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BRIEF RESEARCH ARTICLE

Quality indicators in radiation oncology: proposal of the Spanish Society of Radiation Oncology (SEOR) for a continuous improvement of the quality of care in oncology

J. López Torrecilla[1] · S. Marín i Borràs[2] · A. Ruiz-Alonso[3] · J. Jaen Olasolo[4] · M. L. Vázquez de la Torre[5] · E. Bóveda Carro[6] · A. Rodríguez[7] · E. Ignacio García[8] · F. Caballero Martínez[9] · F. J. Campos Lucas[9] · P. C. Lara Jiménez[10,11] · J. Contreras Martínez[12] · C. Ferrer Albiach[13]

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Abstract

Purpose Current cancer treatment options include surgical intervention, radiotherapy, and chemotherapy. The quality of the provision of each of them and their effective coordination determines the results in terms of benefit/risk. Regarding the radiation oncology treatments, there are not stabilised quality indicators to be used to perform control and continuous improvement processes for healthcare services. Therefore, the Spanish Society of Radiation Oncology has undertaken a comprehensive project to establish quality indicators for use with the information systems available in most Spanish healthcare services.

Methods A two-round Delphi study examines consensus of several possible quality indicators ($n=28$) in daily practice. These indicators were defined after a bibliographic search and the assessment by radiation oncology specialists ($n=8$). They included aspects regarding treatment equipment, patient preparation, treatment, and follow-up processes and were divided in structure, process, and outcome indicators.

Results After the evaluation of the defined quality indicators ($n=28$) by an expert panel (38 radiation oncologist), 26 indicators achieved consensus in terms of agreement with the statement. Two quality indicators did not achieve consensus.

Conclusions There is a high degree of consensus in Spanish Radiation Oncology specialists on which indicators in routine clinical practice can best measure quality. These indicators can be used to classify services based on several parameters (patients, equipments, complexity of the techniques used, and scientific research). Furthermore, these indicators allow assess our current situation and set improvements' objectives.

Keywords Radiation oncology · Quality indicators · Delphi · Consensus · Healthcare services

Purpose

The *Institute of Medicine* [1] reported (2001) 1% of deaths every year caused by medical errors in Unites States (US). Many reasons could promote this situation; the most frequent are: treatment delays, dose errors, treatment delivery errors, unsuitable treatments, or errors in treatment equipment.

The three synergistic pillars of the current cancer treatment are surgery, radiotherapy, and chemotherapy. The quality of the provision of each of them and their effective coordination determines to outcomes.

Radiation oncology (RO) quality assurance in Spain is regulated by law [2]; however, this law does not establish the definition of any type of quality indicators to be used to perform control and continuous improvement processes for healthcare services. This study focuses on: RO treatments, the instrumental quality control (including treatment equipment and patient preparation), treatment, and follow-up processes.

In cancer patients, the National Cancer Institute [3] defines quality of care as "the provision of evidence-based, patient-centered services throughout the continuum of care in a timely and technically competent manner, with good communication, shared decision making, and cultural sensitivity, with the aim of improving clinical outcomes,

✉ J. López Torrecilla
jltorrecilla@eresa.com

Extended author information available on the last page of the article

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including patient survival and health-related quality of life (QoL)".

The complexity of the quality of cancer care is impossible to measure without suitably comprehensive indicators to assess the various components of quality, which are sensitive to progressive and regressive changes in daily practice.

The Spanish Society of RO (SEOR), concerned with ensuring the best possible care to each patient, has undertaken a comprehensive project for the continuous quality improvement in Spanish RO. The aim of this project is to select, prioritise, and define some indicators of use suitability and quality of healthcare for SEOR. The first part of this project was realised by an expert Working Group (WG) that selected the quality indicators that SEOR proposes as appropriate for use with the information systems available in most Spanish healthcare services. On this basis, the project will continue to promote quality measurements in these services and to establish individual/collective improvement objectives. The study was completed establishing detailed standards of good practice for each indicator selected (and additional information to facilitate their correct use and widespread implementation) in collaboration with Spanish Society for Healthcare Quality (SECA, for their initials in Spanish).

Methods

Collaborative project for professional consensus promoted by SEOR, involving RO specialists assisted by SECA specialists and a university technical team specialised in qualitative research techniques and group dynamics. The process was carried out in four consecutive phases, each with different aims and participants, between February and December 2015.

Phase 1

Literature review of the study subject matter by a search in biomedical databases (Medline, Excerpta Médica, CancerLIT, National Guideline Clearinghouse, Cochrane Library Plus, Guía Salud, Lilacs, IME). The objective was to identify the previous proposals, at national or international level, regarding criteria, indicators, and healthcare quality standards in RO, either in general or linked to specific pathologies.

The extensive collection of publications founded ($n = 38$), with information on appropriate use and healthcare quality in RO (original articles, systematic reviews, expert consensus, clinical guidelines, healthcare technology evaluation reports, and other technical documents), was analysed and evaluated by a WG. This WG was composed of eight RO specialists, with interest and/or training in healthcare quality. They analysed the quality of the documents, identifying possible quality indicators and choosing and transcribing those considered appropriate for Spanish RO for discussion among professionals in the subsequent phases of the project.

Subsequently, based on the expert input (who suggested between 10 and 28 items) to avoid concept repetition or overlap, the specialised members of the technical team produced a common documentary base of 48 possible clearly defined indicators (Table 1). According to the classification proposed by Donabedian [4], this initial set was composed of seven structure indicators, 24 process indicators, and 17 outcome indicators (including the treated patients opinion).

Phase 2

Pre-selection of indicators subject to professional consensus. The WG set the international aim of not exceeding 25 indicators, completely covering the patient preparation, the treatment and the follow-up process in RO services. The aim was to ensure the manageability of the final proposal indicators in the improvement plans of the specific healthcare units and the viability of measuring them under real standard practice.

Each group member assessed the relevance of each of the 48 indicators proposed (secret vote), using a scale of 0–10 (lowest–highest relevance), considering the 0–4 range score as a "non-critical indicator", and the 5–10 range as an "essential indicator". The group was then informed of the average score for each indicator after their initial positioning. After free discussion, a second round of secret vote was performed to confirm the final selection of the items with the greatest support. In this round, each member could accept a maximum of 20 indicators; the rest would be rejected. Eventually, *28 indicators* with the most support were chosen (eight structure, 15 process, and five outcome indicators) (Table 1).

Phase 3

Validation of the final selection of the indicators chosen by structured professional consensus. A two-round Delphi technique was carried out to involve an external representative of the WG in the final approval process of the definitive indicators that SEOR would like to disseminate as its own.

A Panel of Experts was constituted with 38 of the 51 expert radiation oncologists invited, using a snowball or chain sampling strategy among SEOR associates. All members, with broad geographical representativeness (nationwide), had recognised professional prestige in the field of study,

Given the experts' expected systematic support for all items (practically all of which are from prestigious scientific documentary sources), the objective was: to endorse

Table 1 Results after the two rounds of the Delphi survey regarding the proposed criteria

No.	Item	Average	Median	Inter-quartile range	% outside the median	Consensus outcome
1.	Number of treatments and radiotherapy (RT) sessions administered per therapy unit	7.11	7	2	21.62	Agreement
2.	Number of external beam radiotherapy treatments and BRT per doctor specialising in radiation oncology	7.08	8	1.5	24.32	Agreement
3.	Percentage of patients evaluated by a Multidisciplinary Committee before any cancer treatment	8.16	9	1	5.41	Agreement
4.	Percentage of treatments performed using special techniques: Non-volumetric IMRT, volumetric IMRT, daily iGRT, stereotactic radiosurgery (SRS), stereotactic body radiotherapy (SBRT), gating, photon total body irradiation, electron total body irradiation, intraoperative radiotherapy, paediatric treatments, treatments under general anaesthesia	7.68	8	2	21.62	Agreement
5.	Percentage of RT equipment time lost due to unscheduled interruptions	7.59	9	2	21.62	Agreement
6.	Percentage of patients referred to another medical center due to a lack of suitable technical resources for patient treatment	7.59	8	2	16.22	Agreement
7.	Percentages of patients with signed informed consent	8.44	9	0	8.33	Agreement
8.	Number of radiotherapy treatments re-scheduled (one or more schedules planned based on CT images during the course of radiotherapy)	6.86	7	2	32.43	Agreement
9.	Time taken to gain access to the radiation oncology service (time between the date of the proposal or request for treatment and the date of registration in the service)	7.05	8	2.5	24.32	Agreement
10.	Response time of the radiation oncology service (time between registering the treatment proposal in the radiation oncology service and the date of the first visit)	8.19	9	2	2.7	Agreement
11.	Time required for the radiotherapy treatment preparation process (time between the date of the simulation (CT) and the date of the first treatment session)	7.92	9	2	13.51	Agreement
12.	Number of patients receiving SBRT treatment for stage I and II lung cancer.	6.13	5	2	58.06	No consensus
13.	Percentage of patients with extended total treatment time (> 7 calendar days) for any cause	7.57	8	2	18.92	Agreement
14.	Appropriate dose of external beam radiotherapy in prostate cancer (percentage of prostate cancer patients treated with external radiotherapy who receive a dose ≥ 75 Gy (≥ 166.3 Gy DBE)	6.95	8	3.5	27.03	Agreement
15.	Appropriate dose of brachytherapy in prostate cancer (percentage of prostate cancer patients treated with brachytherapy who receive a dose > 140 Gy)	6.65	7	3	32.43	Agreement
16.	Use of hypofractionated regimens in prostate cancer (percentage of prostate cancer patients who are treated using external beam radiotherapy treatment regimens with less than 30 fractions or with doses per session ≥ 250 cGy)	6.35	7	3	38.71	Agreement
17.	Patients treated with IMRT in head and neck cancer	7.92	9	1	13.51	Agreement
18.	Patients assessed for whom radiotherapy with curative or palliative intent is indicated, who have had CT scans and a treatment schedule drawn up but do not initiate it	6.9	8	3	29.03	Agreement[a]
19.	Percentage of verifications performed throughout the course of the RT treatment (percentage of RT treatments, where verifications are performed on the shape, size or position of the target in at least 20% of the sessions administered)	7.84	8	2	8.11	Agreement
20.	Use of hypofractionated regimens in breast cancer (percentage of breast cancer patients treated with adjuvant external RT after conservative surgery who receive hypofractionated RT as opposed to conventional treatment)	7.22	8	3	27.03	Agreement
21.	Neoadjuvant radiotherapy in rectal cancer (percentage of patients with locally advanced rectal cancer (T3/T4 and/or N + and M0) who receive neoadjuvant RT ± QT)	7.19	8	2.5	24.32	Agreement

Table 1 (continued)

No.	Item	Average	Median	Inter-quartile range	% outside the median	Consensus outcome
22.	Percentage of re-treatments. Number of patients treated using radiotherapy a second or subsequent time in previously unirradiated areas	7.06	8	3	29.03	Agreement[a]
23.	Percentage of re-irradiations. Number of patients treated using radiotherapy a second or subsequent time in areas that have been previously irradiated	7.24	8	3	27.03	Agreement
24.	Indicator of serious chronic complications (related to radiotherapy treatment ≥ Grade 3 on the CTC scale v4)	8.14	8	1	2.78	Agreement
25.	General indicator of patient satisfaction in relation to the radiotherapy treatment received (EORTC OUTPATSATSAT35 RT satisfaction questionnaire)	7.47	7.5	2	22.22	Agreement
26.	Total number of publications in which the radiation oncology service has taken part and their total impact	7.03	7	1.5	24.32	Agreement
27.	Number of patients entering prospective clinical trials	7.19	7	1	9.68	Agreement[a]
28.	Percentage of patients seen by the radiation oncology service who have the minimum data required in their medical records to be able to assess a patient's indication for treatment	7.65	9	2	21.62	Agreement

[a]Item agreed upon in Delphi round two

the suitability of each indicator and to determine the priority among the indicators according to the need to be implemented in the evaluation processes regarding healthcare quality in the specialty.

The Delphi method is a distance professional consensus technique using written surveys broadly used in biomedical research. This technique allows to explore and bring together the opinions of a professional group on the topic of interest without the difficulties and inconveniences inherent to face-to-face consensus meetings [5].

The method requests the individual/anonymous opinion of each panellist through a confidential online survey. The survey is repeated in a second round, after disseminating the group results of the first questionnaire and the written comments made by the panellists among the participants. This provides an opportunity for each participant to reflect and reconsider his/her opinion between the rounds, without the change in opinion being obvious to the rest of the panellists. The technique preserves anonymity and allows for controlled interaction between the groups (without the risk of influence biases due to the presence of dominant members) and, finally, it objectively validates the consensus level achieved by statistical criteria.

Each item was assessed using a single nine-point Likert ordinal scale, with three ordinal regions set by linguistic qualifiers:

- 1–3: "I disagree with" (lower score implies lower degree of agreement).
- 4–6: "I do not agree or disagree with; I do not have a fully defined opinion on the issue" (choose 4 or 6 if you are closer to disagreeing or agreeing, respectively).
- 7–9: "I agree with" (higher score implies higher degree of agreement).

After each round, the group's opinion and the consensus reached on each issue raised were determined by the position of the group's median score and the "level of agreement" reached by the respondents, according to the following criteria:

- Consensus is considered to be reached regarding an item when there is "agreement" of panel opinion on the panel: that is, when less than one-third of the respondent experts score outside the three-point regions (1–3), (4–6), and (7–9) which contains the median. In this case, the median value determines the group consensus reached: "majority disagreement" with the item, if the median is ≤ 3, or majority "agreement" with the item if the median is ≥ 7. The cases in which the median falls within the 4–6 regions will be considered "uncertain" items.
- Conversely, it is established that exists panel opinion differences in the panel opinion when the scores of one-third or more of the panellists are in the (1–3) regions and another third or more are in the (7–9) regions. The remaining items without agreement or disagreement observed will be considered to have an "undetermined".

All items without a clear consensus (uncertain items, those with disagreement and those "undetermined") are proposed for reconsideration in the second round. Items with a high dispersion of opinion (interquartile range ≥ 4 points; range of scores contained between the p25 and p75 values of the distribution) are also re-evaluated.

Between the rounds, the panellists were informed of response distribution in the first survey (bar charts) and comments and clarifications provided by each participant. After reviewing this information, they were asked to give a new opinion on the items not agreed in the first round.

In addition, the second round also entailed a prioritisation scale aimed at assigning an order of priority among the various indicators in each block (structure, process, and outcome).

Phase 4

Express formulation of a standardised version of the indicators selected according to SECA´s conventional technical format (Table 1). Setting out for each indicator: quality criterion, indicator statement, definition and clarifications of terms, formula for calculating the indicator, indicator type (structure, process, and outcome), justification, calculation period, compliance level (standard/acceptable), information source for measurement, and bibliography.

The university technical group and SECA experts developed a proposal for each item, which was submitted for approval to the SEOR WG. The definition of standards for each indicator (the appropriate compliance benchmarks) was based on available information from the literature consulted. Where such information was not available, the WG determined the values by consensus.

Results

In the first Delphi round regarding the 28 possible indicators evaluated (from the process described in the section of methods), the usefulness of 23 indicators was established by consensus. No indicators were rejected. In the second round, the five indicators not previously agreed upon were revaluated and three reached agreement. Two indicators were eliminated due to insufficient agreement (not due to unanimous rejection by the group). Therefore, the expert panel validated 26 of the 28 indicators analysed (93% of the initial proposal) (Fig. 1).

Table 1 contains the 28 indicators with their detailed results at the end of both rounds. Tables 2, 3 show the indicators with their justification and the formula to follow-up, respectively.

Discussion

With this project, we have established the indicators that could best measure the decision, preparation, and treatment process in RO. For this purpose, we have followed the framework used in the "Patterns of Care" in RO, developed between the years 1994–1997 by Hanks [6], for prostate, breast, and cervical cancer in the US to evaluate the quality of treatments among different populations. One of the objectives of this "Patterns of Care" was the model of Donabedian (1988), which classified quality indicators in clinical practice [4] into three categories: structure, processes, and outcomes.

Structure indicators analyse the setup characteristics, where patient care is provided, which includes material, human, and organisational resources. Therefore, in this

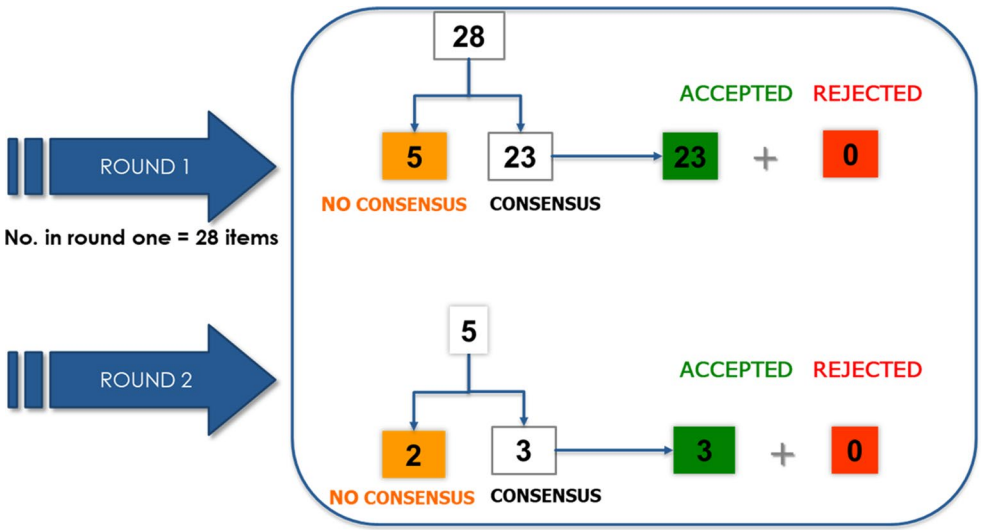

Fig. 1 Overall results of the Delphi process in each round

Table 2 Table of indicators and their justification

No.	Indicator statement	Standard	Justification	Calculation period
Structure indicators				
1	Treatments and radiotherapy (RT) sessions administered per therapy unit [10–12]	RTE 425 pts BT 100 pts	To assess the capacity to respond to the healthcare demand for external radiotherapy and brachytherapy	Annual
2	External Beam Radiotherapy (ERT) treatments performed by doctor [10, 12–15]	170 pts	Values the response to the healthcare demand for doctors specialising in radiation oncology	Annual
3	Brachytherapy (BT) treatments performed by doctor [10, 12–15]	70 pts	It assesses the capacity to respond to the healthcare demand for brachytherapy for radiation oncologists.	Annual
4	Patients assessed by the tumour committee [16, 17]	≥ 40%	Proportion of patients treated who have been presented in multidisciplinary committees prior to undergoing cancer treatments	Annual
5	Patients treated using special techniques [18–23]	≥ 30%	Gives information of the degree of implementation and use of these special techniques	Annual
6	Hours lost per RT therapy unit due to unscheduled interruptions	< 5%	To analyse the percentage of time lost for use in clinical RT in Therapy Units	Annual
7	Patients with indication for radiotherapy (ERT or BT) who are referred to other centers due to lacking the appropriate technique for their treatment	< 13%	The complexity of some techniques or some treatments means that they cannot be carried out in all centers. Knowing the characteristics of this patients and also the number can form a basis for scheduling the implementation of a technique in a department	Annual
8	Access to the Radiation Oncology Department	≥ 95%	Shows the speed of the patient channelling process between the indication for radiotherapy and arrival at the Radiation Oncology Department This interval is merely bureaucratic and it is crucial that it is as short as possible to avoid delays that could worsen the prognosis	Annual
Process indicators				
1	Patients re-scheduled in Radiotherapy [24–27]	≤ 2%	The number of patients re-scheduled increased workloads of Radiotherapy department. This indicator helps detect problems regarding a lengthy waiting list, lack of precision or errors in the radiotherapy process	Annual
2	Response Time of the Radiation Oncology Department	≥ 95%	This interval of time (between the registration of the treatment proposal and the date of the first visit) shows the capacity of the department to respond to the demand for care, directly in relation to an effective and efficient organisation	Annual
3	Time for preparation process for Radiotherapy treatment	≥ 95%	Time when all of the characteristics of the radiotherapy treatment are decided. It is a time that marks the intrinsic effectiveness of radiotherapy departments in terms of their organisation and operational capacity to decide, design and prepare a dosimetry report and set the starting date of irradiation in the shortest possible time	Annual
4	Patients with stage I and II [28–31] lung cancer treated with fractionated stereotactic body radiotherapy (SBRT)	≥ 90%	High doses of radiation precisely administered, with a small number of fractions providing less toxicity and better tolerance for the patient. It represents an advance over the standard treatment of radiotherapy	Annual

Table 2 (continued)

No.	Indicator statement	Standard	Justification	Calculation period
5	Patients who receive treatment for periods longer than planned [32–34]	< 5%	It is important for the final result of radiotherapy treatment to be achieved without interruptions. There are many and varied causes, some of which are attributable to the infrastructure of the service itself, others to the treatment itself and others to the patient. It is essential to know to what extent our treatments are carried out within the expected time frame	Annual
6	Prostate cancer patients with appropriate doses of external beam radiotherapy [35–38]	≥ 90%	To check the extent to which radiation oncologists follow the recommendations in clinical guidelines regarding the dose prescription. To check what percentage of patients receives a dose above 75 Gy may be an indicator of the quality of prostate cancer treatments with external radiotherapy	Annual
7	Prostate cancer patients with appropriate doses of brachytherapy [37, 39, 40]	≥ 90%	To check the extent to which radiation oncologists observed the recommendations in clinical guidelines regarding the dose prescription A biologically effective dose (BED) ≥ 150 Gy achieves 92% biochemical failure-free survival compared to 62% when the BED was < 150 Gy	Annual
8	Prostate cancer patients treated using hypofractionated regimens [41–44]	≥ 90%	Hypofractionation could improve the therapeutic index and also have the advantage of being more convenient for the patient, leading to a better use of resources. With conventional radiotherapy, treatment can last up to 9 weeks, compared to 4–5 weeks with moderate hypofractionation	Annual
9	Patients treated with dose intensity-modulated radiotherapy (IMRT–VMAT) in head and neck cancer [45–47]	≥ 90%	To know the use of the IMRT technique in head and neck cancer and promote its use. IMRT is associated with fewer side effects and a higher survival rate in patients with head and neck cancer. Its use may reduce the incidence of long-term side effects	Annual
10	Scheduled patients who do not start treatment with radiotherapy [48]	< 4%	It is essential to make a precise selection of the patients who will benefit from the treatment and the palliative or curative intent of the treatment to plan resources and reduce the starting time of the treatment	Annual
11	Verifications performed throughout the Radiotherapy treatment (IGRT) [49–51]	≥ 40%	New highly conformal techniques need image-guided radiation therapy (IGRT) to confirm, before each treatment fraction, that the position of the treatment isocenter is as planned. The precision in releasing the dose, the reduction of safety margins, the decrease in late toxicity and the possibility of safely escalating the dose are what justify the use of this technique in most curative treatments	Annual
12	Breast cancer patients undergoing hypofractionated regimens [52, 53]	≥ 90%	Provide information on the use of hypofractionated treatment in breast cancer in radiation oncology departments. These hypofractionated regimens have the advantage of shortening the RT treatment (15 sessions, 3 weeks), which results in an improvement in the quality of life of patients and optimisation of the use of RT equipment	Annual
13	Patients receiving neoadjuvant radiotherapy in rectal cancer [54, 55]	≥ 90%	Neoadjuvant treatment of stage II and III rectal cancer with radiotherapy alone or combined with chemotherapy and prior to complete mesorectal resection has several advantages over adjuvant post-surgical treatment	Annual

Table 2 (continued)

No.	Indicator statement	Standard	Justification	Calculation period
14	Patients re-treated using radiotherapy a second or subsequent time in previously unirradiated areas [56, 57]	≥20%	To calculate the real usage of equipment, as most of the time these calculations are only based on estimations considering the initial incidence of cancer and its indication during this first phase of the disease, without taking into account the second or third treatments with radiotherapy In the follow-up the patients may develop recurrence and metastases, which may also require radiotherapy	Annual
15	Patients re-irradiated using radiotherapy a second or subsequent time in areas that have been previously irradiated [58–61]	≥1%	Re-irradiation on some tumour sites such as head and neck tumours leads to promising results regarding local control and survival in selected patients; however, treatment-related toxicity remains significant despite technological improvements. Many radiation oncologists are reluctant to offer re-irradiation due to lack of experience or fear of the high risk of complications. However, improved definition of re-irradiation volumes and treatment techniques are making it possible to tackle this problem more safely	Annual
Outcome Indicators				
1	Patients with serious chronic complications related to radiotherapy treatment [62]	<5%	To check the quality of the treatment with radiotherapy and also to know and study the patients who show higher levels of toxicity to the radiation and may require individualised treatment This indicator will be used to assess the percentage of patients with unacceptable toxicity rates	Annual
2	Patients satisfied with the radiotherapy treatment received [63–65]	≥80%	The patient satisfaction questionnaire gathers opinions on the positive and negative aspects of the entire healthcare process and constitutes an important source of information that allows us to detect opportunities and areas for improvement in the different levels of healthcare	Annual
3	Publications of the radiation oncology department and their total impact. [66]	≥3.5	Recording the number of publications by the Radiotherapy Departments and the impact of these publications on international scientific literature reflects the research output of the services	Annual
4	Patients in prospective clinical trials [66, 67]	≥10–15%	Clinical trials are the most important way of validating the effectiveness of any therapeutic intervention. The prospective clinical trial is the most robust, since the objectives are defined beforehand and patients are selected and treated accordingly, such that the data obtained is evaluated in a uniform manner to ensure that there are no biases	Annual
5	Patients who have medical records that meet quality criteria [66, 67]	≥90%	This indicator will promote the collection of a minimum set of data on patients treated using radiotherapy to have a good quality medical record and a more reasoned indication for radiotherapy, in addition to being able to evaluate, using clear criteria, the outcome of the treatment according to the criteria that set the patients apart	Annual
6	Patients undergoing treatment with signed informed consent [68]	100%	According to Law 41/2002, informed consent	Annual

Table 3 Table of indicators and their formula

	Indicator statement	Standard	Formula
Structure indicators			
1	Treatments and radiotherapy (RT) sessions administered per therapy unit [10–12]	RT 425 pts BT 100	Number of RT treatments completed in the year/Total number of therapy units available in the Center Number of RT sessions administered in the year/Total number of therapy units available in the Center Number of Brachytherapy treatments completed in the year/Total number of therapy units available in the Center Number of Brachytherapy sessions administered in the year/Total number of therapy units available in the Center
2	External Beam Radiotherapy (ERT) treatments performed by doctor [10, 12–15]	170 pts	Treatments per year in external RT/medical specialists in radiation oncology with dedication in external radiotherapy full-time
3	Brachytherapy (BT) treatments performed by doctor [10, 12–15]	70 pts	Treatments per year in BT/medical specialists in radiation oncology with dedication in BT full-time
4	Patients assessed by the tumour committee [16, 17]	≥40%	Patients assessed by the committee/patients treated in the OR Service × 100
5	Patients treated using special techniques [18–23]	≥30%	Patients treated special techniques/RT treatments completed × 100
6	Hours lost per RT therapy unit due to unscheduled interruptions	<5%	Hours of unscheduled interruptions/Hours available for RT treatments × 100
7	Patients with indication for radiotherapy (ERT or BT) who are referred to other centers due to lacking the appropriate technique for their treatment	<13%	Patients with radiotherapy indication (ERT or BT) derived/Treated patients × 100
8	Access to the radiation oncology department	≥95%	Patients who are registered in the Radiation Oncology Service with an access time of less than three calendar days/patients who are registered × 100
Process indicators			
1	Patients re-scheduled in Radiotherapy [24–27]	≤2%	Patients who have their initial radiotherapy treatment modified (replanned)/Total of patients treated with RT × 100
2	Response time of the radiation oncology department	≥95%	Patients who have a first visit with a time of access from the registry less than seven calendar days/patients who have a first visit × 100
3	Time for preparation process for radiotherapy treatment	≥95%	(a) FOR CONVENTIONAL TECHNIQUES: Patients in therapy with conventional techniques who perform the first session in a time ≤ 15 calendar days/Patients in therapy with conventional techniques who perform the first session × 100 (b) FOR PATIENTS IN TE: Patients in TE who perform the first session in a time ≤ 21 calendar days/Patients in TE who perform the first session × 100
4	Patients with stage I and II [28–31] lung cancer treated with fractionated stereotactic body radiotherapy (SBRT)	≥90%	Patients with lung cancer, stages I and II, who underwent SBRT treatment/Patients with stage I and II lung cancer who underwent treatments with radical intention × 100
5	Patients who receive treatment for periods longer than planned [32–34]	<5%	Patients treated in the Radiation Oncology Service who receive treatment in periods longer than planned/Treated patients × 100
6	Prostate cancer patients with appropriate doses of external beam radiotherapy [35–38]	≥90%	Prostate cancer patients treated with external radiation therapy with curative intent with doses ≥ 75 Gy or ≥ 166.3 Gy DBE/Patients with prostate cancer treated with external radiotherapy with curative intent × 100

Table 3 (continued)

	Indicator statement	Standard	Formula
7	Prostate cancer patients with appropriate doses of brachytherapy [37, 39, 40]	≥90%	Patients with prostate cancer treated with brachytherapy whose D90 is > 140 Gy/ Patients with prostate cancer treated with brachytherapy with curative intent without external radiotherapy × 100
8	Prostate cancer patients treated using hypofractionated regimens [41–44]	≥90%	Patients with prostate cancer treated with external radiotherapy with curative intent with a hypofractionation scheme/patients with prostate cancer treated with external radiotherapy with curative intent × 100
9	Patients treated with dose intensity-modulated radiotherapy (IMRT–VMAT) in head and neck cancer [45–47]	≥90%	Patients with head and neck cancer treated with IMRT with curative intent/patients with head and neck cancer treated with external radiotherapy with curative intent × 100
10	Scheduled patients who do not start treatment with radiotherapy [48]	<4%	Planned patients who do not start treatment with radiotherapy/planned patients who are indicated for treatment in the RO service × 100
11	Verifications performed throughout the Radiotherapy treatment (IGRT) [49–51]	≥80%	Radiation therapy treatments in which verification has been carried out in at least 20% of the sessions administered/Treatments of the radiotherapy service × 100
		≥40%	Number of sessions verified/Number of total sessions administered × 100
12	Breast cancer patients undergoing hypofractionated regimens [52, 53]	≥90%	Patients with breast cancer treated with adjuvant external RT with a hypofractionation scheme/patients with breast cancer treated with adjuvant external RT × 100
13	Patients receiving neoadjuvant radiotherapy in rectal cancer [54, 55]	≥90%	Patients with stage II–III (T3/T4) rectal cancer treated with neodjuvant RT/patients with stage II–III (T3/T4) rectal cancer receiving RT × 100
14	Patients re-treated using radiotherapy a second or subsequent time in previously unirradiated areas [56, 57]	≥20%	Cancer patients re-treated with radiotherapy/Cancer patients treated with RT × 100
15	Patients re-irradiated using radiotherapy a second or subsequent time in areas that have been previously irradiated [58–61]	≥1%	Cancer patients re-irradiated/Cancer patients treated with RT × 100
Outcome indicators			
1	Patients with serious chronic complications related to radiotherapy treatment [62]	<5%	Patients treated with radiotherapy who have severe chronic complications/patients treated with radiotherapy × 100
2	Patients satisfied with the radiotherapy treatment received [63–65]	≥80%	Patients who have on mean the equivalent of good, very good or excellent/surveyed patients
3	Publications of the radiation oncology department and their total impact. [66]	≥3.5	Sum of the total of Impact Index of all publications of the RT Service
4	Patients in prospective clinical trials. [66, 67]	≥10–15%	Patients who participated in a prospective clinical trial in the last year/patients treated in the last year × 100
5	Patients who have medical records that meet quality criteria [66, 67]	≥90%	Patients who meet medical records with quality criteria/patients cared for in the Radiation Oncology service for treatment assessment × 100
6	Patients undergoing treatment with signed informed consent [68]	100%	Patients treated in the RO service with signed informed consent/patients treated in the RO Service × 100

section, we chose as indicators the number of patients treated per radiation oncologist and per treatment unit, distinguishing between the treatment complexity and type used (external beam radiotherapy and brachytherapy), common in most quality indicator studies. This is primarily based on surgical data that showed better results in hospitals with larger volumes of patients [7]. The treatment equipment quality and their obsolescence may have an impact on its operation; therefore, we also introduced the quantification of interruptions due to breakdowns and patient referrals that may be due to equipment shortages. From the point of view of the organisation, we believe that joint decision making regarding treatments in tumour committees guarantees a better therapeutic choice, and therefore, knowing the percentage of patients evaluated in them must be taken into account. Finally, RO departments are not available in all hospitals, which sometimes make the access difficult, delay the treatment initiation, and determine their end result. Thus, it was important to assess the accessibility of the service.

Most of these structure indicators have been considered by different authors and societies and are considered for accreditation programmes. The advantage of these indicators is that they are usually easy to gather, given that there are recommendations on their values ranges. This is a controversial point, because the available ranges are very wide, and therefore, it is vitally important to know the real values of Spanish RO departments, which can better set the quality of these indicators. As Hayman says [8], although structural characteristics are important to provide good care, they do not guarantee quality per se, and therefore, the relationship between structural performance and quality is more implied than proven.

Process indicators measure what is actually done, the activities realised by professionals to decide upon, prepare, and administer a treatment, thus showing the internal working of the organisation to manage their work in a consistent manner. Process indicators are often based on clinical trial data and are primarily focused on what we do and how we do it, and allow us to take swift action for improvement. Given the influence that processes have on the final service quality and that they are often considered the best quality measures [9], this is where we observed the most impact, having defined 15, with which we believe that we are covering most of the RO department facets. Using them, our aim is to assess their capacity to respond to treatment demands with indicators such as the department response time and the time required for the treatment preparation process. We also pretend to assess the knowledge and equipment to apply it, using indicators such as the appropriate dose of external beam radiotherapy or brachytherapy in prostate cancer, patients with head and neck tumours treated with intensity modulation, patients receiving fractionated extracranial stereotactic radiotherapy, the percentage of verifications performed throughout the treatment, and patients with rectal cancer receiving neoadjuvant radiotherapy or re-treated patients and re-irradiated patients. The treatment duration is a factor that affects the equipment workloads and the QoL of patients and their loved ones, and therefore, we believe that the use of hypofractionated treatment regimens in prostate and breast cancer should be evaluated. Finally, malfunctions in established work processes can also lead to increased workloads, and therefore, we wanted to measure patients who require rescheduling, not due to tumour changes during treatment, and also those patients who receive treatment for longer than planned.

Outcome indicators measure the effect of the care received by patients on their health and their satisfaction level. Thus, we place considerable value on the complications rate and patient satisfaction. In addition, we have included three other indicators that may indirectly influence the results: the medical records quality, reflecting the essential data to decide upon a treatment; the publications of the department, due to their impact on the analysis of the patients being treated; and the number of patients in prospective clinical studies due to what is set out in the regulations required by trials.

We are aware that outcome indicators are usually focused on analysing the final effect of the treatment (survival and disease control); however, at least in the first phase, we have not considered them because of difficulty in collecting them, the time required to be significant, in case of survival 5–10 years, and the complexity due to the final outcomes in most tumours depends on multiple factors external to the RO departments, such as diagnosis delays, unsuitable surgery, improper instructions prior to radiotherapy, etc. Nevertheless, we have considered others which may lead to improvement measures in our preparation and treatment processes.

The care burden of RO services often makes it difficult to collect data for the indicators that we have defined, but fortunately, our services now have more and more electronic systems that were initially designed exclusively to reduce the risk of errors and control the operation of linear accelerators. These systems were later extended to connect the scheduling and treatment systems and eventually expanded to electronic systems that store demographic, staging, prescription, and treatment data.

With the support of these information systems, we must collect data prospectively to have quality indicators in a fast and simple way. Most data used to obtain the indicators can be easily extracted from the information systems available to most RO departments, even if in some cases, it is necessary to make some modifications.

In summary, we completely agree with Hayman statement [8] "I believe assessment of the quality of the care we deliver is central to improving the care that we provide to our patients

and is an area in which we as radiation oncologists should assume a leadership role".

The Delphi method seemed to us to be the most appropriate due to providing a better intersubjective/prospective understanding of the difficult subject that is quality indicators in RO. In addition, it allows us to analyse preferences among the participants and to discuss the need for each of the indicators, as they are ultimately the ones who are going to use them. Finally, it allows us to create a current of opinion regarding the need to measure the quality of daily clinical practice and RO departments.

Study limitations

Some of the reference quality indicator comes from data of authors environment, due to the lack of published data; therefore, these data may not be corroborated by other Spanish departments and are, consequently, exposed to future modifications throughout the different phases of this project.

Conclusions

This is the first SEOR project to measure the quality of RO departments using objective quality indicators. These indicators are a starting point for assessing our current situation and setting collective and individual improvement objectives. There is significant consensus among participants regarding which indicators can best measure quality in RO. These indicators can be used to classify services not only by the number of patients and equipment that they have installed, but also by the complexity of the techniques that they use, their participation in research projects, and the scientific activity that they carry out.

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Compliance with Ethical Standards

Conflict of interest The Quality Indicators in Radiation Oncology is a scientific initiative by the Spanish Society of Radiation Oncology (SEOR). The authors declare that they have no conflict of interest.

Ethical approval This article does not contain any studies with human participants or animals.

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

Appendix 1

JOSÉ ANTONIO MEDINA CARMONA (H. Virgen de la Victoria, Málaga); LAURA DÍAZ GÓMEZ (H. Universitario Puerta del Mar, Puerto de Santa María); MIGUEL MARTÍNEZ CARRILLO (Complejo Hospitalario Jaén, Jaén); AMALIA PALACIOS EITO (H. Reina Sofía, Córdoba); JOSÉ EXPÓSITO HERNÁNDEZ (H. Virgen de las Nieves, Granada); ELOÍSA BAYO LOZANO (H. Virgen Macarena, Sevilla); DAVID VICENTE CARMONA (H. Juan Ramón Jiménez, Huelva); ISMAEL HERRUZO CABRERA (H. Regional Univ. Carlos Haya, Málaga); JOSÉ ANTONIO GONZÁLEZ FERREIRA (Genesis Care Sevilla, Sevilla); MARTIN TEJEDOR (H. Univ. Miguel Servet, Zaragoza); GERMAN JUAN (H. Univ. Central de Asturias, Oviedo); JOSE PARDO (H. Universitari Son Espases, Mallorca); CARLOS FERRER (H. Provincial de Castellón, Castellón); LUIS LARREA (Clínica Virgen del Consuelo (VITAS), Valencia); LEONCIO ARRIBAS (Fund. Inst. Valenciano de Oncología (IVO) Valencia); ENRIQUE GARCIA MIRAGALL (H. General Elche); EDUARDO FERRER (H. Clínico Universitario de Valencia); Alejandro Tormo (H. Universitario La Fe, Valencia); PABLO SOLER (IMED, Elche); MARTA LLORET (H. Negrín, Las Palmas); MARIA VICTORIA VILLAS (Complejo Hospitalario Univ. de Albacete); EVA LOZANO (H. de Ciudad Real); MERCEDES TEIJEIRA (H. Provincial Divino Vallés, Burgos); LUIS PEREZ ROMASANTA (H. Universitario de Salamanca); MANUEL ALGARA (H. de l'Esperança, Barcelona); MERITXELL ARENAS (H. Univ. De Sant Joan de Reus); JORDI GIRALT (H. Gral. de la Vall d'Hebrón, Barcelona); LUIS ANGLADA (H. Univ. de Girona Dr. Josep Trueta ICO); BENJAMIN GUIX (Inst.Médico de Oncología Radioterápica (IMOR), Barcelona); GEMMA SANCHO (H. Santa Creu i Sant Pau, Barcelona); JULIA LUISA MUÑOZ (H. Infanta Cristina, Badajoz); ANTONIO GOMEZ Caamaño (H. Clínico Universitario de Santiago); VICTOR MUÑOZ (H. Do Meixoeiro, Vigo); MAITE MURILLO (H. Univ. de la Princesa, Madrid); PILAR SAMPER (H. Rey Juan Carlos, Móstoles); MARIA JESUS RUIZ (H. Univ. La Paz, Madrid); JUAN SALINAS (H. General Universitario Santa Lucia, Cartagena); FERNANDO ARIAS (H. de Navarra, Pamplona); JUAN PABLO CIRIA (H. Universitario Donostia, San Sebastián).

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Affiliations

J. López Torrecilla[1] · S. Marín i Borràs[2] · A. Ruiz-Alonso[3] · J. Jaen Olasolo[4] · M. L. Vázquez de la Torre[5] · E. Bóveda Carro[6] · A. Rodríguez[7] · E. Ignacio García[8] · F. Caballero Martínez[9] · F. J. Campos Lucas[9] · P. C. Lara Jiménez[10,11] · J. Contreras Martínez[12] · C. Ferrer Albiach[13]

S. Marín i Borràs
smarin@iconcologia.net

A. Ruiz-Alonso
aruialo@gmail.com

J. Jaen Olasolo
Jjaen2008@gmail.com

M. L. Vázquez de la Torre
maria.luisa.vazquez.de.la.torre.gonzalez@sergas.es

E. Bóveda Carro
ELSIRA.BOVEDACARRO@osakidetza.net

A. Rodríguez
arodriguez@ruberinternacional.es

E. Ignacio García
emilio.ignacio@uca.es

F. Caballero Martínez
f.caballero@ufv.es

F. J. Campos Lucas
f.campos@ufv.es

P. C. Lara Jiménez
plara@dcc.ulpgc.es

J. Contreras Martínez
jorgecontrerasmartinez@gmail.com

C. Ferrer Albiach
ferreralbiach@gmail.com

[1] Department of Radiation Oncology-ERESA, Hospital General Universitario de Valencia, Av. Tres Cruces, 2, 46007 Valencia, Spain

[2] Department of Radiation Oncology, Hospital Duran i Reynals, Institut Català d´Oncologia, Avinguda de la Granvia, 199, 08908 L'Hospitalet de Llobregat, Barcelona, Spain

[3] Department of Radiation Oncology, Hospital Universitario Doce de Octubre, Avda. de Córdoba s/n, 28041 Madrid, Spain

[4] Department of Radiation Oncology, Hospital Universitario Puerta del Mar. Instituto de Investigación Biomédica de Cádiz (INiBICA), Av Ana de Viya, 21, 11009 Cádiz, Spain

[5] Department of Radiation Oncology, Hospital Do Meixoeiro, Camiño Meixoeiro, s/n, 36214 Vigo, Pontevedra, Spain

[6] Department of Radiation Oncology, Hospital Universitario Cruces, Plaza de Cruces, S/N, 48903 Baracaldo, Vizcaya, Spain

[7] Department of Radiation Oncology, Hospital Ruber Internacional, Calle de la Masó, 38, 28034 Madrid, Spain

[8] Departamento de Enfermería y Fisioterapia, Universidad de Cádiz, Avda. Ana de Viya, 52, 11009 Cádiz, Spain

[9] School of Health Sciences, Francisco de Vitoria University, Ctra. Pozuelo-Majadahonda (M-515) Km. 1.800, 28223 Pozuelo de Alarcón, Madrid, Spain

[10] Department of Radiation Oncology, Hospital Universitario Dr Negrín, Barranco de la Ballena s/n, 35010 Las Palmas, Spain

[11] Clinical Oncology, Universidad de Las Palmas, Las Palmas, Spain

[12] Department of Radiation Oncology, Hospital Regional, Universitario Carlos Haya, Av. de Carlos Haya, s/n, 29010 Málaga, Spain

[13] Department of Radiation Oncology, Consorcio Hospitalario Provincial de Castellón, Avda del Dr Clará 19, 12002 Castellón, Spain