Clin Transl Oncol (2007) 9:789-796
DOI 10.1007/s12094-007-0141-1

Evidence-based estimation and radiotherapy utilisation rate in Andalusia

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Abstract *Introduction:* The objective of this study was to estimate the theoretical needs –based on evidence– of radiotherapy treatments (RDT) in Andalusia, compare these needs with actual use of RDT in 2006 and analyse their evolution from 2003. *Materials and methods:* Correlation between quantitative variables was analysed with Pearson's correlation coefficient. This dealt with differences between administered/estimated treatments and treatments carried out in years with the Student's t-distribution, and the χ^2 test among qualitative variables. *Results:* In Andalusia, the evidence-based rate of cancer irradiation is 55%. Eighty-five percent of theoretical treatments were administered in 2006. From this group, 107% were in gynaecological tumours, 100% in breast cancer cases, 71% in head and neck cancer and 48% in lung cancers; differences in the last two conditions were significant ($p<0.01$). As for regional distribution, differences were reported with reference to irradiation rates ($p<0.0002$) and resource distribution. In the last three years, an increment of 17% was observed in treatments conducted in public hospitals. The rate increased from 61% (with regard to optimal values) to 85% in 2006; in a parallel way, an increment was seen in therapy units (from 22 to 26) and radiation oncologists (from 57 to 69). *Conclusions:* Despite the increment of irradiation rates seen in the last years, there is still a serious underutilisation of RDT for some cancer types (lung, head and neck cancer), as well as a great variability in the use of RDT between hospitals.

Key words Cancer • Epidemiology • Evidence-based medicine • Utilisation rate of radiotherapy • Health care policy

Jaén Olasolo J, Alonso Redondo E, Expósito Hernández J et al (2007) Evidence-based estimation and radiotherapy utilisation rate in Andalusia. Clin Transl Oncol 9:789-796

Introduction

In absolute numbers, cancer was reported to be the leading cause of death in Spain in 2000; it represented 25.6% of deaths [1]. More than half of cancer patients receive radiotherapy during the evolution of this condition; the treatment accounts for 40% of healings [2, 3]. In view of the complex framework of this type of unit, their geographical distribution has always been based on the unfolding of this technique in reference hospitals rather than on demographic reasons and equity criteria. This has produced serious cases of inequity, where privileged zones around large urban areas have a greater political and economical weight than areas that are more dispersed and depressed [4]. In the UK, for instance, the number of linear accelerators per million of the population varies from 2 to 6 according to different regions [5]. These differences can also be seen in other areas; mean figures of 3–6 units per million of the population are reported in England and France, respectively. Great geographical disparities are also seen in the USA [6]. A recent study on the number of RDT Services per 1000 annual expected cases reported figures that vary between 0.84 in Rhode Island and 3.38 in North Dakota; it reported a mean value of 1.69, and revealed extensive rural zones (Nevada, Utah, Wyoming, South Dakota) where the distance from the nearest RDT centre is very high. With regard to this point, we know that distances may be a significant hindrance, both in Europe [7, 8] and the USA [9], for RDT, specially in post-operative treatments.

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Received 14 May 2007 / Accepted 5 October 2007

The only studies available in our country, both at national level [4, 10] and in Andalusia [11], are globally descriptive; no differences are adjusted among patients and therefore such studies are focused on differences in equipment and infrastructures.

As a result of all this and with regard to our state of affairs, the European Commission financed a project called Quantification of Radiation Therapy Infrastructure and Staffing needs (QUARTS) [12]; it was carried out by the European Society for Therapeutic Radiology and Oncology (ESTRO) with the aim of providing the European health-care authorities with objective estimations of RDT needs, both for infrastructure and staff.

The first objective of this study was to estimate the evidence-based theoretical needs for RDT treatments in Andalusia and their distribution per province; this was carried out by a methodology similar to that of the European project QUARTS. The second objective was to study the relation between the theoretical needs and the "actual" situation; this relation was obtained from the data reported in individual public hospitals with the aid of a survey requested by the Dirección del Plan Integral de Oncología de Andalucía. The third objective was to carry out a comparative analysis of rates of irradiation sessions in 2006, with reference to the situation seen in 2003, using the VARA study as a comparison model [13].

Materials and methods

First and foremost, an estimate was made of the incidence of new cancer types (anatomic localisation) and geographical distribution per provinces with the aid of data supplied by the only Andalusian Record Office for the control of cancer-affected population, located in Granada province, in the period 1998–2000 (3 years). These data, divided by three for annual incidence calculation, will be extrapolated to the rest of the Andalusian provinces to be multiplied by a weighting factor obtained from population figures supplied by the National Institute of Statistics; these figures make reference to the regulation 1-1-2006 (Royal Decree 1627/2006, 29 December). This demographic weighting factor will be obtained by dividing the population of each province by that of Granada.

Secondly, appropriate evidence-based rates for the utilisation of RDT on different cancer types were grouped in 23 anatomic localisations according to the Collaboration for Cancer Outcomes Research and Evaluation (CCORE) [14]. This is the percentage of cancers that should receive RDT in an ideal situation. In order to employ those rates on local data, all cancer types from the Granada Record Office were grouped into this model comprising the 23 anatomic localisations mentioned in the report. Once these percentages were applied to the absolute incidence value, a non-corrected estimate was obtained with regard to the number of RDT that are necessary for newly diagnosed cancers during that year.

Thirdly, theoretical data on the number of necessary treatments were compared with those that were really conducted; this was performed with the aid of data supplied by individual public hospitals in Andalusia and in response to a survey requested by the Plan Integral de Oncología de Andalucía", where it referred to the number of RDT treatments conducted during 2006. In particular, it mentioned the total number of patients who were treated *in situ* and those who were sent to private centres; this survey also made reference to the four most prevalent tumour localisations (breast, lung, gynaecology and head and neck cancer). Information on the number of treatment units and radiation oncologists was also requested.

On the basis of the distinct complexity of treatments and "re-treatment" factors (patients who receive more than a RDT treatment), some necessary corrections were made in order to evaluate the need of resources (number of treatment units) throughout Andalusia geography with the use of the methodology employed in the QUARTS project. The following weighting factors should be applied to the calculation process previously described referring to annual RDT:

1. Complexity factor according to tumour localisations. Obtained through the process of dividing the mean number of fractions delivered on each tumour site by the mean number of total fractions with the use of data supplied by the SBU (Swedish Council on Technology Assessments in Health Care) survey [15]. For instance: head & neck, 1.54; colorectal, 0.38, etc.
2. Re-treatment factors. The European literature shows distinct figures of re-treatment rates; this depends on the uses observed in each region, where these figures may reach values of 1.25. In our sphere, though, a figure of 1.15, based on previous data drawn from public hospitals in Andalusia, is more plausible.

Once all these factors have been applied, a corrected assessment was obtained on the number of RDT treatments that are needed annually, both for tumour localisations and geographic zones (provinces).

Finally, a comparative study was conducted on RDT utilisation rates in 2006 with regard to data obtained in 2003, where this information was obtained through the VARA study. This study was chiefly designed to analyse the variability of RDT employment; it also renders data on first-attempted RDT treatments (re-treatments excluded) during the first semester of 2003 in Andalusia. In this period of time, 4833 new cases were treated with RDT in Andalusia; from this group 3954 were in public centres and 879 (18%) in private ones through agreements between the parties. Five tumour localisations were studied specifically (breast, lung, endometrium,

cervix and ORL tumours), and this allowed us to consult 1536 case histories out of a group of 1782 cases treated in public hospitals.

Statistical methodology

The correlation study between qualitative variables was conducted with Pearson's correlation coefficient. Comparisons between quantitative variables of treatments administered and treatments estimated, or treatments delivered in 2003 against those conducted in 2003, were carried out using the Student's t-test for paired samples. Differences between qualitative variables (centres, provinces, types of cancer, etc) were analysed using the χ^2 test. Levels of statistical significance showing p-values inferior to 5%, two-tailed calculation, were taken into consideration. These analyses employed Statistical Product and Service Solution (SPSS), version 12.0.

Results

A mean value of 0.55 is obtained when appropriate rates (evidence-based) of RDT utilisation from the CCORE report are applied to the distribution of cancer types in Andalusia (extrapolated from the Granada Record Office). So, we expect to treat 55% of new diagnosed cancers in our sphere.

Figs. 1 and 2 show, comparatively, the estimates on the appropriate theoretical number of treatments/years and those that were really administered during 2006; they are listed per province, where the whole Andalusian region is included. Figs. 1 and 2 also show the four types of cancer under analysis (breast, lung, gynaecological and head and neck tumours). In our administrative region, gynaecological tumours tend to be over-irradiated (107% with reference to theoretical rates) non-significantly (p=0.98). However, some geographical differences were found: in four provinces, tumours were treated well above the expected values (103%, 107%, 122% and 147%), while in the rest of provinces, values were lower (71%, 76%, 90% and 91%). With regard to breast cancer, adequate RDT utilisation rates superimposed globally with actual ones (100%); some differences, though, were observed among provinces: four of these provinces delivered less treatments than expected (61%, 76%, 86% and 85%), while more treatments (105%, 111%, 116% and 124%) were observed in the rest of provinces. Head and neck tumours and lung cancers were treated less than expected and showed global figures that reached 71% and 48%, respectively; these differences were statistically significant (both showed p<0.001). With regard to irradiation rates (actual against theoretical), differences observed among provinces were statistically significant (p=0.0002).

The relation between available resources (therapy units and radiation oncologists), total amount of new treatments administered to patients of the Andalusian Public Healthcare System in 2006 and the theoretical number calculation can be found in Table 1. In all, 85% of optimal theoretical treatments were administered. We also find here geographic differences that are statistically significant (p<0.0001): two provinces administered treatments around 50% of what is regarded as optimum, while in the other three provinces figures got close to 100% (95%, 96% and 98%); the rest of the provinces showed intermediate figures (82%, 86% and 88%). Available public healthcare resources, such as staff (radiation oncologists) and technical equipment (therapy units) can also be found in Table 1. We conclude from all this that the geographical distribution of resources is unequal; the mean number of units per inhabitant is 3.2 (range, 2.5–4.6) and the number of radiation oncologists is 8.5 (range, 0.6–11.4) per million of population.

Table 2 shows the differences observed between the performance of therapy units and the number of radiation oncologists; treatments conducted in private centres under agreement are excluded. These data are merely descriptive and are not part of this study. It should be taken into account that despite the marked differences observed among centres, all figures are conditioned by the peculiarities of each centre: type and age of the units (cobalt-therapy units, linear accelerators with/without multileaf collimation), use of special techniques, operational timetable, healthcare activity, etc. In the whole region of Andalusia, the mean annual rate of new treatments/year/therapy unit was 374, ranging between 171 and 689. The mean annual rate of new treatments per radiation oncologist was 145, ranging between 71 and 212.

The relation between the number of treatments administered in each public centre and population rates concerning both radiation oncologists and therapy units was also analysed; it yielded a significant statistical correlation (r=0.888/p<0.001 and r=0.823/p=0.001).

As for the calculation of RDT treatments, we shall use the corrected estimates while we bear in mind the "complexity" and "re-treatments" factors involved. Table 3 shows the expected annual incidence in Andalusia for the distinct types of cancer as well as the number of new RDT treatments that could be generated if patients really received treatments based on the best evidence. It shows a global figure of 15,786 RDT treatments each year. That means 35 units are needed for a single therapy unit ratio for each 450 treatments/year in Andalusia. Breast, lung, colon, head & neck, prostate, bladder and gynaecological are, in order of importance, the cancer types involved in the highest number of new RDT treatments. These conditions represent 60% of theoretically expected treatments in a RDT unit.

Table 4 shows the assessed annual incidence of the total of cancers per province, the number of evidence-based treatments/year, the number of therapy units

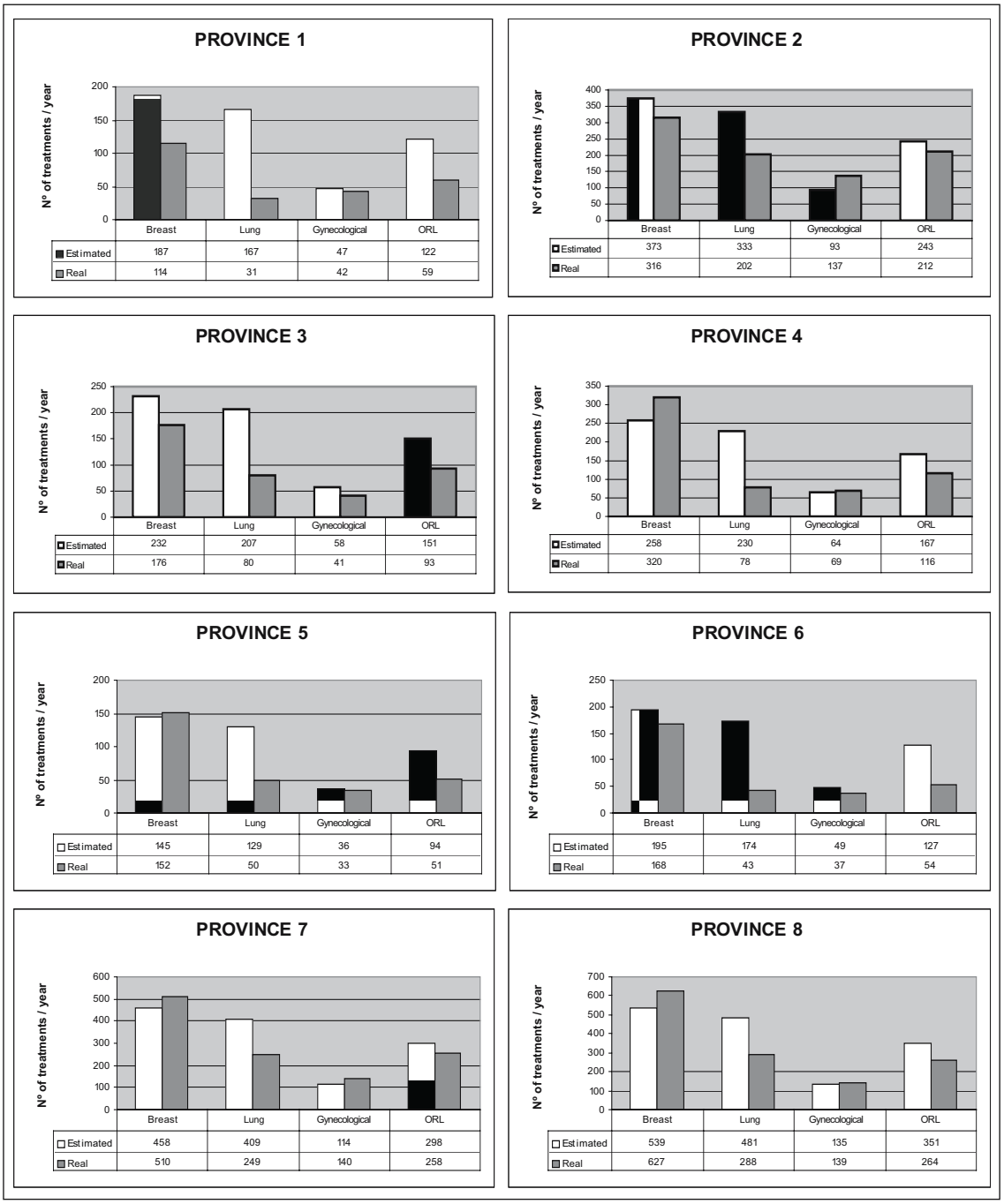

Fig. 1 Relation between evidence-based estimation and real use of RDT in Andalusia, per province and cancer type in 2006

available to cover the needs and the current number of units. Population figures showed in the provinces of Cádiz and Málaga include the population of Ceuta and Melilla, respectively, as their inhabitants are treated in the aforesaid provinces. A ratio of 450 treatments/year/unit has been taken into consideration for the calculation of the theoretical needs of therapy units. Thus, the range of units each province needs varies between 2 and 8 depending on its demography. Fig. 3 shows the current situation with regard to the number of therapy units in Andalusia, both public and private.

Finally, an evolutionary study was conducted in order to compare the situation in 2003, through the VARA study (data of a semester extrapolated to a single year) and that of 2006 through a survey requested by the Plan Integral de Oncología de Andalucía.

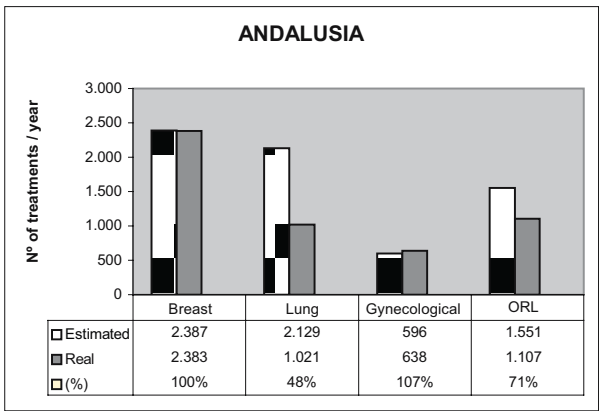

Fig. 2 Relation between evidence-based estimation and real use of RDT in Andalusia (global) on cancer types in 2006

We can affirm, bearing in mind some reservation, as the methodology for acquiring data was different, that there was an increment of 6% in total new treatments administered in Andalusia in 2006, compared with data collected in 2003 (10,255 *vs.* 9,666) and the percentage of patients sent to private centres has dropped to 50% (from 18 to 9). In other words, new treatments performed in the Public Services of Andalusia, have increased up to 15% in the last three years (9,319 *vs.* 7,908). The analysis per province and hospital shows a significant variability, just as has been the norm in this study. If we take into consideration the percentage of treatments administered with reference to theoretical ones (evidenced-based), this percentage has increased from a value of 61% in 2003 to 85% in 2006. With regard to the four anatomic localisations analysed

Table 1 Relation between resources, real use and evidence-based estimation of RDT in Andalusia in 2006 with reference to the total treatments/year

Provinces	Estimate	Treated	(%)[a]	Units per million of population[b]	Radiation oncologists per million population[c]
P1	947	458	48	3.1	6.3
P2	1891	1551	82	3.1	6.3
P3	1174	1118	95	2.5	10.1
P4	1305	1257	96	4.6	11.4
P5	733	634	86	4.1	10.2
P6	987	541	55	3.0	6.0
P7	2321	2284	98	2.6	7.1
P8	2733	2412	88	3.3	9.3
Total	12,092	10,255	85	3.2	8.5

[a]Relation between real rate of utilisation (number of patients treated, in public and centres or sent to private facilities) and evidence-based RDT treatments estimated, expressed by percentage values
[b]Public RDT units
[c]Radiation oncologists in public hospitals

Table 2 Variability observed in public hospitals. Annual rates of treatments per unit and per available radiation oncologist

Hospital	No.	Therapy units[a]	Treatments per unit	R.O.[b]	Treatments by R.O.[c]
H1	458	2 (1.4)	327	4	115
H2	128	1 (0.75	171	2 (1.8)	71
H3	1081	3	360	6	180
H4	1111	2	556	8 (7.5)	148
H5	827	2	414	6	138
H6	430	2	215	4	108
H7	634	2 (1.75)	362	5	127
H8	541	2	271	4	135
H9	689	1	689	4 (3.25)	212
H10	999	3	333	7	143
H11	1647	4	412	9 (8.2)	201
H12	765	2	383	8 (7.25)	106
Total	9310	26 (24.9)	374	69 (64)	145

[a]Therapy units in each centre. Parentheses comprise whole numbers and decimals that make reference to partial time use (new units)
[b]Radiation oncologists in each centre. Parentheses comprise whole numbers and decimals that make reference to their partial time occupation (new job contracts and partial time contracts)
[c]Number of annual treatments administered by each centre. Private centre figures are not considered

Table 3 Evidence-based needs for the utilisation of RDT in Andalusia, expressed by cancer types

Cancer type	Expected annual incidence	Expected annual treatments
Testicle	83	32
Oesophagus	222	185
Myeloma	383	117
Thyroids	386	31
CNS	439	500
Melanoma	479	36
Pancreas	488	223
Kidney	494	107
Gall bladder	500	52
Liver	664	0
Leukaemia	723	23
Rectum	995	262
Lymphoma	1013	528
Stomach	1072	584
Unknown	1130	553
Gynaecological	1702	790
Bladder	1949	1676
Prostate	1952	1682
ORL	1989	2729
Colon	2100	236
Lung	2801	2105
Breast	2875	3018
Others	797	319
Total	25,237	15,787

by the VARA study and the data assessed in 2003, 90% of breast cancers, 30% of lung cancers, 105% of gynaecological tumours and 61% of head and neck tumours underwent treatment. It is interesting to see that percentage values have undergone an upward correction in 2006 (100%, 48%, 107% and 71% respectively), although similar differences are still observed among all of them.

It is worth mentioning that the increment of treatments has occurred parallel to the improvement of available resources between 2003 and 2006. Specifically, the number of therapy units in public centres increased from 22 to 26 and from 57 to 69 in the case of radiation oncologists.

Discussion

There are two studies that deal with the use of "evidenced-based" RDT. The first study is Canadian and was presented by Tyldesley et al. in 2001 [16]; it was conducted by the Cancer Care & Epidemiology Division of the Queen's Cancer Research Institute (QCRI). The second, Australian, study (CCORE) was selected for the carrying out of calculations in the study. Both studies use a similar decision trees methodology for estimating an optimal rate of RDT utilization, based on the incidence of each type of cancer obtained from cancer registries, and the proportion of patients included in different clinical situations (i.e. stage of the disease) in which RDT was recommended as the treatment of choice on the basis of published evidence.

After the application of these rates to the incidence of cancer in the Andalusian region, an appropriate RDT utilisation figure is obtained for new cancer cases; it reaches 55% and is higher than that described by Delaney et al. [14] and CCORE (52%). We find that 85% of expected treatments are administered when theoretical rates are compared with real data. As for lung cancer, it is worth mentioning that values do not even reach half of what is expectable (48%). The lack of availability in RDT resources would force lung cancer patients who need RDT to undergo other types of treatment, such as chemotherapy, palliative treatments, etc. Less than the expected number of head and neck tumours are treated (71%), while breast cancers show the expected percentage (100%); the figure is higher (107%) for gynaecological tumours.

The geographical variability cannot be explained by differences in technological equipment, as all provinces owned linear accelerators at the time of the study. Other factors could also be involved, for instance, epidemiological factors, as data from the only population record in Granada had to be extrapolated.

Another possible cause of bias could be related with the group of patients who consult private centres and

Table 4 Evidence-based needs in RDT utilisation per province in Andalusia

Provinces	Expected annual incidence of cancers	Expected annual treatments[a]	Units needed[b]	Available units
P1	1997	1236	2.7	2
P2	3948	2469	5.5	4 (+1[c])
P3	2450	1553	3.4	2
P4	2723	1704	3.8	4
P5	1530	957	2.1	2
P6	2060	1289	2.9	2
P7	4844	3030	6.7	4 (+3[c])
P8	5704	3568	7.9	6 (+1[c])
Andalusia	25,236	15,786	35	26 (+[c])

[a]Expected annual treatments and corrected by "complexity" and "re-treatment" factors
[b]Therapy units needed to cover theoretical needs, on the basis of a ratio of 450 treatments/year/unit
[c]Private units

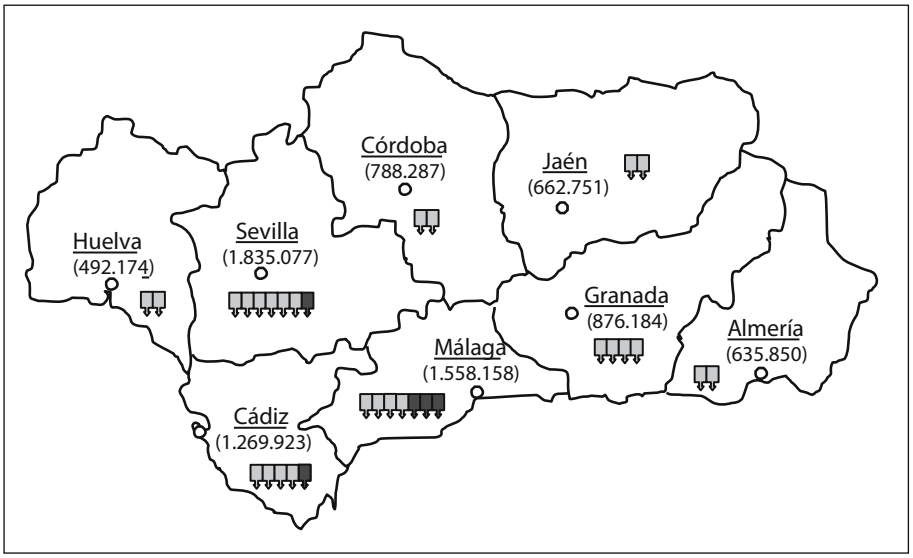

Fig. 3 Geographical distribution of therapy units that are available in the Andalusian region at present. Figures in parentheses represent present population. Data taken from the National Institute of Statistics. Cádiz and Málaga include Ceuta and Melilla population, respectively
Public therapy units; Private therapy units

who are not regarded in this study; we believe, though, the number is very small and it does not influence the general conclusion substantially. The most probable hypothesis with reference to these differences could be related to the variability in the clinic practice.

There is in fact an obvious relation between the number of treatments administered in each public centre and human and technical resources (physicians and units).

As for the number of theoretical treatments, which is considered according to the level of complexity and retreatment factors, it is expected that a total of 15,786 annual treatments will be administered in our administrative region. Therefore, it would be necessary to have some 35 therapy units available; this figure has not yet been reached. At present, 25 units are used for treatments in public centres, to which 5 more units have been added from private facilities.

All things considered, we can see that in the last three years there has been an increment in treatments administered to patients; this increment has been parallel to the increment of available resources as it has been a consequence of the boost driven by the first Plan Integral de Oncología de Andalucía 2002–2006 [17]. An example of this is the fact that at present 85% of the optimal cases estimated are under treatment, while in 2003 the figure of recorded cases was 61%. Nevertheless, and despite the efforts carried out, we still detect a serious underutilisation of RDT in some types of cancer, such as in the case of lung or head and neck tumours. Therefore, public investment is necessary to help reach the number of therapy units needed to undertake, with medical criteria ("evidenced-based"), 100% of RDT demands; above all, we must bear in mind this study has not dealt with the use of special techniques (total body irradiation, radiosurgery, etc), or the progressive implementation of new technologies (high-dose intensity modulated, image-guided RDT, etc) that are now in used in clinical practice and which demand additional resources.

On the other hand, there is significant variability observed in the use of RDT, which cannot be explained by epidemiological differences or patient's choices, but is on account of the unequal distribution of resources or the different practice styles of professionals. It is curious to see how global rates of irradiation sessions have increased in this period under study; there are no data, though, that can make us think of a reduction in the practice of variability. Hence, we think that resources should be increased without neglecting the employment of some actions that may minimise the variability issue. We refer to the process of generalisation observed in multidisciplinary equipment centres devoted to the treatment of cancer conditions, which are enrolled in clinical commissions or functional units, and the unfolding of diagnosis–therapeutic procedures that are evidence-based and have reached a consensus.

Acknowledgements The authors would like to thank the personnel in charge of all the radiotherapy units of the Andalusian public hospitals for the information they supplied on their professional activity and resources.

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