of Indian population is based in villages. The distance has gone wider with time due to non-decentralization of treatment facilities from these large cities and catchments.

In our study, we observed that as of 2016, India has almost 3.28 million people living diagnosed with cancer of which 1.21 million new cases were found in the year of 2016. Uttar Pradesh, having the geographical area equivalent to the United Kingdom and the population equivalent to Brazil, contributed maximum cases (0.20 million) in incidence followed by Bihar and Maharashtra. About 50% of cancer incidence burden was from only five states of the country namely Uttar Pradesh, Maharashtra, Bihar, West Bengal and Madhya Pradesh. Same is the pattern of contribution by Indian states to cancer prevalence with top three states having the highest incidence, responsible for a total of 1.13 million patients living diagnosed with cancer.

Individually Uttar Pradesh tops the chart with a prevalence of almost 0.55 million cases followed by Bihar with 0.29 million cases and Maharashtra with 0.29 million cases. For such a high burden of cancer incidence and prevalence, India is currently equipped with only 494 Radiation Therapy Unit (RTU) against requirement as per WHO guideline of one radiotherapy machine per million populations for LMICs of almost 1294 RTU, amounting to 0.39 RTU per million population[24]. This disparity thereby causes short fall of by more than 800 RTU in 2016 with a deficit of more than 150% of current installed RTU treatment capacity for the fight against cancer. In comparison, the developed nations as the United States of America, Australia, and the United Kingdom fare far better in RTU availability for treatment of diagnosed cancer patients, with RTU per million population density of 12.45, 10.12 and 5.04 respectively. This reflects in terms of the mortality burden from cancer, which is much higher in India than in the developed nations, thus, the mortality to incidence ratio being 0·69 for India,compared with other developed nations of Europe and America which is less than 0·40[25].

As per World Cancer Report (IARC, 2014), the increasing trend of cancer especially in LMICs, will be responsible for overwhelming morbidity, mortality and economic burden in the next two decades. Cancer would become a major impediment to the socio-economic development of these economically emerging nations due to the exchequer spent and also the advanced disease profile at presentation. Overall, cancer caused 208.3 million DALYs worldwide in 2015 for both sexes combined[6]. Although an appreciable emphasis is placed on communicable diseases, cancer and NCDs need further prioritization otherwise it will be detrimental, manifold future health burdens, which the health systems with present capacity will not be able to handle.

In a country like India, it is not only the disease but the economic burden of treatment cause major stress to patients and families more so with sparse metro-centric facilities for cancer treatment. Along with the National Cancer Control Programme of Government of India a major share of cancer management is done by private sector healthcare facilities. With health budget of approximately 1.4% of GDP, most of the public healthcare expenditure is concentrated on maternal and child health care programs and eradication of communicable diseases.

Drawing on evidence from the report by R Srinivasan, Healthcare in India, planning commission, almost 75% of all health care expenses are out of pocket spending borne by patient and their households, more so in cases of chronic NCDs like cancer [26]. Selvaraj and Karan, drawing an inference from past morbidity and health survey (1986-87 to 2004) and consumer expenditure surveys of NSSO (1993-94 to 2004) rightly pointed to new abysmal depths reached by healthcare in India in terms of delivery by public or state-sponsored hospitals[27].

In context of GDP growth with regards to individual's affordability, planning commission's Deputy Chairman noted that though diminution in magnitude of population below the poverty line is a clear indicator of progress but still many of families that in terms of per capita consumption lie above the poverty line may not have proper access to even basic services such as education, health, sanitation etc.

In our study, we observed that out of 35 States and UTs, only four are equipped according to WHO guidelines for cancer treatment, while the situation is abysmal in states of Arunachal Pradesh, Sikkim, Dadra & Nagar Haveli, Andaman & Nicobar Islands, Daman & Diu and Lakshadweep with no radiotherapy treatment facilities whatsoever. Patients from these states face greater difficulties in getting treatment as these states are all remotely located and not well connected, thereby, may result in higher mortality to incidence ratio. The condition is nodifferent in other states also. Indian states namely Bihar, Uttar Pradesh, Odisha, West Bengal, Rajasthan, Madhya Pradesh, Gujarat, Maharashtra, Andhra Pradesh, Tamil Nadu and Karnataka, each having prevalence of more than 100,000 cases in 2016, have ratio of RTU to per million population of 0.05, 0.17, 0.19, 0.22, 0.23, 0.25, 0.41, 0.6, 0.61, 0.66 and 0.8 respectively, contrary to WHO guideline for LMICs of 1 RTU per million population. For a total population of 446 million and 1.15 million patients living with the diagnosis of cancer residing in Bihar, Maharashtra and Uttar Pradesh, only 115 RTU are commissioned, thus a shortage of 332 RTU in this fight against cancer, almost 300% of current RTU infrastructure. One of the limiting factors for machine procurement is its cost, which the state must bear, and thus this creates insufficiency in state's policies to achieve the machine to patient ratio in a proper way[17, 28]. Currently, only about 24.5% geographical extent of the India is under coverage of currently installed RTU, leaving rest three forth of the nation is suffering from inadequacy of treatment facilities for cancer.

With almost 70% population of India residing in rural areas, the situation of cancer care in rural India is much grave. The public sponsored healthcare infrastructure for cancer treatment, and research is centralized with all the resources centered in metro/ major cities. In our study, we observed that wide disparity exists in India concerning RTU availability and density per million populations in between metro cities and rest of India. Eight metro cities of India with a combined

population of 111.92 million hold control of 184 RTU under their boundaries. Thus, while habitants of these eight metro cities, constituting only 8.76 % of the national population, avail treatment benefit from 37% of total RTU capacity of India, rest of Indian population at 1165.85 million strengths is left prey to the wrath of cancer with just 310 machines at disposal. Thereby, RTU density per million population in these metros at an average of 1.64 abide by the WHO standards for LMICs; it is the rest of India which faces the brunt with merely 0.27 RTU permillion population, even way below national average and those of African LMICs.

Out of 640 districts, only 157 districts are equipped for cancer treatment by radiotherapy. Thus, leaving residents of 483 districts barely have a reach to modern cancer care. This distribution pattern of RTU is also shadowed by vast differences seen across the regions. There is an obvious concentration of RT facilities in the southern districts of India, while a dearth is observed indistricts of the north and central India except National capital territory. Districts of Jammu & Kashmir, Himachal Pradesh, Uttarakhand and north-eastern seven sister states are lacking decentradiation treatment facilities. These areas constitute hilly and remote terrain with poor connectivity and therefore difficult to be traversed by the patient for availing treatment.

It is well documented by other researchers that for a progressive increase in distance travelled by patients to avail health care facilities, result into incremental chances of mortality[33]. Thus, these centralized resources which are distant to the rural population is of no much use to them, and few who travel to avail these facilities face difficulties due to the distance, long waiting periods, overburdened staff and lack of financial resources.

Since there is a huge gap at present in the RTU services at a metro and rural level, this study extrapolated the incidence and prevalence of cancer as well as requirement of RTUs in the year 2026. Considering the present scenario of cancer growth maintaining the similar trend and projections of new cancer cases detected across the nation with 20% increment and 50% increment over current rates, in 2026, will be 1.56 million, 1.87 million and 2.34 million respectively. Similarly, number of patients living with the diagnosis will swell up to 4.20 million, 5.05 million and 6.31 million respectively. If there is no increase in the current number of RTU, in 2026 the gap will be more than 930 RTUs with estimated cumulative cancer incidence of 1.56 million and prevalence of 4.20 million at the national level with no change in cancer rates.

CONCLUSION

For India, it is of utmost priority that early detection, health education and awareness for cancer, along with dealing with the huge volume of undetected advanced disease, be addressed and brought down to a minimum or at par with advanced nations to limit the cancer related mortality and morbidity. It is the dire need of the hour that infrastructure for the treatment of cancer patients pertaining to radiotherapy treatment units should be upgraded in context of availability across the nation, as per WHO guidelines of 1 RTU per million population. Also, to be taken onto account is the accessibility to RTU's with efforts needed for even distribution of machines with special emphasis on rural and hilly areas. With, 70% of district in the country having population of one million or more, a bare minimum of one RTU should be made operational at the level of government district hospital. This will not only result into timely treatment accessibility to patients of the region apart from reducing queues at already overburdened centres, thus leading to improvement of quality of cancer care, but also provide affordable cancercare to under privileged and economically weaker sections of the society.

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