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RESEARCH ARTICLE

A population perspective on the use of external beam radiotherapy in Catalonia, Spain

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Abstract

Purpose To assess the use of external beam radiotherapy in Catalonia (Spain), overall and by health management area.

Methods We assessed radiotherapy treatments in a cohort of patients diagnosed with cancer from 2009 to 2011, using the population-based cancer registries in Girona and Tarragona. Participants had to have a minimum follow-up of 5 years from the time the cancer registry database was linked to the catalan health service database for financing radiation oncology. Outcomes included the proportion of patients receiving radiotherapy within 1 and 5 years of diagnosis. A log-binomial model was used to assess age-related trends in the use of radiotherapy by tumour site. Finally, we calculated the standardized utilization rate and 95% confidence intervals by health management area covered by the radiation oncology services, using indirect methods.

Results At 1 and 5 years from diagnosis, 21.4 and 24.4% of patients, respectively, had received external beam radiotherapy. Patients aged 40–64 years had the most indications for the treatment, and there was a negative correlation between the patients' age and the use of radiotherapy for most tumour sites (exceptions were cervical, thyroid, and uterine cancers). There were no statistically significant differences in the use of radiotherapy according to th health management area.

Conclusions Population-based data show that external beam radiotherapy is underutilized in Catalonia. This situation requires a careful analysis to understand the causes, as well as an improvement of the available resources, oriented toward achieving realistic targets for the optimal use of external beam radiotherapy in our country.

Keywords External beam radiotherapy · Access · Utilization · Cancer incidence · Cancer registry

Introduction

Healthcare resource planning for therapies that involve costly investments, such as radiation oncology treatments, requires a needs assessment based on the best available evidence about therapeutic indications as well as an assessment of the current real-world utilization of the treatment. This approach can elucidate potential gaps between theory and practice.

In recent years, investigators have estimated the so-called optimal utilization proportion of external beam radiotherapy. The epidemiological model used is based on the incidence

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of the disease and the stage at diagnosis, and it defines the percentage of incident cases that have a therapeutic indication for external beam radiotherapy at least once during the course of the disease for each clinical circumstance [1, 2]. Evidence on therapeutic indications for each tumour type and stage is based on clinical practice guidelines and the literature, as well as on clinical practice in the absence of published evidence. Combining Globocan incidence data [3] with cancer registry data from patients whose stage at diagnosis was available, the model was applied to different European countries to project the number of patients who would be candidates for external beam radiotherapy in 2025 [4, 5]. In Spain, the estimated percentage of incident cases that should receive this treatment was 50% [4].

This optimal utilization proportion should be contrasted with the utilization observed from population-based incidence data. In this paper, we assess the percentage of external beam radiotherapy use in patients with incident cancer in two regions covered by population-based cancer registries in Catalonia (Spain). We also report results by the individual health management area where patients resided.

Methods

The study included all patients diagnosed with cancer from 2009 to 2011 who were in the population-based cancer registries of Girona and Tarragona [6, 7], except patients with non-melanoma skin cancer. These two registries cover populations of 750,000 (Girona) and 800,000 (Tarragona), or 21% of the population in Catalonia. In both provinces, there is a single radiation oncology service providing services for the entire population. In Girona, there are three linear accelerators and in Tarragona, four, one of which is in a satellite unit 80 km from the reference hospital that manages it.

Incident cases were followed for at least 5 years to assess whether they received an indication for external beam radiotherapy in that time period. To identify the indication, we cross-referenced the registry database with the database that monitors the financing of radiation oncology in all patients receiving publicly funded radiotherapy through the Catalan Health Service. That database includes patient identification information, age, sex, tumour site, therapeutic indication (palliative or radical), total doses administered, and the dates when treatment began and finished. The cross-linkage was undertaken in the Catalan Health Service, and anonymized data were extracted for the analysis. Data were not available for treatments administered in the private sector; however, few areas have private centres offering these services, so patients would have had to travel at least 100 km to Barcelona to access private radiotherapy services.

The use of radiotherapy was calculated as the proportion of patients receiving radiotherapy within 1 year of diagnosis (by tumour type and age group) and within 5 years (by tumour type), and the percentage of treatments administered with a radical intent within 5 years. A log-binomial model [8] was used to perform a test for trend to assess the correlation between age and the use of radiotherapy by tumour type.

Finally, we calculated the standardized rate of utilization with 95% confidence intervals using the indirect method, wherein we divided the number of observed cases receiving radiotherapy by the number of expected cases in each health management area. The rates of radiotherapy use were stratified by age and sex, with the reference population being the total number of cases diagnosed with cancer in the two provinces studied. The standardization enabled comparison between the two regions on equal terms. Ratios were compared to the mean use of radiotherapy in both regions; statistically significant values of less than one were classified as underutilization, and values of more than one as overutilization. Health management areas are defined as the territory of reference for a specific hospital. All calculations were performed using SPSS software, version 21.

Results

There were 25,288 new cancer cases diagnosed in the study period (12,388 in Girona and 12,900 in Tarragona). Table 1 presents the percentage of patients treated with external beam radiotherapy within 1 and 5 years, by tumour type. In the first year, 21.4% received radiotherapy, compared to 24.4% within 5 years. The sites with the most frequent indications for this treatment were the breast, head and neck, rectum, prostate, and lung.

Table 2 shows the utilization during the first year from diagnosis, according to tumour type and age group. Patients aged 40–64 years had the most frequent indications for external beam radiotherapy, with the rate decreasing as patients' age increased for all tumour sites except the cervix, thyroid and uterus (Fig. 1). In addition, the overall percentage of treatments with a radical intent is 83.5%; by site, this frequency is especially high in neuro-oncological tumours and those located in the breast, cervix, head and neck, prostate, and rectum (Table 1). Radiotherapy with palliative intent was most frequent in tumours of the urinary bladder, ovaries, lung, and liver as well as in those with an unknown primary site.

Figure 2 shows the standardized utilization rate for radiotherapy in the first year since diagnosis, according to the health management area where the patient resided. There were no statistically significant differences between different areas.

Table 1 Current utilization of external beam radiotherapy (EBRT) within 1 and 5 years of diagnosis

Tumour	Optimal utilization proportion, Spain (%)[a]	Total cancers (*n*)	Within 1 year		Within 5 years			
			RT treatments *n* (%)		RT treatments *n* (%)		Radical intent *n* (%)[b]	
Bladder	47.1	1873	95	(5.1)	144	(7.7)	85	(63.4)
Brain	92.0	648	166	(25.6)	178	(27.5)	153	(96.2)
Breast	86.2	2969	1729	(58.2)	1846	(62.2)	1581	(96.1)
Cervix	70.3	921	95	(10.3)	99	(10.7)	86	(95.6)
Colon	3.4	3079	87	(2.8)	169	(5.5)	97	(59.1)
Gallbladder	20.4	71	3	(4.2)	3	(4.2)	3	(100.0)
Head and neck	80.2	1040	439	(42.2)	477	(45.9)	435	(97.1)
Kidney	12.4	566	29	(5.1)	45	(8.0)	1	(2.4)
Leukaemia	3.0	610	3	(0.5)	7	(1.1)	4	(80.0)
Liver	0.0	548	14	(2.6)	19	(3.5)	4	(22.2)
Lung	76.9	2326	686	(29.5)	763	(32.8)	348	(48.7)
Lymphoma	73.2	773	113	(14.6)	129	(16.7)	97	(76.4)
Melanoma	11.7	663	18	(2.7)	47	(7.1)	20	(43.5)
Myeloma	48.6	158	18	(11.4)	28	(17.7)	6	(22.2)
Oesophagus	72.6	325	80	(24.6)	89	(27.4)	73	(85.9)
Ovary	3.5	290	3	(1.0)	9	(3.1)	3	(33.3)
Pancreas	53.8	612	58	(9.5)	63	(10.3)	46	(78.0)
Prostate	58.5	3011	992	(32.9)	1179	(39.2)	1020	(93.2)
Rectum	63.0	904	377	(41.7)	403	(44.6)	349	(92.8)
Stomach	30.4	589	67	(11.4)	72	(12.2)	49	(80.3)
Testis	3.4	138	2	(1.4)	2	(1.4)	0	(0.0)
Thyroid	5.9	295	3	(1.0)	8	(2.7)	2	(25.0)
Uterus	35.2	681	135	(19.8)	149	(21.9)	126	(90.6)
Vagina	95.0	13	3	(23.1)	3	(23.1)	3	(100.0)
Vulva	36.1	91	16	(17.6)	20	(22.0)	18	(100.0)
Unknown primary	61.3	697	60	(8.6)	64	(9.2)	25	(41.0)
Others	19.8	1392	111	(8.0)	143	(10.3)	101	(74.8)
Overall	50.0	25,283	5402	(21.4)	6158	(24.4)	4735	(83.5)

[a]Source: Borras et al. 2015 [4]

[b]Denominator: number of RT treatments with intent of cure information available

Discussion

Our assessment of external beam radiotherapy reveals the underutilization of this therapeutic strategy in Catalonia, where just 24.4% of incident patients received it, compared to the estimated 50% in Spain who should [4], according to the CCORE model of evidence-based therapeutic indications for radiation oncology [1]. Our utilization data are similar to those published in some countries, for example, Australia, where 26% of incident patients were treated [9, 10]. However, they are lower than the 29% observed in Norway [11] and the 31.2% in the USA [12] and notably inferior to the 37% found in Belgium by means of similar methods as those applied in our study [13]. In short, our data show the need to improve indications for external beam radiotherapy, even in comparison to population utilization data from other health systems.

The fact that just half the candidates for treatment with external beam radiotherapy receive it should be considered in light of two factors affecting the CCORE model used to estimate need. First of all, the model does not take age into account as a variable that influences therapeutic decision-making, and in our study this was shown to be a significant aspect. Secondly, there may be other competing treatments supported by a similar level of evidence that could reduce the indications for external beam radiotherapy in clinical practice. Taken together, these factors suggest that optimal utilization rates could overestimate the indications that are clinically applicable [2]. In fact, the Malthus programme developed more recently in England with different methods and using English epidemiological data and treatment

Table 2 Current utilization of external beam radiotherapy (EBRT) within 1 year after diagnosis, by tumour type, age and therapeutic indication

Tumour	Age at diagnosis (years)								
	< 40		40–64		65–74		≥ 75		β*
	N total cancers	% EBRT treatments	*N* total cancers	% EBRT treatments	*N* total cancers	% EBRT treatments	*N* total cancers	% EBRT treatments	
Bladder	29	6.9	530	4.5	516	3.5	798	6.4	
Brain	96	24.0	248	36.7	122	25.4	181	11.0	−
Breast	176	63.1	1629	66.4	481	64.7	656	32.9	−
Cervix	487	3.1	363	14.6	38	42.1	19	57.9	+
Colon	57	7.0	907	3.2	823	3.4	1277	2.0	−
Gallbladder	1	0.0	15	6.7	18	11.1	37	0.0	
Head and neck	28	57.1	518	46.7	207	37.7	286	36.0	−
Kidney	28	3.6	194	8.8	161	3.1	183	3.3	
Leukaemia	80	0.0	164	1.2	113	0.9	253	0.0	
Liver	15	0.0	180	4.4	147	2.7	206	1.0	
Lung	17	29.4	876	40.1	639	31.3	787	16.0	−
Lymphoma	130	23.1	285	15.8	149	12.8	208	9.1	−
Melanoma	92	2.2	257	1.6	149	2.7	152	5.3	
Myeloma	2	50.0	45	13.3	38	5.3	73	12.3	
Oesophagus	3	33.3	133	35.3	87	28.7	102	6.9	−
Ovary	27	0.0	138	2.2	52	0.0	73	0.0	
Pancreas	4	0.0	163	16.0	158	13.3	286	3.8	−
Prostate	0	0.0	833	25.1	1139	43.7	1025	27.4	
Rectum	14	50.0	293	49.5	252	47.2	339	30.4	−
Stomach	13	15.4	164	21.3	140	15.0	271	3.0	−
Testis	111	0.9	22	4.5	1	0.0	3	0.0	
Thyroid	83	0.0	155	0.0	33	0.0	24	12.5	+
Uterus	127	0.8	282	24.5	124	31.5	145	17.2	+
Vagina	1	0.0	3	0.0	2	50.0	7	28.6	
Vulva	11	0.0	23	17.4	11	18.2	46	21.7	
Unknown primary	11	0.0	140	15.0	151	11.3	392	5.1	−
Others	126	6.3	385	14.5	257	9.3	623	3.7	−
Overall	1769	13.0	8945	28.7	6008	24.7	8452	12.9	−

EBRT external beam radiotherapy

*β Is the slope of the log-binomial model used to measure the temporal trend

β^{+}Statistically significant positive correlation between age and EBRT $p < 0.05$

β^{-}Statistically significant negative correlation between age and EBRT $p < 0.05$

indications, estimated that just 40.6% of incident cases have an indication for radiotherapy, compared to the 50% calculated using the evidence-based CCORE model [14, 15]. This difference indicates the uncertainty inherent to evaluating the need for treatment, a process which depends on a consideration of the latest evidence and the variations in cancer incidence across geographical areas.

The association between advanced age and a lower probability of having an indication for radiation oncology is known [16] in all population-based utilization studies. Our data confirm this relationship (Table 2), with declining utilization in the group aged over 75 across all tumour sites except cervical, vulva and thyroid cancers along with melanoma and myeloma. One factor that could explain the limited indication for external beam radiation in these elderly patients is the greater probability of comorbidity [17] and of alternative strategies like watchful waiting, used in elderly patients with prostate cancer.

Another factor that could contribute to this difference is the existence of competing treatments, which were not considered in the model as factors precluding an indication for radiotherapy. One example could be surgery as an alternative to radiotherapy for prostate cancer [18], with specialists divided over the best strategy to follow; faced with the same case of prostate cancer, urologists may prefer surgery, while radiation oncologists would recommend radiotherapy

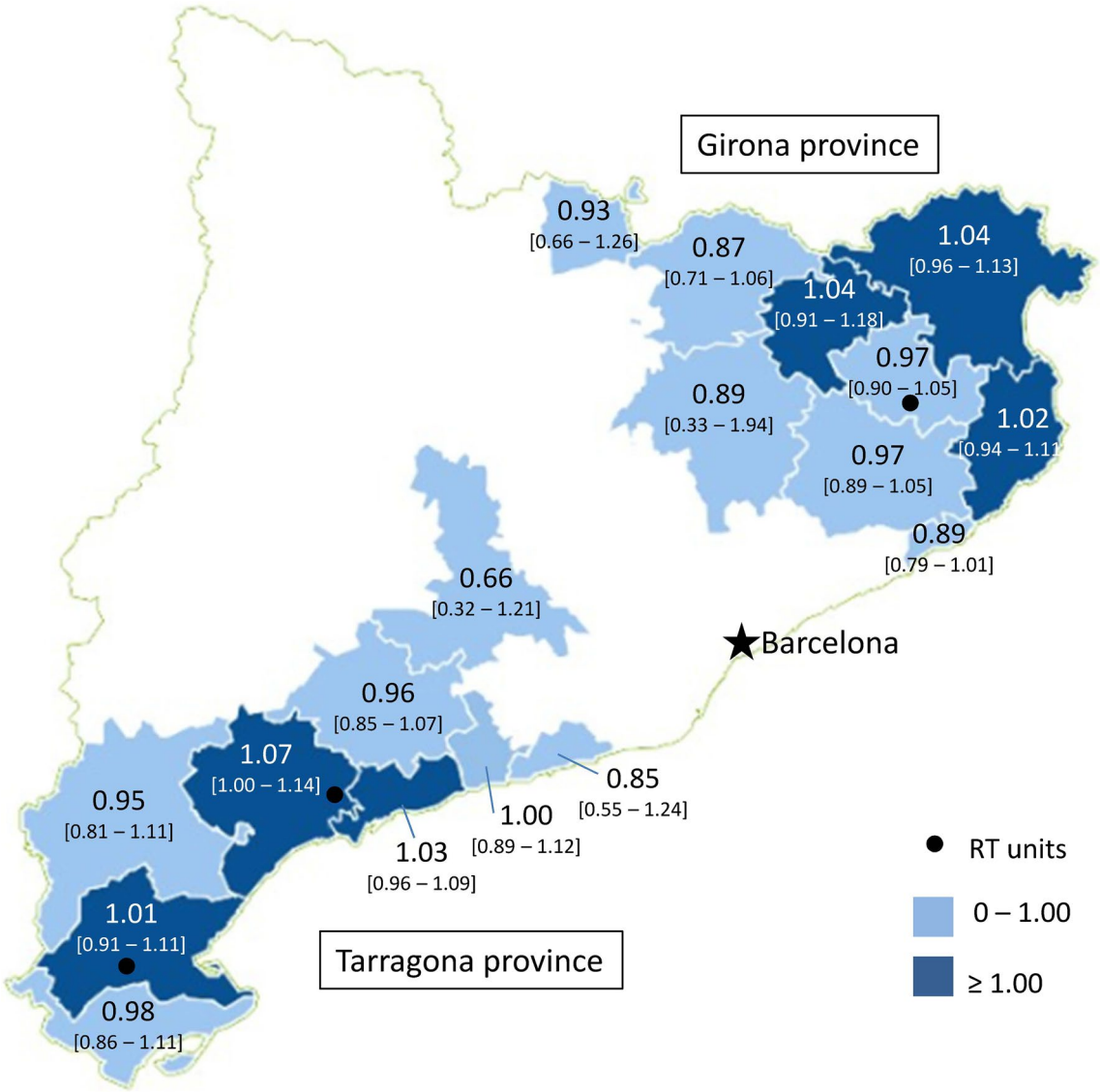

Fig. 1 Standardized rate of activity/utilization of external beam radiotherapy (EBRT), by health management area covered by radiation oncology service. EBRT external beam radiotherapy

[19]. This reduced indication for external beam radiotherapy, due to age or professional preferences, probably explains a significant portion of the differences between observed and optimal usage patterns, although quantifying this impact was not possible. In any case, if we consider a range of optimal need of 40–50% of incident cases, our data clearly support the affirmation that this therapeutic strategy is underutilized and that a proportion of 40% would be a reasonable healthcare planning target.

In addition to age and comorbidity, another factor that is traditionally associated with reduced odds of a radiotherapy indication is distance from the nearest radiation oncology service [20]. In our case, the data obtained allow us to rule out the hypothesis that the low rates of utilization are attributable to the long distances between patients' place of residence and the treatment centres. In our setting, the vast majority of municipalities are less than 100 km from the nearest treatment centre. Moreover, a satellite unit established in Southern Catalonia in 2010 has further improved geographical access for the population living furthest from the reference hospital [21], which is consistent with experiences elsewhere [22].

The tumours most likely to be treated with external beam radiotherapy in our study are for the most part in line with the evidence. That said, there are notable differences in neuro-oncological tumours (25.6% observed vs. 92% optimal [1]) and in cervical cancers (10.3% observed vs. 70% optimal), although in the latter case competition with brachytherapy

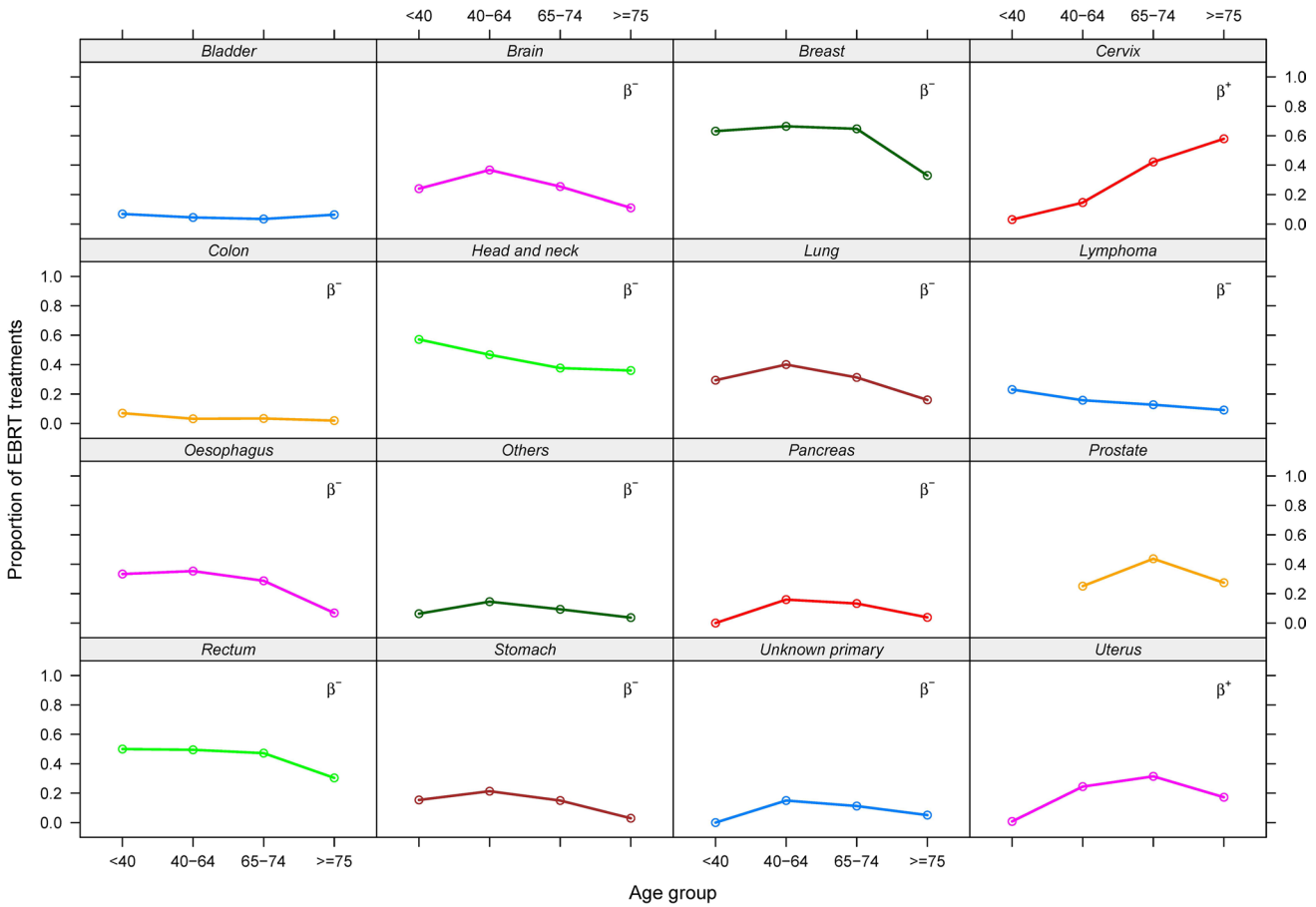

Fig. 2 Overall trend in the use of external beam radiotherapy (EBRT) by age, according to tumour type (tumours with an indication for EBRT for > 50 cases). EBRT external beam radiotherapy. *β Is the slope of the log-binomial model used to measure the temporal trend. β^+Statistically significant positive correlation $p < 0.05$, β^-Statistically significant negative correlation $p < 0.05$

could explain much of this discrepancy. Another tumour site with very low indications for radiotherapy in our study is the urinary bladder (optimal rate 47%), but this difference could also be explained by competitive treatments. In general, there were no tumours for which the observed indication was even close to the optimal rate, meaning that there is a gap between theory and practice across the board rather than in a single tumour. It is clearly necessary to improve multidisciplinary discussions through greater participation from radiation oncologists and to generate increased healthcare resources in our country. Data from the Spanish Society for Radiation Oncology (SEOR) highlight the need to step up investments in technology and increase the number of available machines as a way to improve access to treatment and make progress toward achieving optimal utilization rates [23, 24]. In light of the differences in estimates from evidence-based models and the lack of consideration given to relevant factors in therapeutic decision-making like age or competing treatments, the optimal use should probably be around 80% of what has been proposed [25]. This would imply realistic objectives for growth in the field, both with regard to professional and therapeutic resources.

We observed a high proportion of patients with an initial indication for treatment with a radical intent (83.5% of all cases). This result contrasts with the much higher proportion of patients receiving palliative radiotherapy in other countries, for example, 46% in Sweden [26] and a similar percentage in Norway [10], and with the benchmark in Canada of 33.9% for palliative treatments [27]. Even taking into account the variations in different estimates, then, palliative external beam radiotherapy is clearly underused, with most therapies applied with a radical intent. This finding suggests the need to better assess the indications for palliative treatments, which could be a key explanatory factor in the overall underutilization of external beam radiotherapy in Catalonia.

Our results should be analysed in light of certain study limitations. First of all, patients treated in private centres were not included in this analysis, so the percentage observed likely underestimates the true utilization rates by about 10% (the rate of overall private activity in radiation

oncology in our setting). Likewise, even though the population-based cancer registries are of very good quality [6, 7], we cannot rule out the possibility that some patients whose treatments were paid for were not correctly identified during the database cross-linkage. Finally, we did not analyse re-treatments, so the percentage of cases observed is a very conservative estimate.

Conclusions

All in all, population-based data show a suboptimal use of external beam radiotherapy in Catalonia. The gap observed implies that not all patients are offered all of the benefits of effective treatments for the local control of the disease, improved quality of life, or better overall cancer survival. These results highlight the need for a detailed analysis of the contributing causes, with a focus on the indications and the need for multidisciplinary discussion of the initial treatment strategy as well as qualitative and quantitative improvements in available resources. This increase in resources should be oriented toward achieving realistic targets for the optimal use of external beam radiotherapy and improving the indications for treatments with a palliative intent, which could be the greatest contributor to the underutilization of radiotherapy in our country.

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Authors contribution JC, JE and JMB contributed to the study conception and design. JG, RM, MC, AI, LV, LL contributed to data collection. JC, JS, JG, JE, JB were responsible for data analysis and data interpretation. JC and JB were responsible for manuscript writing. All authors were responsible for the approval of the manuscript.

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Compliance with ethical standards

Conflict of interest The authors declared no conflicts of interest.

Availability of data and material Data is not publicly available. Data can be requested through e-mail to corresponding author.

Ethical approval All procedures performed in the study involving human participants were in accordance with the ethical standards of the Trust and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent For this type of study formal consent is not required.

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