Advances in Radiation Oncology (2021) 6, 100771

advances in radiation oncology

www.advancesradonc.org

Scientific Article

Estimation of the Need for Radiation Therapy Services According to the Incidence of Cancer in Colombia to 2035

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Received May 17, 2021; revised July 23, 2021; accepted July 28, 2021

Abstract

Purpose: To estimate the supply and demand of current and future radiation therapy services by 2035 for Colombia.

Methods and Materials: The present study was performed by surveying different radiation therapy services identified in Colombia through the Colombian Association of Radiation Oncology. The demand was estimated based on incident cases and published information on the use of radiation therapy by type of cancer. Future demand was estimated under the assumption that incidence rates do not change and therefore the change in the number of cases is due to the change in the age structure of the Colombian population. Sensitivity analyses were conducted on the percentage of radiation therapy use by type of cancer. A Monte Carlo simulation was carried out to estimate the distribution of cases requiring radiation therapy, the amount of equipment, and the number of staff needed for care with the use of this technology.

Results: In total, Colombia has 69 linear accelerators, 2 radiosurgery equipment, 30 high-dose-rate brachytherapy pieces of equipment, 124 radiation therapy oncologists (113 working, 9 not working, and 2 not informed), and 275 radiation therapy technologists as of June 2020. It was estimated that to meet the current cancer burden the country would need a total of 162 radiation therapy oncologists, 121 medical physicists, and 323 radiation therapy technologists and to increase the number of radiation therapy technologists, radiation therapy oncologists, and medical physicists to 491, 246, and 184, respectively, to meet the disease burden by 2035 (73,684-88,743 cases per year).

Conclusions: In Colombia it is estimated that there is a deficit of human resources and technology for radiation therapy; therefore, there is need to investment resources from the public and private sectors to provide timely and quality care to cancer patients requiring this treatment.

Introduction

Cancer has become a major public health problem in the world. According to Global Cancer Observatory in 2018, the incidence rate was 236.9 and mortality was 125.2 per 100,000 person-years for all cancers.[1] Although

Sources of support: The work was supported by the National Cancer Institute from Colombia.

Disclosures: none.

Research data are stored in an institutional repository and will be shared upon request to the corresponding author.

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https://doi.org/10.1016/j.adro.2021.100771

millions of people die from cancer each year, high-income countries have achieved a decrease in incidence and mortality owing to influencing factors such as risk control, early detection, diagnostic approach, and timely treatment.[2]

In Colombia, according to Globocan in 2018, the incidence rate was 215.9 and mortality was 102.5 per 100,000 person-years. Among the main causes of cancer death in the country are lung, colon, rectum, stomach, prostate, and breast.[1] The priority problems that hinder comprehensive cancer care and negatively affect the decrease in cancer incidence and mortality in the country are lack of specialized and subspecialized human resources in oncology; underdevelopment of palliative care and support services for families and caregivers; fragmentation of service delivery; and lack of articulation between preventive and curative services; deficient system of regulation, monitoring and control of the supply of services, use of oncological medicines and quality of care; difficult control of care costs due to fragmentation, contracting and payment modalities, negotiation of rates, and supply of medicines; and nonexistence of integrated critical care routes.[3,4] Achieving comprehensive cancer care for patients depends on the articulation of the different medical, surgical, and radiation therapy oncology specialties and the effective interaction between services of diagnostic and social support that are complementary.[5]

In high-income countries where the burden of cancer disease is high, the cancer care is concentrated in comprehensive treatment centers that allow multimodal management with radiation therapy, surgery, and chemotherapy. The high volume of patients at these centers improves the medical experience and clinical outcomes.[5]

Specialized services such as radiation therapy are essential in the comprehensive treatment of cancer. The utilization rate of radiation therapy varies widely internationally but approximately 50% of all patients with cancer must receive radiation at some point during their treatment.[6] In Colombia these specialized services are concentrated in the 5 large cities, and it is not known if the number of equipment and radiation therapy centers are sufficient according to the cancer disease burden.[4] The study seeks to estimate the supply and demand of radiation therapy services in the country and to estimate future needs according to the cancer disease burden in the Colombian population in 2035.

Methods and Materials

A descriptive observational study was conducted to estimate the supply and demand of radiation therapy services and future needs according to the projected cancer burden for the country in 2035. A telephone survey was carried out to the different radiation therapy services identified in the country through the Colombian Association of Radiation therapy Oncology (ACRO by its Spanish acronym). The questions were number of external radiation therapy equipment, number of high rate and low-rate brachytherapy equipment, and the number of radiation therapy technologists. The census of radiation oncologists was not part of this survey, and the information was obtained directly from the ACRO. The number of physicists cannot be verified because they may work in more than one radiation therapy service, and therefore the number of medical physicists could be overestimated.

The demand for radiation therapy in Colombia was estimated from the cases that required this treatment according to the incidence rates by age reported for Colombia in 2018 by Globocan[1] and the Colombian population projections published by the United Nations.[7] The estimate was made under the assumption that incidence rates by age remained constant during the period analyzed, and therefore the increase in the number of new cases is due to changes in the age structure of the population.

The cases that required radiation therapy were estimated by type of cancer, as reported in the study of Barton et al,[8] whichmakes an estimation of the optimal utilization of radiation therapy services for all cancers according to the evidence-based indications that show better clinical outcomes (overall survival, disease-free survival, quality of life, or toxicity profiles) with the use of radiation therapy compared with alternative treatments. Table 1 shows the percentage of optimal use by type of cancer and sex. Only the use of one radiation therapy treatment was estimated in the initial management. Therefore, re-radiations were not included in the estimate. To estimate the supply of radiation therapy needed to meet the demand for cases requiring treatment, international recommendations were used for the number of patients by linear accelerator, medical radiation oncologist, medical physicist, and radiation therapist technologist (Table 1).[9]

One-way sensitivity analyses were performed for percentages of radiation therapy utilization according to different oncological locations and their effect on equipment and staff needs for care with this technology. Monte Carlo simulation was performed to estimate the number per year of cancer cases that would use radiation therapy, equipment, radiation therapy oncologists, medical physicists, and radiation therapy technologist. The information of the survey was analyzed using descriptive statistics, estimating measures of central tendency (median) and dispersion (ranges) for the quantitative variables, and absolute and relative frequencies for the qualitative ones. For the analysis, Stata 11 program was used.

Results

There was a response from 49 radiation therapy services, which correspond to the totality of services in Colombia. The country has 69 linear accelerators, 2 multiphoton

Table 1 Optimal radiotherapy use data by cancer type and sex used in the model

Cancer location	Women (AS range)	Men (AS range)	Source
Breast	0.87 (0.83-0.88)	0	Barton et al, 2014[8]
Cervix	0.71 (0.58-0.72)	0	
Prostate	0	0.58 (0.57-0.6)	
Uterine	0.38 (0.35-0.39)	0	
Colorectal	0.2 (0.14-0.21)	0.2 (0.14-0.21)	
Stomach	0.27 (0.26-0.68)	0.27 (0.26-0.68)	
Lung	0.77 (0.76-0.78)	0.77 (0.76-0.78)	
Thyroid	0.04 (0.03-0.1)	0.04 (0.03-0.1)	
Non-Hodgkin's Lymphoma	0.73 (0.65-0.74)	0.73 (0.65-0.74)	
Leukemia	0.04 (0.03-0.05)	0.04 (0.03-0.05)	
Pancreas	0.49 (0.48-0.57)	0.49 (0.48-0.57)	
Liver	0 (0)	0 (0)	
Skin melanoma	0.21 (0.2-0.23)	0.21 (0.2-0.23)	
Central nervous system	0.8 (0.79-0.92)	0.8 (0.79-0.92)	
Kidney	0.15 (0.14-0.27)	0.15 (0.14-0.27)	
Bladder	0.47 (0.46-0.58)	0.47 (0.46-0.58)	
Gallbladder	0.17 (0.13-0.18)	0.17 (0.13-0.18)	
Multiple myeloma	0.45 (0.38-0.46)	0.45 (0.38-0.46)	
Ovary	0.04 (0.035-0.045)	0	
Vulva	0.39 (0.34-0.41)	0	
Testicles	0	0.07 (0.05-0.49)	
Esophagus	0.71 (0.7-0.8)	0.71 (0.7-0.8)	
Larynx	0.74 (0.73-0.78)	0.74 (0.73-0.78)	
Lips and oral cavity	0.74 (0.73-0.78)	0.74 (0.73-0.78)	
Hodgkin's lymphoma	0.73 (0.65-0.74)	0.73 (0.65-0.74)	
Salivary glands	0.74 (0.73-0.78)	0.74 (0.73-0.78)	
Oropharynx	0.74 (0.73-0.78)	0.74 (0.73-0.78)	
Kaposi's Sarcoma	0.19 (0.18-0.2)	0.19 (0.18-0.2)	
Vagina	0.94 (0.93-1)	0	
Penis	0	0.39 (0.38-0.4)	
Nasopharynx	0.74 (0.73-0.78)	0.74 (0.73-0.78)	
Hypopharynx	0.74 (0.73-0.78)	0.74 (0.73-0.78)	
Mesothelioma	0.19 (0.18-0.2)	0.19 (0.18-0.2)	
Others	0.19 (0.18-0.5)	0.19 (0.18-0.5)	
Staff per no. of cancer cases*			
Patients per equipment		500 (400-1000)	Atun et al, 2015[9]
Patients per radiation oncologist		300 (200-400)	
Patients per medical physicist		400 (350-750)	
Patients per radiotherapy technologist		150 (100-250)	

* The upper limits corresponded to the opinion of national experts.

source radiosurgery equipment, 30 high-rate brachytherapy equipment, 124 radiation therapy oncologists (113 working, 9 not working and 2 not informed), 275 radiation therapy technologists and 104 medical physicists as of June 2020 (Table 2). The median number of radiation oncologists, radiation therapy technologists and medical physicist per service was 2 (range, 1-9), 4 (range, 1-30), and 2 (range, 1-6), respectively. The median number of accelerators per service was 1 (range, 1-4).

According to the estimate made, the number of cancer cases that would need radiation therapy would be 48,461 in 2020 and 73,684 in 2035. To attend this population, the country would need to have 97 accelerators, 162 radiation therapy oncologists, 121 medical physicists, and 323 radiation therapy technologists by 2020 and increase the number of accelerators to 147, the number of radiation therapy technologists, radiation therapy oncologists, and medical physicists to 491, 246 and 184 respectively (Table 3).

The estimate of the number of cases per radiation therapy oncologist, medical physicist, radiation therapy technologist, and linear accelerators according to the regions defined by the National Planning Department (DNP by its Spanish acronym) is shown in Figure 1, where it is observed that in the South Central region there is a deficit in equipment and staff**,** in the Llanos region there is also a deficit in medical physicists, technologists, and linear accelerators according to the best practices of the number of cases per staff and linear accelerators.

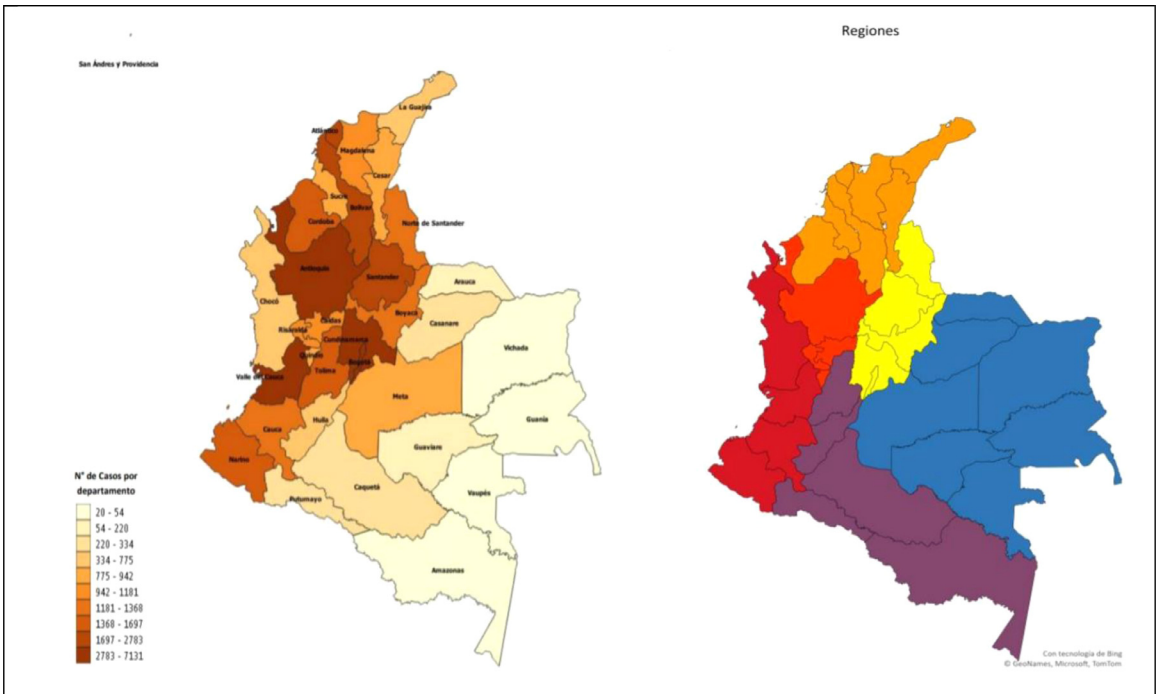
Table 2 Radiation therapy staff and services offered by department in Colombia 2020

Department	Linear accelerators	Helical	CyberKnife	Intraoperative	Cobalt-60	GammaKnife	HDR brachytherapy	Radiation Oncologists	Medical physicists	Radiation therapy technologists
Antioquia	11	1	1	0	0	0	5	23	19	39
Atlántico	4	0	0	0	0	0	2	9	4	13
Bogotá	14	0	0	1	0	1	4	28	26	80
Bolívar	2	0	0	0	0	0	2	4	4	7
Boyacá	1	0	0	0	0	0	0	1	3	2
Caldas	2	0	0	0	0	0	0	2	2	4
Cauca	1	0	0	0	0	0	1	1	1	2
Cesar	3	0	0	0	0	0	3	5	5	6
Córdoba	2	0	0	0	0	0	1	3	2	6
Huila	1	0	0	0	0	0	1	2	2	4
Magdalena	1	1	0	0	0	0	0	2	1	5
Meta	1	0	0	0	0	0	0	4	1	3
Nariño	2	0	0	0	0	0	1	4	3	11
Norte de Santander	3	0	0	0	0	0	2	5	3	10
Quindío	1	0	0	0	0	0	0	2	1	5
Risaralda	2	0	0	0	0	0	1	4	3	8
Santander	3	1	1	0	0	0	3	11	9	19
Sucre	1	0	0	0	0	0	0	2	1	1
Tolima	1	0	0	0	0	0	1	1	1	5
Valle de Cauca	7	0	0	0	0	1	3	11	13	45
Total general	63	3	2	1	0	2	30	124	104	275

Source of information: ACRO[10], available at: http://www.acro.net.co/publicaciones.php. HDR = high dose rate.

Table 3 Estimation of the number of cases requiring radiotherapy, the human resources, and the number of equipment needed to attend the cancer burden in Colombia from 2018-2035

Year	Cases			Equipment			Radiation Oncologist			Medical Physicist			Technologists		
	Average	Range		Average	Range		Average	Range		Average	Range		Average	Range	
2018	45.235	42.398	54.340	90	54	106	151	136	212	113	72	121	302	217	424
2019	46.828	43.900	56.258	94	56	110	156	141	220	117	75	125	312	225	439
2020	48.461	45.439	58.223	97	58	114	162	146	227	121	78	130	323	233	454
2021	50.056	46.943	60.145	100	60	117	167	150	235	125	80	134	334	241	469
2022	51.679	48.473	62.100	103	62	121	172	155	242	129	83	138	345	248	485
2023	53.333	50.032	64.094	107	64	125	178	160	250	133	85	143	356	256	500
2024	55.025	51.628	66.136	110	66	129	183	165	258	138	88	148	367	265	516
2025	56.760	53.265	68.231	114	68	133	189	171	266	142	91	152	378	273	533
2026	58.446	54.856	70.270	117	70	137	195	176	274	146	94	157	390	281	549
2027	60.151	56.465	72.332	120	72	141	201	181	282	150	96	161	401	289	565
2028	61.876	58.092	74.420	124	74	145	206	186	290	155	99	166	413	298	581
2029	63.623	59.741	76.536	127	77	149	212	191	299	159	102	171	424	306	597
2030	65.391	61.409	78.680	131	79	154	218	197	307	163	105	175	436	315	614
2031	67.062	62.987	80.708	134	81	157	224	202	315	168	108	180	447	323	630
2032	68.742	64.572	82.747	137	83	161	229	207	323	172	110	184	458	331	646
2033	70.417	66.153	84.782	141	85	165	235	212	331	176	113	189	469	339	662
2034	72.067	67.711	86.784	144	87	169	240	217	339	180	116	193	480	347	677
2035	73.684	69.237	88.743	147	89	173	246	222	346	184	118	198	491	355	692



Region	Cases per			
	Physicians	Physicists	Technologists	Equipment
Center East (yellow)	323	362	134	706
Caribbean (orange)	362	532	238	696
Coffee Triangle (light red)	286	366	163	572
Pacific (dark red)	484	456	134	775
South Central (purple)	987	987	329	1481
Plains (blue)	376	1504	501	1504
Country	359	435	165	718

Fig. 1 Cancer cases requiring radiation therapy by department, human resources and available linear accelerators, Colombia 2020.

Discussion

This study presents a description of the supply and demand of current and future radiation therapy services for Colombia. Radiation therapy is an essential component for the treatment of cancer considering that between 40% and 60% of patients with cancer need radiation therapy as part of their clinical management.[11] According to the estimates made in the present study for Colombia in 2020, the percentage of cancers that would

need radiation therapy for their initial management would be between 42% and 53% (48,461-58,223 cases in 2020), not including palliative management and re-irradiations. The International Atomic Energy Agency estimates that in low- and middle-income countries (LMIC) the optimal rate of radiation therapy use is 55% for incident cancers with a 10% probability of retreatment.[12] To manage this population, the country would need to have 97 accelerators and increase the number of these to 147 to meet the disease burden in 2035 (73,684-88,743 cases per year).

The study estimated that megavoltage machine coverage is 65% (63/97), which is lower than that estimated for Latin America (75%-88%) and higher than that of Asia (45%-61%).[13,14] Compared with countries of upper middle-income countries (U-MIC) such as Colombia in Latin America and Asia, the behavior is similar, 76% and 51%, respectively.[13] Currently, the number of megavoltage machines per million people in our country is 1.305 (63/48,258,494), lower than that of U-MIC countries in Latin America (1.638) and such as that of U-MIC countries in Asia (1.135).[14]

In high-income countries, radiation therapy is used in more than 50% of the cases with different purposes such as cure, palliation of symptoms, and control of disease progression.[9] Although radiation therapy is critical to the survival of cancer patients, the inclusion of this treatment in clinical management is often the last resort considered, resulting in unacceptably low access to radiation therapy worldwide.[9]

Radiation therapy allows for the treatment of many cancer cases and generates economic benefits for the health sector by being effective, when it is used as an adjuvant or curative definitive treatment, and low cost compared with the costs of new chemotherapy treatments. However, the availability of these services varies around the world because it depends largely on the economic resources and infrastructure of health services in the country.[10]

The growing cancer burden and the high cost of its management by new technologies, mainly chemotherapy, presents a challenge to health systems, which require highly cost-effective technologies such as radiation therapy to make efficient use of scarce health resources. Countries such as Brazil, where 830,000 new cases of cancer are estimated for the year 2035, in response to the growing cancer burden, in 2011 the government proposed to expand radiation therapy services to correct the deficit of services and meet the existing demand, providing the country with high-tech equipment.[9] Among its main challenges for rapid expansion was the training of an adequate number and quality of human talent specialized in radiation therapy.[9] It is clear that there is a deficit in access to radiation therapy throughout the world, but the main limitations are the lack of investment, which causes difficulties in access to services, especially in LMIC, where the technology is obsolete.[9]

Since Law 100 was passed in 1993, Colombia has adopted a system of universal and compulsory insurance for the General System of Social Security in Health (SGSSS by its Spanish acronym). This reform sought to increase coverage in the provision of health services, increase the amount of money in the system, improve efficiency in the use of resources, and finally have a positive effect on the morbidity and mortality indicators of the Colombian population, among other purposes.[15] The SGSSS is organized as a model of regulated competition

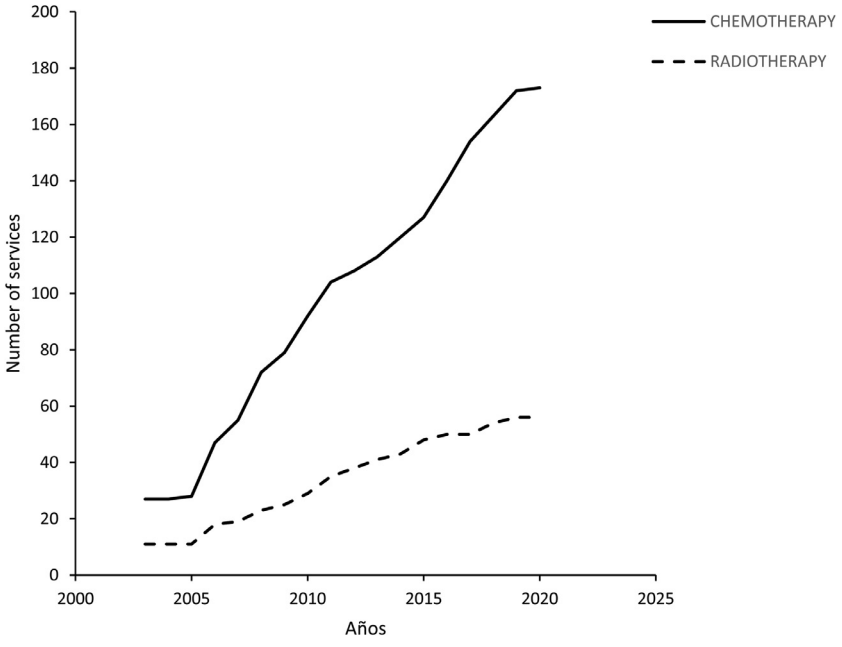


Fig. 2 Growth of chemotherapy and radiation therapy services, Colombia 2000 to 2020.

on 2 levels. The first level is constituted by the Health Promotion Companies (EPS by its Spanish acronym) that compete for members through the network of services and quality they offer. At the second level are the Health Care Provider Institutions (IPS by its Spanish acronym) that compete among themselves to obtain contracts from the EPS, through price and quality.[16]

Under this market model, the state cannot regulate the supply of health services, and so it is difficult to demand that centers serving patients with cancer offer quality comprehensive care, with access to the 3 pillars of cancer treatment: surgery, radiation therapy, and chemotherapy in one place or through a networking model between institutions. Although these issues have been the subject of different regulations (law 1388 of 2010, resolution 1419 of 2013, resolution 1477 of 2016), Colombia has not been able to obtain an adequate development of oncological services, given that there is an accelerated growth of chemotherapy services, compared with radiation therapy services (Fig 2); as chemotherapy services are less costly to implement.[17] At market prices the cost of a linear accelerator is in the range of $US 2,100,000 to 2,520,000, a brachytherapy equipment $US 350,000 to 500,000, an exclusive TAC for simulation $US 500,000 to 620,000, the costs of dosimetry, mold room, immobilization systems approximately $US 620,000. In addition, the infrastructure costs are around $US 1,000,000, and the maintenance of the equipment in the order of $US 50,000 per month. The high cost of implementation and the low tariffs have not encouraged the development of this type of service in the country.

The study of Atun et al[9] reports that the construction cost for a radiation therapy facility and shielded treatment room would be of $1200/m^2 and $1800/m^2, respectively. The operating cost per fraction for U-MIC is estimated in US $86 and the cost per additional fraction to establish new capacity (includes the investment in construction and equipment and human resource training costs) is $357. The study of Zubizarreta et al[14] estimates that the cost per radiation therapy course to guarantee full access radiation therapy in Latin America is $2079. Currently in Colombia we do not have information available on the profitability of radiation therapy services; according to available tariff manuals, the approximate cost of a 3-dimensional conformal radiation therapy treatment is $1800 and $3100 for intensity modulated radiation therapy. If 70% of patients are managed with conformal radiation therapy and 30% with intensity modulated radiation therapy, the average cost of a radiation therapy course is $2196, which would be enough to cover operational costs, but insufficient to develop new capacity.

The inadequate development of oncological services in Colombia has caused many oncological institutions to provide only some of the services of comprehensive cancer care (eg, chemotherapy).[3] The organizational and logistical problems implicit in the Colombian health system have led to the fragmentation of the attention of the oncological patient, generating problems of opportunity for the access to treatments with curative intention, integrality in the attention, and probably unsatisfactory oncological results.[3,17]

However, hand in hand with the deficiency of radiation therapy services is the deficiency of human talent. According to the results observed, Colombia does not have a sufficient supply of trained staff to deal with the estimated disease burden. By 2020, the country should have 162 radiation therapy oncologists, 121 medical physicists, and 323 radiation therapy technologists, and increase the number of radiation therapy oncologists, medical physicists, and radiation therapy technologists to 246, 184, and 491, respectively, to attend to the disease burden in 2035 (73,684-88,743 cases per year; Table 3).

Regarding these gaps, the National Institute of Cancerology (INC by its Spanish acronym) began the training of radiation therapy oncologists in Colombia by granting scholarships that allowed the general practitioner to ensure their training and receive the respective degree without economic obstacles. In the 90s, under the new regulation of the state, the academic degree can only be done by the university or technological institutions legally authorized to offer specialized training programs (Law 30 of 1992). This situation did not promote the creation of more residency programs in radiation oncology, on the contrary, the fact that the student must pay a tuition fee to the university, together with the fact that the State transformed the INC into a State Social Enterprise, structurally limited the capacity to increase the offer in the training of human talent in radiation oncology. Currently Colombia only has one training program in Radiation Oncology, which receives 2 residents a year.

Studies conducted in Europe on the resources and needs in radiation therapy report average staff per million inhabitants of 12.8 for radiation therapy oncologists, 7.6 for physicists, 3.5 for dosimetrists, 26.6 for radiation therapy technologists, and 14.8 for nurses; there was a variation between countries of up to 20 times.[18] This variability may be related to the differences between countries in terms of cancer incidence, distribution of tumor location, and tumor stage, these variablese are fundamental in determining the optimal use of radiation therapy and, therefore, the level of radiation therapy resources needed.[18] At present, Europe shows a deficit of 18.3%, 22.7%, and 10.6% in radiation therapy oncologists, medical physicists, and radiation therapy technologists, respectively.[19]

In low and middle-income countries, the outlook is more discouraging for 2012, according to information from the Directory of Radiation Therapy Centers. They observed a deficit of 38.9% in radiation oncologists, 68.4% in medical physicists, and 66.5% in radiation therapy technologists. For Colombia, the deficit in staff numbers for 2012 was 92 radiation therapy oncologists, 50 medical physicists, and 170 radiation therapy technologists.[20]

The gaps between radiation therapy need and the actual available workforce represent a large gap in terms of time and educational resources required to achieve the goal and pose a problem about the quality and safety of radiation therapy use. Newly trained human resources must be able to provide quality, efficient and safe radiation therapy based on internationally accepted standards.[21]

Colombia in 2020 had 124 radiation therapy oncologists (Table 2) with a deficit for the same year of 38 radiation therapy oncologists on average according to estimates. In our country there is only one residency program in radiation oncology with a duration of 4 years and with 2 radiation oncologists graduated per year. The United States has one residency program for every 3.3 million inhabitants, unlike Colombia, which has one program for every 45 million inhabitants.[22] Despite the deficit of human talent, ACRO refers to the enrollment of staff trained abroad who come to practice in the country. Although the deficit of medical radiation oncologists continues according to estimates, the deficit of radiation therapy equipment continues; therefore, there may even be unemployment of medical radiation oncologists trained in the country. Not counting the deficit present in the other professionals necessary for the execution of radiation therapy services.

According to the burden of oncological disease based on the percentage of cases that require radiation therapy and the current availability of radiation therapy services in the country, it is likely that there is an overload in these, which may affect quality owing to the reduction of time from the specialist in activities such as treatment planning, monitoring, and clinical follow-up.[22]

The study has limitations in relation to the fact that the estimates are based on theoretical assumptions without having a real measurement of the number of cancer cases that currently have access to radiation therapy as a fundamental part of the comprehensive management of this disease. The High-Cost Account tries to estimate the use of this treatment, however, presents problems of underregistration and quality of information, which is why studies that make estimates like the one presented in this article become a valuable source of information for the generation of public policies that allow planning the oncological services required by the country to deal with a growing cancer disease burden in Colombia.

As Colombia is a LMIC, the analysis of the supply of radiation therapy services according to the demand focused on the cancer disease burden allows to guide decision making and investments in health from the public and private sectors to guarantee an effective and quality access to cancer patients who require this treatment. Future studies should address access to new technologies in radiation therapy such as intracranial and body stereotactic radiosurgery (SRS and SBRT), gynecologic cancer brachytherapy, image guided radiation therapy, total body radiation therapy, and total electron beam skin therapy, to have a more complete picture of the current situation of radiation therapy in Colombia.

Conclusions

The country currently does not have an offer of radiation therapy services in accordance with the disease burden, causing fragmentation in the care, problems of opportunity for access to treatment with curative intent, quality of delivery, comprehensiveness of care, and probably unsatisfactory oncological results. Increasing the supply of services and human resources in radiation therapy becomes a challenge for the country because the training of specialized staff and the construction of radiation therapy facilities requires a high investment of resources and time to be implemented. However, owing to the imminent increase in the incidence of cancer this challenge must be accepted. A strategy in line with the country could be the strengthening of the supply of comprehensive cancer care centers according to the deficit by region (Fig 1) through investments from partnerships of public and private entities, the establishment of adequate tariffs that stimulate investment in this technology and quality-oriented payment modalities.

References

1. Ferlay J, Ervik M, Lam F, et al. Global cancer observatory: Cancer today. Lyon, France: International Agency for Research on Cancer. Available at: https://gco.iarc.fr/today. Accessed December 15, 2020.
2. Luengo-Fernandez R, Leal J, Gray A, Sullivan R. Economic burden of cancer across the European Union: A population-based cost analysis. *Lancet Oncol*. 2013;14:1165–1174.
3. de Vries E, Buitrago G, Quitian H, Wiesner C, Castillo JS. Access to cancer care in Colombia: A middle-income country with universal health coverage. *J Cancer Policy*. 2018;15:104–112.
4. Ministerio de Salud y Protección Social. Instituto Nacional de Cancerología E. Plan decenal para la detección del cancer en colombia 2012-2021. Available at: https://www.minsalud.gov.co/Documents/Plan-Decenal Cancer/PlanDecenal_ControlCancer_2012-2021.pdf. Accessed December 1, 2020.
5. Murcia E, Aguilera J, Wiesner C, Pardo C. Oncology services supply in Colombia. *Colombia Médica*. 2018;49:89–96.
6. Delaney G, Jacob S, Featherstone C, Barton M. The role of radiotherapy in cancer treatment: estimating optimal utilization from a review of evidence-based clinical guidelines. *Cancer*. 2005;104:1129–1137.
7. United Nations. Department of Economic and Social Affairs. Population dynamics. World population prospects 2019. Available at: https://population.un.org/wpp/Download/Standard/Population/. Accessed December 1, 2020.
8. Barton MB, Jacob S, Shafiq J, et al. Estimating the demand for radiotherapy from the evidence: a review of changes from 2003 to 2012. *Radiother Oncol*. 2014;112:140–144.
9. Atun R, Jaffray DA, Barton MB, et al. Expanding global access to radiotherapy. *Lancet Oncol*. 2015;16:1153–1186.
10. Bobadilla I. Representatividad de Radioterapia en Colombia: Centros y recurso humano. *Asociación Colombiana de Radioterapia Oncológica (ACRO)*. 2020. Available at: http://

www.acro.net.co/publicaciones.php. Accessed September 20, 2021.
11. Van Dyk J, Zubizarreta E, Lievens Y. Cost evaluation to optimise radiation therapy implementation in different income settings: A time-driven activity-based analysis. *Radiother Oncol*. 2017;125:178–185.
12. Rosenblatt E, Zubizarreta E. *Radiotherapy in cancer care: Facing the global challenge*. International Atomic Energy Agency Vienna; 2017.
13. Zubizarreta E, Fidarova E, Healy B, Rosenblatt E. Need for radiotherapy in low and middle income countries: The silent crisis continues. *Clin Oncol*. 2015;27:107–114.
14. Zubizarreta E, Van Dyk J, Lievens Y. Analysis of global radiotherapy needs and costs by geographic region and income level. *Clin Oncol*. 2017;29:84–92.
15. Congreso de la Republica de Colombia. *Ley 100 de 1993*. 1993. Available at: https://www.minsalud.gov.co/sites/rid/Lists/BibliotecaDigital/RIDE/DE/DIJ/ley-100-de-1993.pdf. Accessed September 20, 2021.
16. Congreso de la República de Colombia. *Ley 100 de 1993 Por la cual se crea el sistema de seguridad social integral y se dictan otras disposiciones*. 1993. Available at: http://www.secretariasenado.gov.co/senado/basedoc/ley_0100_1993.html.
17. Mariño MAG. Diagnóstico de instituciones prestadoras de salud con habilitación de servicios oncológicos en Bogotá, Colombia. *Gerencia y Políticas de Salud*. 2012:11.
18. Lievens Y, Dunscombe P, Defourny N, Gasparotto C, Borras J, Grau C. HERO (Health Economics in Radiation Oncology): A pan-European project on radiotherapy resources and needs. *Clin Oncol*. 2015;27:115–124.
19. Datta NR, Samiei M, Bodis S. Radiotherapy infrastructure and human resources in Europe—present status and its implications for 2020. *Eur J Cancer*. 2014;50:2735–2743.
20. Datta NR, Samiei M, Bodis S. Radiation therapy infrastructure and human resources in low-and middle-income countries: Present status and projections for 2020. *Int J Radiat Oncol Biol Phys*. 2014;89:448–457.
21. Abdel-Wahab M, Fidarova E, Polo A. Global access to radiotherapy in low-and middle-income countries. *Clin Oncol*. 2017;29:99–104.
22. Murillo R, González A, Galvis JC, et al. Radiation oncology workforce in Colombia. *JCO Glob Oncol*. 2020;6:190–194.