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ESTRO-HERO survey

Guidelines for equipment and staffing of radiotherapy facilities in the European countries: Final results of the ESTRO-HERO survey

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ABSTRACT

Background and purpose: In planning to meet evidence based needs for radiotherapy, guidelines for the provision of capital and human resources are central if access, quality and safety are not to be compromised. A component of the ESTRO-HERO (Health Economics in Radiation Oncology) project is to document the current availability and content of guidelines for radiotherapy in Europe.

Materials and methods: An 84 part questionnaire was distributed to the European countries through their national scientific and professional radiotherapy societies with 30 items relating to the availability of guidelines for equipment and staffing and selected operational issues. Twenty-nine countries provided full or partial evaluable responses.

Results: The availability of guidelines across Europe is far from uniform. The metrics used for capital and human resources are variable. There seem to have been no major changes in the availability or specifics of guidelines over the ten-year period since the QUARTS study with the exception of the recent expansion of RTT staffing models. Where comparison is possible it appears that staffing for radiation oncologists, medical physicists and particularly RTTs tend to exceed guidelines suggesting developments in clinical radiotherapy are moving faster than guideline updating.

Conclusion: The efficient provision of safe, high quality radiotherapy services would benefit from the availability of well-structured guidelines for capital and human resources, based on agreed upon metrics, which could be linked to detailed estimates of need.

Many significant studies over the last decade have served to further confirm the essential role of radiotherapy in the care of cancer patients [1–3]. Such studies, which have been primarily based on evidence from the peer reviewed literature and on current best practice, have not only reinforced the vital role of radiotherapy in the treatment of cancer but, importantly, provided the community with quantitative data upon which to base the essential resource requirements for the delivery of an appropriate radiotherapy service. These studies are an important part of the context of the HERO project.

ESTRO's Health Economics in Radiation Oncology (HERO) project has, as its overarching aim, the development of a knowledge base and model for the health economic evaluation of radiation treatments in Europe, which can then be used in the design and justification of appropriate services for the populations of European countries [4]. The HERO project is currently addressing the needs for and availability of radiotherapy services in Europe and will shortly progress to an examination of costs followed by evaluations of cost effectiveness.

Limitations on access to appropriate radiotherapy care can take many forms including insurance and personal wealth in the private sector, geographic factors and personal biases of referring physicians to mention just a few [5]. However, even assuming such impediments can be removed, the ultimate limitation on access, that of the availability of capital and human resources to deliver safe and high quality radiotherapy, will be encountered in the majority of countries across the globe.

If the intention is to deliver state of the art radiotherapy, without waiting times and without creating expensive over capacity, there needs to be guidance at a national or regional level on the

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capital and human resources required. In this component of the HERO project, the availability of guidelines for radiotherapy equipment and staffing is examined. Under the QUARTS umbrella, a similar survey of European nations was undertaken ten years ago [6] thus affording the opportunity to identify any significant changes in guideline development over time.

This paper is one of a trilogy, which presents and discusses the information gleaned from a detailed survey of European countries. The availability of current capital and human resource data from the complementary components of the project [7,8] makes it possible to compare the actual situation with guideline recommendations in those countries providing the necessary data.

Materials and methods

An 84-part web-based questionnaire relating to population and cancer incidence, radiotherapy courses and resources, guidelines and reimbursement was developed and distributed to national scientific and professional radiotherapy societies, hereinafter referred to as national societies, in the countries defined by the European Cancer Observatory (ECO) [9]. The current report includes a detailed analysis of 30 questions (No. 24, 25, 27, 28, 30–33, 35–41, 43–46 and 61–72) relating to guidelines for radiotherapy capital and human resources and selected operational issues. The analysis was conducted in early 2014, and is based on partial or complete responses from 29 countries. Further details of the analysis can be found in the Supplementary material.

The 15 equipment specific items in the questionnaire explored the availability and content of guidelines not just for linear accelerators but also for newer technology including multileaf collimators (MLC), Electronic Portal Imaging Devices (EPID) and dedicated CT scanners. With the growing demand for radiotherapy leading to problems of access for many patients, the questionnaire also sought to identify the criteria used in different countries for the numbers of machines nationally and per department, e.g., is the number based on inhabitants, patients or treatments. The issue of guidelines for satellite centers was also addressed during the survey.

The ability to deliver safe, high quality radiotherapy will clearly be compromised by inadequate staffing levels particularly in an environment where new technology and techniques are being rapidly developed and introduced. Details of guidelines for radiation oncologists, medical physicists, dosimetrists and radiation therapists (RTTs) (including nurses who work directly on treatment machines) were also sought through the questionnaire.

Four questions addressed specific operational issues. These were the percentage of radiation oncologists also delivering chemotherapy, limitations on working hours as a result of radiation protection regulations and professional responsibilities for the key activities of treatment planning and quality assurance.

As with the companion papers [7,8], the relationship between guideline development and GNI/n was explored using data from the World Bank Database [10].

Responses were assigned to four categories for the purposes of analysis and discussion. Where there was no response to a particular inquiry or the authors of this paper were unable to evaluate the response, this has been designated n.r. in Tables 1 and 2. Some responders simply reported that they do not have guidelines for the item requested and this is indicated in the tables (No). Most countries responded to most questions but with responses of varying degrees of detail. We have separated such responses into two categories: declared which means that the country has stated that some basis exists for allocating capital and human resources and explicit, which is a sub-set of declared, where the country has provided a metric for identifying or allocating resources. Such metrics include, for example, linear accelerators per million population and RTTs per linac. Some countries referred to documents such as the QUARTS study [6] which include relevant metrics and the guidelines for these countries were categorized as explicit.

ECO regards the United Kingdom as "one country" although the survey was distributed to England, Wales, Scotland and Northern Ireland. If one of those countries responded with a metric to any question then the response of the UK to that question was interpreted as confirming the existence of an explicit criterion based guideline.

Results

Table 1 summarizes data collected from the questionnaire regarding radiotherapy equipment and Table 2 presents data from the staffing survey elements. As the HERO question "Are there future plans for radiotherapy needs" applies to both capital and human resources, responses are repeated in both tables. Table 3 gives an insight into the variability of roles and responsibilities of radiotherapy professionals in various countries by focusing on specific radiotherapy tasks (treatment planning and quality assurance) and on the proportion of radiation oncologists administering chemotherapy. These three tables encompass 23 of the 30 survey questions analyzed in this report with the remainder being discussed in the text. Although 29 countries did respond to the survey, not all countries responded to every question.

Tables 1 and 2 use shading and fonts to distinguish between those guidelines assessed as being declared or explicit as defined above. Where explicit guidelines had been identified in the previous QUARTS study [6], this is also indicated in the tables although the table cells contain the responses to this HERO survey. For responses to the QUARTS survey, the reader is referred to the original manuscript [6].

Cancer plans

21/29 of responding countries have undertaken some level of planning to accommodate future radiotherapy needs with the majority approaching this issue at the national level. Three countries plan on a regional basis. Only 2 responding countries have developed explicit guidelines for satellites: Belgium requires a minimum of 500 patients per year and at least 2 machines whereas in the Netherlands sufficient workload for two machines in combination with at least 4 linear accelerators at the main site, operating under the same quality management system, is required in order to consider establishing a satellite.

Equipment

National guidelines for equipment in general exist in 21 of responding countries. Five countries declared no guidelines and 3 did not respond to this question. Half (15/29) of the general equipment guidelines are stated as being national with an additional 3 being attributed to professional society recommendations, which are presumably national too, 2 that are based on the (unspecified) literature and 1 which is under development. Although 8 countries either did not respond to this question or declared having no national general equipment guidelines, 2 of these countries did specify explicit guidelines when queried about the inventory of machines at the national level.

Turning to guidelines for treatment machine inventory at the national level, 25 countries declared guidelines with 11 being explicit as defined above. The basis for the calculation of the required number of linear accelerators nationally was exclusively the population served in 9 jurisdictions and exclusively the

Table 1
European guidelines for equipment.

Country	Cancer plans for RT needs	Guidelines for equipment	Satellites	Machines at country level	Machines at department level (Minimum Number)	Machine complexity		Simulators	CT Scanners
						MLC	EPID		
Albania	No	n.r.	n.r.	n.r.	n.r.	No	No	Gifts or donation from IAEA	No
Austria	Regional	National	n.r.	*1 MV / 130,000 inhabitants*	Inhabitants in the region, 1 MV / 400 courses (2 MV / dept.)	No	No	≥ 1 Sim. / center	≥ 1 CT / center operation curative
Belarus	National	National	No	1 MV / 4,000,000 inhabitants	n.r.	No	No	IAEA, National	No
Belgium	No	National	500 pts / yr, ≥ 2 MV	n.r.	(≥ 2 MV / dept.)	No	No	≥ 1 Sim. / centre	No
Bulgaria	Society	Gradual development	No	*Level of skills of the personnel and academic approach but in the practice: national political decision depending on availability of financial resource*	(≥ 2 L / dept.)	1 / L	1 EPID / L because their numbers are not enough	≥ 1 Sim. / MV machine, every MV has to be equipped by kind of simulator	≥ 1 CT / center
Czech Republic	Society	Society	No	*1 MV / 450 Npts*	1 MV / 450 Npts (≥ 2 MV / dept)	No	No	≥ 1 Sim. / centre curative RT	≥ 1 Sim or CT / center curative RT
Denmark	Society	National, Cancer plan I, 2000	Political decision based on cancer incidence and regional geographical issues	1 MV / 200 Npts	1 MV / 5,000 fractions[1] (2 MV / dept.)	Implied standard	Implied standard	Local needs, no. patients	Implied standard
Estonia	National	National, Cancer Care Quality Requirements in Estonia, 2011	No	Inhabitants, Patients, 2015 target : ESTRO -QUARTS	(≥ 2 MV / dept.)	No	No	≥ 1 Sim. / center	≥ 1 CT
Finland	No	n.r.	No	No	No	No	No	Center needs	No
France	National	Society	No	*Inhabitants*	(≥ 2 MV / center (agreement criteria))	93% of accelerators with MLC	No	≥ 1 any type CT /centre	Every center must have access to a CT (dedicated or not)
Germany	No	n.r.	No	Patients	Patients, (1 – 2 MV / dept.[2])	No	No	Based on work flow	No
Hungary	National	National	No	Inhabitants	(≥ 2 MV / center)	No	No	≥ 1 Sim. / dept., > 2 Sim. when dept. > 3 L	No
Iceland*	National	National	No	Patients	Treatment courses	n.r.	Yes	1 Sim. for all country	
Ireland	National	National	No	*Inhabitants, patients*	Patients, treatment course, fraction [Regional recommendation]	No	No	Match with workload	No

(*continued on next page*)

Table 1 (*continued*)

Italy	Regional	National	No[3]	*Health planning on a regional basis*	Demographics, regional health authorities planning, hospital priorities, budget	No[4]	≥ 1 EPID[5]	≥ 1 Sim. or CT-scan / dept.	≥ 1 Sim. or CT / dept.
Lithuania	Society	No	No	No	n.a.	No	No	Financial resources	No
Luxembourg*	No	No	No	Inhabitants	n.a.	No	No	Center's needs	No
Malta*	National	Literature	n.r.	Literature	Patients, fraction, treatment courses	Literature	Literature	Literature	Literature
Montenegro*	National	National	n.r.	Inhabitants	Patients	No	No	2 Sim. / center	No
The Netherlands	National	National	Mother center: ≥ 4; satellite ≥ 2 & same quality system	*1 MV / 500 teletherapy courses*	1 MV / 500 teletherapy courses, (Mother center: ≥ 4 L / dept., satellite ≥ 2)	No, but 100% for new equipment.	No, but 100% for new equipment	Now replaced by CT scans	≥ 1 CT / dept.; 1 CT / 4 -6 L
Norway	No	No	No	1 L / 350 patients[6]	n.a.	No	No	n.r.	No
Poland	National	National	No	*1 MV / 250,000 inhabitants*	≤ 500 Npts / MV / yr (2 - 3 MV / center depending of procedure)	No	1 EPID / L	1 Sim. / 2 L	≥ 1 Sim. or CT / center for curative RT
Portugal	National	National	No	Patients, 1 MV / 6,000,000 inhabitants, QUARTS	ESTRO-QUARTS	No	No	Local needs, per patients	No
Romania	No	Literature	No	Patients	Patients	No	No	Based on MV machine	No
Slovak Republic	No	No	No	*Patients, hospital priorities*	Patients, hospital priorities	No	No	≥ 1 Sim. / dept.	No
Slovenia*	National	National	No	1 MV / 6,000,000 inhabitants	n.a., 1 national dept.	**All machines**	**All machines**	1 Sim. / 4 L	No
Spain	National	Society recommendation	No	*Inhabitants*	(2 MV / dept. : mainland)	No	No	1 Sim. / dept.	1 CT / dept.
Switzerland	Regional	No	No	1 MV / 128,333 inhabitants, 1 MV / 333 Npts	1 MV / 350 - 400 courses	No	No	> 1 Sim. / therapy	No
United Kingdom	National	National	Yes	*Patients, inhabitants ,local needs*	50,000 fractions / 1,000,000 inhabitants modified according to local needs	Yes	Yes	Yes	Yes
England	National	National	Professional body's guidelines	Patients & local needs	≥ 2 MV in order to ensure continuity of service for patients within one centre- not a legal requirement	Yes	Yes	Local assessment	No
Scotland	National	National	≥ 2 L	Patients	No. of patients	Yes	Yes	Local assessment	No
Wales	National	National	RCR / SCoR / IPEM Guidance	Inhabitants	No. of patients	Yes	Yes	Society's recommendations	Society's recommendations
Northern Ireland	Regional	National	Within business case for expansion of radiotherapy incl. new department in Londonderry	Inhabitants	No. fractions	No	No	1 Sim. or CT / 3 MV	≥ 1 Sim. or CT / 3 MV

European and International guidelines									
QUARTS (ref 6)	No	No	No.	1 MV / 450 patients / yr, Increasing complexity: 1 / 400 - 450 patients / yr	1 MV / 450 patients / yr, Increasing complexity: 1 / 400 - 450 patients / yr	No	No	No	No
IAEA (ref 6)	No	No	No	No	1 MV / 200 - 500 patients / yr depending on complexity	No	No	> 0.75	No

n.r. = not reported, not available or no evaluable response was given to the question.
Light shaded: guideline was declared to the HERO survey.
Dark shaded: an explicit guideline was declared to the HERO survey. See text for definition of explicit.
Italics: an explicit guideline had been previously been declared to the QUARTS survey (6).
The authors have attempted to reproduce as faithfully as possible, within space limitations, the national societies' responses. For machines, some responses have been MV = megavoltage which presumably includes cobalt machines and others have been more specific and used L = linear accelerators.
*Countries with one radiotherapy center.
[1]This is based on the official national cancer plan from year 2000 and is out-dated. Some departments use 6000 fractions/L but this is an unofficial estimate.
[2]Depends on the state : some states in Germany require an absolute minimum of only 1 megavoltage machine, other states 2.
[3]The guidelines do not cover this issue, but they state that, before being authorized to operate, a center equipped with one MV should have an explicit agreement with a nearby center to complete the treatment in case of prolonged breakdown of the machine.
[4]While the guidelines are out of date, yet they suggest that also the Centers with the capacity of treating patients only with 2D techniques should have a TPS capable of producing 2D treatment plans and devices to produce at least personalized blocks.
[5]Film dosimetry is allowed only for very simple treatments.
[6]Deduced from a national cancer plan from 1997 estimating a need of 40 Linacs for an expected cancer incidence of 25,900 in 2003, and 54% of them needing radiotherapy.

number of patients in 7 jurisdictions. Eight countries reported using multiple criteria in establishing recommended national equipment inventories and 1 country referred to "literature". 17 responders declared guidelines for the number of machines per department with 7 being explicit and based on the number of patients or treatment courses or fractions or some combination. 12 respondents declared explicit criteria for the minimum number of machines per department. This minimum number was typically 2 but ranged from 1 to 4. As cobalt units continue to be phased out (Grau et al. [7] report that less than 5% of all MV units in Europe are Cobalt machines) it is not surprising that there are fewer recommendations specifically addressing this treatment modality (Supplementary material). Eleven countries group requirements for megavoltage units, i.e., linear accelerators and cobalt units, together.

Explicit numerical criteria for simulation facilities were declared in 17 of the surveyed countries. The guideline is typically stated in terms of either numbers per center, e.g., 1, per center, or per linac, ranging from 1 simulator to 1 linear accelerator or 1 simulator to 4 linear accelerators.

Relatively few responders to this questionnaire have explicit recommendations on newer technology such as multileaf collimators (3), electronic portal imagers (5) and dedicated CT-scanners (9). There was some form of recommendation for ancillary quality assurance equipment in only 10 responses.

Staffing

Table 2 summarizes selected responses to those questions addressing guidelines on clinical staffing for radiation treatment facilities. 24 of the responding 29 countries do have recommendations for staffing levels. These recommendations are mainly at the national level and may be based on recommendations from IAEA [11], EFOMP [12], EORTC [13] or national professional societies. As staffing levels are likely to be influenced by working hours, HERO sought information on this aspect of employment contracts. Thirteen countries provided details of working hour limitations for radiotherapy professionals although several respondents pointed out that there were differences between the public and private sectors. In two instances limiting working hours would be as a result of the level of radiation exposure.

Guidelines for the number of radiation oncologists were present in 27/29 of responding countries, of which 16 were explicit with recommendations ranging from 130 to 300 patients per year per oncologist. Sufficient staffing to ensure that a radiation oncologist was always present when patients were being treated was mentioned in two responses. As demonstrated in Table 3, in about three quarters of the countries (23) radiation oncologists are administering chemotherapy as well as radiotherapy.

Twenty-five of 29 responding countries reported guidelines for the number of medical physicists. Of these, 19 were explicit: up to 2.75 physicists per machine, or from 400 to 750 patients per physicist. 11 countries reported staffing guidelines for dosimetrists, of which 3 were explicit, and 27 for the number of RTTs, of which 20 were explicit. In the majority, the numbers of RTTs needed were expressed per linac with a range of 2–6, while, in only 4 countries, workload (annual patients or treatments delivered per RTT) defined their numbers.

Twenty-two countries reported the involvement of physicists, with or without others, in treatment planning while physicists, with or without others, continue to perform most (28/29) of the quality assurance procedures with physics assistants playing a role in some countries (Table 3).

In the companion papers [7,8] strong correlations were found between the inventories of capital equipment and staffing and GNI/n. No such relationship exists for the availability of guidelines.

Table 2
European guidelines for staffing.

Country	Cancer plans for RT needs	Guideline for personnel	Are working hrs for RT personnel limited by radiation protection regulations	Radiation Oncologists	Medical Phycisists	Dosimetrists	RTT
				Criterion	Criterion	Criterion	Criterion
Albania	No	Yes, not specified	Only in public sector all the RT personnel are working 6 hrs a day: 30 hrs / week; 48 weeks / yr	n.r.	n.r.	n.a.	2 / L & 2 / CT sim (private sector)
Austria	Regional	National	Technicians/radiographers: 40 hrs / week, No. weeks / yr is not regulated, usually 46	*6 / 800 patients*[1]	*Per number of L + 1*[1]	n.a.	≥ 13 / 800 patients, nurses (in addition to RTT) : 3.5 / 800 patients[1]
Belarus	National	National	RO, MP, engineers, RTT, dosimetrists: 30 for RO; 35 for MP / engineers	*1 / 10 patients or 1 / 1 RT unit*	*2 / L*	1 / RT unit	4 / RT unit
Belgium	No	National	No	*1 / 200 - 250 patients (ifo complexity)*	*1 / 750 patients (more if complex treatment)*	No	3 / MV, 2 / sim, 0,3 FTE / 100 brachytherapies
Bulgaria	Society	National	For all staff working with IR: 36 hrs / week	Based on the center technological level /RT modalities/ and staff skills	Based on the center technological level /RT modalities/ and staff skills	n.a.	Based on the center technological level /RT modalities/ and staff skills
Czech Republic	Society	Society[2]	No	*1 / 200 Npts*	*EFOMP 07/1997*	n.a.	Based on treatment machine
Denmark	Society	National	No	2.5 / L	*1.8 / accelerators*	Local needs	6 / L + 1.8 secretaries
Estonia	National	National	No	Based on the centre's practice	IAEA TECDOC	Local needs	3 - 4 / treatment unit
Finland	No	National	No	1 / 250 patients	1 / 400 patients	n.a.	2 / L during treatment
France	National	Society[3]	No	*Enough to be present during all treatments*	*≥ 2 /center*	n.r.	2 / RT machine
Germany	No	National[4]	It is forbidden to continuing work if a borderline exposure to ionizing	1 / device + 1 RO[5], if more than 1 method: + 1 RO, If – on annual average- > 350	> 1 / L + 1 MP, thus > 2 MP when one shift,[6] if more than 1 method: + 1	n.r.	> 2 / machine[4]

			irradiation is exceeded.	treatment series / device: + 1RO	MP; If –on annual average - > 350 treatment series / device: + 1 MP		
Hungary	National	National	RO, physicist, and RTT as well: 40 hrs / week	*1 / 300 patients*	1 / 500 patients	Local policy	1 / 200 patients
Iceland*	National	No	No	4 / dept.	4 / dept.	4 / dept.	12
Ireland	National	National	No	1 / 250 Npts	11 / dept. with 4L	No	Hollywood report, p 182, 194
Italy	Regional	National	European directives and national regulations	*1 / 200 patients*	*1 / 400 patients*	n.a.	1 / 150 patients / yr
Lithuania	Society	National	Radiation oncologists, physicists, RT technologists, nurses:38 hrs / weeks, 47 weeks / yr	*1 / 250 patients*	1 / 400 patients	Center needs	Center needs
Luxembourg*	No	No	No	*Needs of the center*	*Center needs*	Center needs	Center needs
Malta*	National	Literature	n.r.	*Literature*	Literature	Literature	Literature
Montenegro*	National	n.r.	40 hrs / week	According to country needs, 1 national dept.	Hospital recommendation	No	No
The Netherlands	National	National	No	*1 / 250 Npts or N = 8 / 250 treatments, FTE = 6.4*	*1 / 650 patients (previously T2Neq)*	n.a.	1 / 55 treatments (previously T2Neq)
Norway	No	No	No	*n.r.*	*n.r.*	n.r.	4 / L
Poland	National	National	From July 2014 Nurse work 5 hrs shift / daily RT, physicians 7.5 hrs / day	Per activity	Per activity based on min requirement by IAEA	Per activity	Per activity
Portugal	National	National	No	*ESTRO (patients treated)*	*n.r.*	Patients treated	2 / machine during treatment period
Romania	No but QUARTS	No but QUARTS	RT oncologist, physicists, RTT:30 hrs / week, 45 weeks / yrs	Treatment machine and patients treated	MV machine & patients	n.r.	Based on treatment machine & patients treated
Slovak Republic	No	National	Radiation oncologists, medical physicists and RTTs: 32,5 hrs / week	*≥ 1 FTE*	*EFOMP 1997*	Not specified	3 / L ; > 2 cobalt
Slovenia*	National	ESTRO	RO, MP, RTT, dosimetrists, radiographers: 36 hrs / week, 44 weeks /yr	IAEA	IAEA	IAEA	Per treatment machine+2 shifts vacation
Spain	National	National	No	Per number of patients	n.r.	Collecting it now.	2 / machine & turn
Switzerland	Regional	No	No	ESTRO ; EORTC	ESTRO ; EORTC	ESTRO ; EORTC	ESTRO ; EORTC
United Kingdom	National	National	No	*Needs, patients, personnel*	IPEM	IPEM	Yes

(*continued on next page*)

Table 2 (*continued*)

England	National	National	No	Local needs and center personnel	Institute of Physics and Engineering in Medicine Recommendations for the Provision of a Physics Service to Radiotherapy 2009	n.r.	1.33 FTE / operational L
Scotland	National	National	No	Per new patients	Per no. of new patients	n.r.	> 2 when treating, Society and College of radiographers
Wales	National	National	No	Dept. patterns and patients	Dept. and patients	Recommendation Professional Society IPEM	Recommendations of Professional society and college of radiographer
Northern Ireland	Regional	National	No	RCR guidance	IPEM recommandations at minimum	Demonstrated need and funding/ Minimum recommendation Professional Society IPEM	SCoR Guidance 1.33 FTE / L / hr
European and International guidelines							
QUARTS [6]	No	No	No	250 patients / yr , Increasing complexity: 1 / 200 - 250 patients / yr	450 - 500 patients / yr	No	Great diversity makes comparison between countries impossible
IAEA [11]	No	No	No	250 - 300 patients / yr / RO	300 - 400 patients / yr / MP	No	100 - 150 patients / yr / RTTs
EORTC [13]	No	No	No	≤ 300 patients / FTE	≤ 500 patients / FTE	No	≥ 2 / treatment unit
IPEM [14]	No	No	No	No	Complex algorithm	No	No
EFOMP [12]	No	No	No	No	0.37 WTE / L + 0.11 WTE / 100 patients / yr	No	No

n.r. = not reported, not available or no evaluable response was given to the question.
Light shaded: guideline was declared to the HERO survey.
Dark shaded: an explicit guideline was declared to the HERO survey. See text for definition of explicit.
Italics: an explicit guideline had been previously been declared to the QUARTS survey (6).
Npts: new patients, L: linear accelerator, MV: mega voltage machine.
The authors have attempted to reproduce as faithfully as possible, within space limitations, the national societies' responses.
*Countries with one radiotherapy center.
[1]Additional staffing for special procedures (STX, Whole Body Irradiation, IMRT, IORT): one additional radiation oncologist and RTT per every 100 cases/year; one additional medical physicist per every 200 cases/year.
[2]Národní Radiologické Standardy – Radiační Onkologie [National Radiological standards-Radiation Oncology], 2012.
[3]Livre Blanc de la Radiotherapie 2013 [White book of Radiotherapy].
[4]Strahlenschutzverordnung [Radiation Protection Guidance].
[5]Institution can have different working hours [in terms of Schichtbetried referring to 8 h daily, i.e., 1½ Schichtbetried correspond to 12 h/day]. For RO and MP, if the organizational structure is of 2 Schichtbetried:+1/2 device; for RTT: 2 RTT/device.
[6]For details on the complex rules, see guideline.

Table 3
Tasks performed by different radiotherapy professionals.

Country	% ROs administering chemotherapy	Most treatment planning performed by	Most QA procedures performed by
Albania	0%	Medical physicists	Medical physicists, technicians/engineers
Austria	25–75%	Technologists, radiographers	Medical physicists
Belarus	25–75%	Medical physicists, but sometimes it's performed trained radiation oncologists	Medical physicists, technicians/engineers
Belgium	<25%	Dosimetrists	Medical physicists
Bulgaria	25–75%	Medical physicists	Medical physicists, technicians/engineers
Czech Republic	>75%	Medical physicists	Medical physicists
Denmark	>75%	Medical physicists	Medical physicists
Estonia	>75%	Medical physicists	Medical physicists
Finland	>75%	Medical physicists	Medical physicists
France	25–75%	Medical physicists, dosimetrists, technologists, radiographers	Medical physicists, technicians/engineers
Germany	25–75%	Medical physicists	Medical physicists, RTT
Hungary	25–75%	Medical physicists	Medical physicists
Iceland	>75%	Technologists, radiographers	Medical physicists
Ireland	0%	Technologists, radiographers	Medical physicists
Italy	>75%	Medical physicists	Medical physicists
Lithuania	0%	Medical physicists, radiation oncologists	Medical physicists
Luxembourg	>75%	Medical physicists, dosimetrist	Medical physicists, technicians/engineers
Malta	>75%	Medical physicists	Medical physicists
Montenegro	0%	Medical physicists	Medical physicists
The Netherlands	0%	Technologists, radiographers	Physics assistants
Norway	>75%	Technologists, radiographers	Medical physicists
Poland	<25%	Medical physicists	Medical physicists
Portugal	0%	Dosimetrists	Medical physicists, technologist/radiographers
Romania	25–75%	Medical physicists	Medical physicists
Slovak Republic	25–75%	Medical physicists	Medical physicists
Slovenia	>75%	Medical physicists, dosimetrists	Medical physicist with the help of technicians/engineers
Spain	<25%	Medical physicists, dosimetrist	Medical physicists, technicians
Switzerland	<25%	Medical physicists, dosimetrists, technologists, radiographers	Medical physicists, technicians/engineers, technologist/radiographers, dosimetrist
United Kingdom	>75%	Medical physicists, dosimetrists, technologists, RTT	Medical physicists, technicians/engineers
England	>75%, About 50% time of radiation oncologist devotes their time to supervising chemotherapy	Dosimetrists, technologists, radiographers	Medical physicists, technicians/engineers
Scotland	>75%	Medical physicists, dosimetrists, RTTs, it varies between departments depending on skill mix	Medical physicists, technicians/engineers
Wales	>75%	Medical physicist, technologists	Medical physicists, technicians
Northern Ireland	>75%	Medical physicists, dosimetrists	Daily machine checks are carried out by radiographers, medical physicists, technicians/engineers, technologists/radiographers

Less affluent countries are just as likely to have developed guidelines as the wealthier (Supplementary material).

Complete results of the HERO survey and additional commentary are available in the Supplementary material.

Discussion

While some of the information sought in the current survey was similar to that incorporated in the previous QUARTS study [6], the current study was more extensive but with a slightly lower overall response rate. Of the 40 ECO countries included, 29 responded in total or in part to this guidelines component of the HERO survey. QUARTS elicited responses from 41 countries [6].

Turning first to the equipment component, a higher number of countries declared having guidelines for the total number of linacs required nationally than was the case ten years ago (25 vs. 17). However, only 11 of the 25 guidelines identified during the HERO survey were categorized as explicit whereas all 17 of those reported by QUARTS [6] had criteria associated with them. It can also be observed that there are differences between the group of countries which reported explicit guidelines to the QUARTS study and to the present HERO survey (Tables 1 and 2). Where such national guidelines exist, these are currently based, entirely or partially, on the population in 14/25 of responses compared with 10/17 for QUARTS. 13/25 guidelines at the national level are based on the number of patients/treatment courses compared with 7/17 for QUARTS, although, as noted above, there are many cases where more than one criterion is used. At the department level, similarly, 14 countries' linear accelerator guidelines depend on the number of patients, treatments and/or fractions with 7 of these being explicit. Although 13 countries have established satellite centers [7], only 2 responding countries have developed explicit criterion based guidelines.

Fig. 1 compares QUARTS and HERO guidelines with actual megavoltage unit workload as reported by Grau et al. [7]. Although the data are incomplete, with only 9/29 comparable data sets, it appears that, for these countries, explicit guidelines for courses per machine have not changed greatly over ten years. It was noted during the analysis that three countries, Austria, Czech Republic and Poland, defined megavoltage unit workload in terms new patients for the QUARTS survey but patients, i.e., not specifying new patients, for this HERO survey. For consistency with the companion publications [7,8], where new patients are specified in a questionnaire response for either QUARTS or HERO a multiplier of 1.25 is applied to yield total patients (courses) treated. One country, the Netherlands is notable in reporting a lower number of courses per machine than their national guideline recommends. This could reflect clinical exigencies overtaking

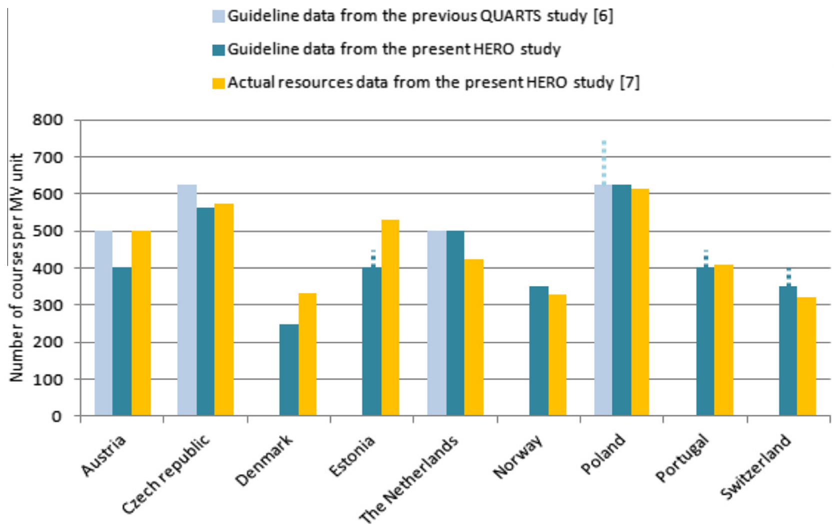

Fig. 1. QUARTS guidelines, HERO guidelines and actual (HERO) megavoltage unit workload. *Notes:* Dotted lines are the ranges when provided by countries. Only countries having data from at least two of the three data sources are shown. HERO and QUARTS guideline data have been adjusted for a 25% re-treatment rate whenever the guideline stated explicitly new patients.

guideline development as more complex and time-consuming treatments are introduced.

Guidelines for the lifetimes of treatment machines, at 8–15 years with a most frequent value of 10 years, appear not to have changed over the last decade. One respondent only stated a recommended lifetime for simulators and that was 10 years (Supplementary material). Of course, the lifetime of a machine is determined at least partly by technological obsolescence in a rapidly changing environment, which makes the development of such lifetime guidelines challenging. However, in-the-field upgrades, such as to Volumetric Modulated Arc Therapy, are an increasingly popular and practical means of maintaining state of the art capability.

Rapid technological changes may also explain the paucity of explicit recommendations for newer devices such as multileaf collimators, electronic portal imagers and CT simulators. While only a third of responding countries had criterion based guidelines for CT simulators, 26 countries participating in this study have such devices [7]. It is noted that two countries regard a multileaf collimator as a standard feature of a linac purchase (Table 1) constituting an implied guideline. Although the number of formal guidelines for multileaf collimators is small, over half the linacs installed are IMRT capable, implying widespread adoption of this newer technology [7]. Surprisingly there seem to be fewer recommendations on the number of treatment planning workstations than there were 10 years ago (21% vs. 40%) although this may be a reflection of the introduction of networked configurations as opposed to stand-alone systems.

Twenty-seven of 29 respondents report having guidelines for the number of radiation oncologists although only 16 of these are explicit. This compares with 17 of the 41 countries responding to the QUARTS survey [6]. The workload for radiation oncologists is presently recommended to be between 130 and 300 patients per year which is slightly lower than that found in the QUARTS study where the range was 150–350 patients annually [6]. This reduction in workload is reflected in the recent data on personnel resources gathered through the HERO project [8]. This may in part echo the increase in treatment complexity and related time requirements observed in the past decade. Interestingly, however, there is also a suggestion that the number of radiation oncologists delivering chemotherapy has increased somewhat over the last ten years. In the present study 38% (11/29) of countries reported that >75% of radiation oncologists deliver chemotherapy whereas it was 19.5% in the QUARTS study. Correspondingly, <25% of radiation oncologists currently deliver chemotherapy in 14% (4/29) of countries whereas the comparable number was 39% ten years ago [6]. This change may be a reflection of the increased uptake of concurrent chemo-radiation protocols [7].

Guidelines for the number of physicists are now present in 25/29 of countries, of which 19 are explicit, compared to 18/41 (explicit) in QUARTS. However, any change from the recommended staffing levels reported in the QUARTS study is lost in the variability of the responses. Staffing guidelines for dosimetrists were not reported in the QUARTS study. Currently, there are 10 guidelines for dosimetrist staffing of which 2 are explicit. As noted in the companion paper [8], and is apparent from Table 3, there is overlap in the functions of medical physicists, dosimetrists and RTTs particularly in the area of treatment planning. This may be part of the reason for the relatively small number of guidelines for dosimetrists. This survey has identified 27 guidelines for RTTs, of which 19 are explicit, compared with 19 in the QUARTS study [6]. As was noted in the HERO staffing paper [8], guidelines typically link the number of RTTs or nurses to machines which, in turn, are frequently linked to the population base being served. It would be more appropriate to use fractions, perhaps including complexity, as the basis for RTT staffing models as fractions are a more accurate reflection of actual workload.

It is possible to compare recommendations made in staffing guidelines reported during this survey with those reported 10 years ago as part of the QUARTS study [6] and with the actual situation [8]. Fig. 2 shows such comparisons for radiation oncologists and medical physicists. Fig. 3 shows comparisons between guidelines reported to this study and actual staffing levels [8] for RTTs per machine. Such data were not collected during the QUARTS study [6]. Where both HERO and QUARTS explicit guidelines for radiation oncologists and physicists do exist, it is apparent that they have not changed greatly over ten years. However, for both radiation oncologists and medical physicists the actual number of courses per professional is lower than guidelines in three quarters of responding countries. This may be another example of increasing clinical complexity overtaking guideline development. Similarly, in all five evaluable reports, RTT staffing exceeded recommendations, sometimes by a considerable margin (Fig. 3).

In addition to using QUARTS [6] as a basis for guidelines, many countries refer to recommendations from other organisations such as IAEA [11], EFOMP [12], EORTC [13] and IPEM [14]. These recommendations seem to have been accepted as some kind of 'gold stan-

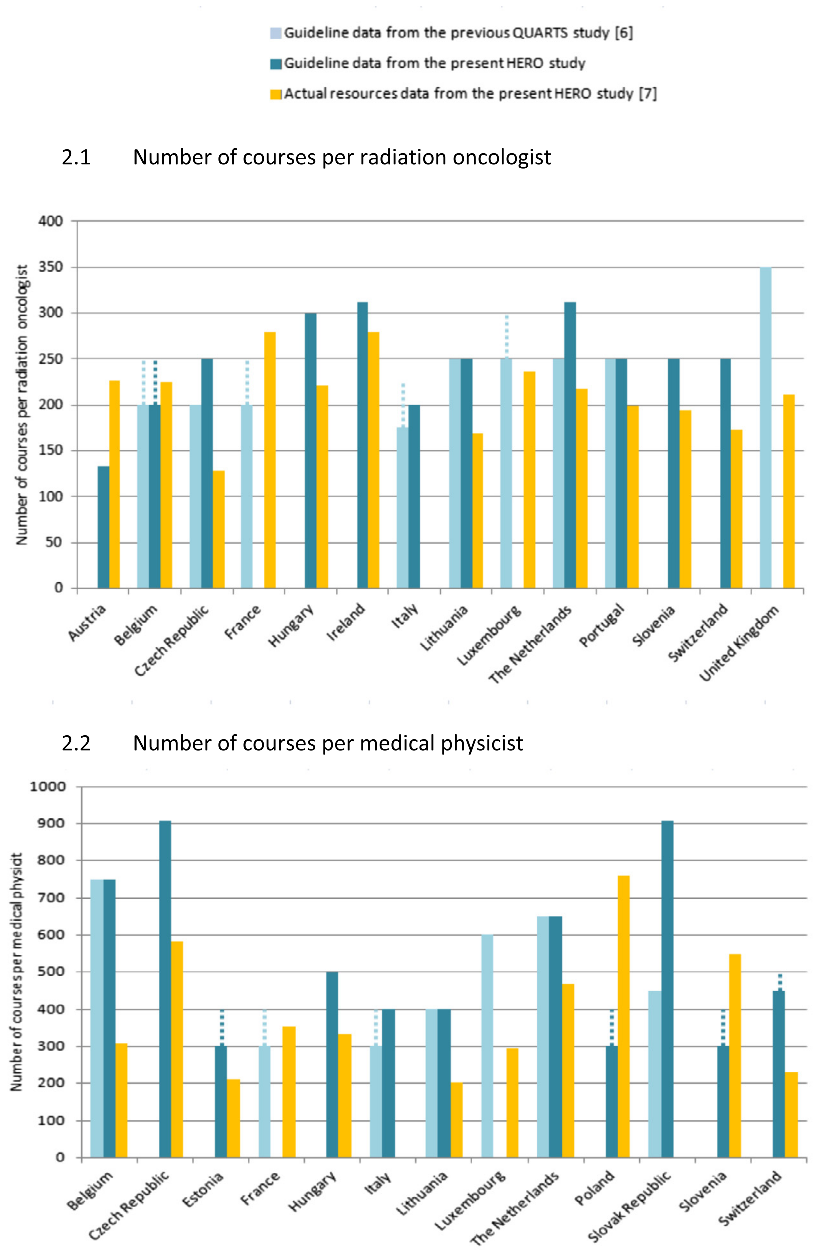

Fig. 2. QUARTS guidelines, HERO guidelines and actual (HERO) staff workload. *Notes:* Only countries having data from at least two of the three data sources are shown. Dotted lines are the ranges when provided by countries.

dard' by the jurisdictions that use them. Their recommendations tend be somewhat similar, based, as they are, on prevailing practice about a decade ago. But none of these has ever looked at real needs as determined by actual cancer statistics as a basis for doing so [1–3] was not available at the time of development. Moreover, there does not seem to exist a tradition of periodic updates. Those changes that do happen can be provoked by ad-hoc incentives such as radiotherapy accidents or enforced safety regulations and not as part of a regular review. For example, in Poland much stricter regulations on staff, equipment and maintenance were passed after the patients' overdosage in Bialystok in 2001 [15], while in France a strict regulation on reporting and public information was initiated after the events in Epinal in 2004–5 [16]. It is apparent from a comparison of the results presented here with those in the companion papers [7,8] that the process of guideline updating is much slower than changes in practice.

With sophisticated models such as those developed by Delaney et al. [1,3] and/or best practice studies of the type conducted by the group at Queen's University [2] it is possible to estimate demand, within some level of accuracy, based on the cancer profiles of the country or region [9]. The role of guidelines of the type surveyed here is to translate demand into operational parameters such as numbers of machines, numbers and types of staff and the other characteristics of a radiotherapy treatment facility. With advancing technology, such as Image Guided Radiation Therapy, and changing practice, for example Stereotactic Ablative Body Radiotherapy, it has to be acknowledged that guidelines will need to be under constant review. However, without guidelines, or non-adherence to guidelines, the introduction of new facilities or upgrading of current facilities can become haphazard with instabilities compromising safety and quality, and possibly waste through unnecessary duplication and inefficient use of limited resources [8].

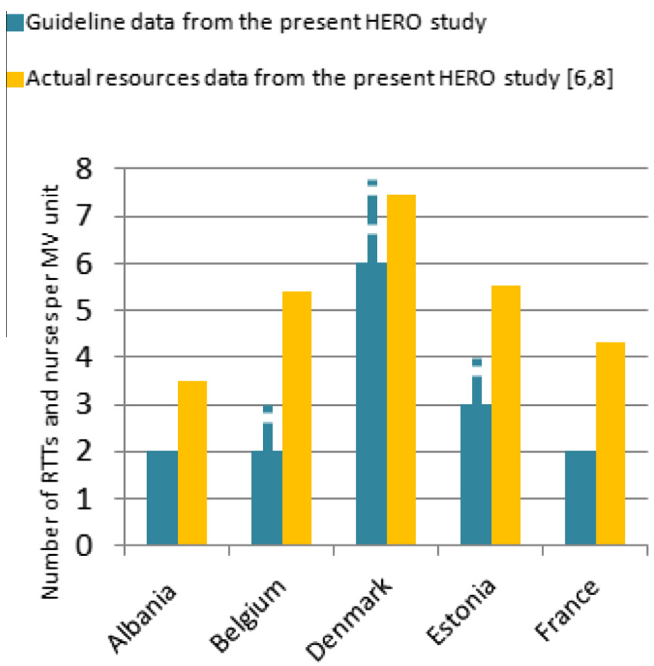

Fig. 3. Number of RTTs and radiotherapy nurses per mega voltage unit. *Notes:* Only countries having data from at least two of the three data sources are shown. Dotted lines are the ranges when provided by countries.

Although over half the countries responding to this questionnaire do have plans for future radiotherapy equipment and staffing, the recommendations analyzed here suffer from several limitations that render them insufficient to forecast the evolution in human and capital resource requirements for modern radiotherapy. Key elements, such as acknowledging the role of volumetric imaging, seem to be lacking. From Table 1 it can be inferred that the level of detail of existing capital resource guidelines decreases with the newness of the technology, for example multileaf collimators and portal imagers. Moreover, even where a substantial number of guidelines does exist, such as for linear accelerators, different denominators are used: inhabitants, patients, and fractions. Are patients new patients or is it courses that are meant? The same variability in denominators is observed for staffing guidelines (Table 2). For example, for RTTs sometimes it is the number of patients treated but mostly it is therapists per linac. The same holds for medical physicists. Resource recommendations, whether for capital or human resources, should be stated as input divided by output (or vice versa). RTTs (and other staff) and linacs are both inputs to the radiotherapy process so specifying staffing recommendations as RTTs per linac does not make sense without also specifying fractions per hour or some such metric. Not asked for in this study, but clearly of relevance, are the operating hours of linear accelerators and other equipment: double the number of hours and half the amount of equipment, although lifetime might be reduced [17]. Of course operating hours can also confound staffing models which are based on RTTs per linac, for example, instead of some valid measure of output such as fractions treated. An IAEA initiative, currently underway, is designed to accommodate this necessary level of complexity by including working hours in the estimation of personnel resources needed [18].

The current recommendations for equipment, staff and staff mix show significant variability. With downward pressures on budgets in most jurisdictions [19], it behooves the radiation treatment community to get a better handle on the capital and human resources required to deliver safe, high quality radiotherapy in the modern era. Looking to the future, staffing algorithms could, for example, provide the basis for examining the impact of substituting generalists (assistants) for specialists as economic and demographic pressures force us to rethink our operational models. There is no evidence from the current survey that such a shift has started yet.

There are, of course, limitations to the study presented here. The most significant has resulted from the challenge of interpreting the responses submitted by the national societies. Some were brief and some were much more detailed. Given publication space restrictions, the authors were obliged to distill the responses down to the salient points. To minimize the risk of misinterpreting responses, the national societies were asked for clarifications as the analysis proceeded and have been given the opportunity to review their data as presented in this paper. A final ambiguity is associated with the question as to whether or not the guidelines reported by the national societies have any legal status or are recommendations for best practice.

To assist the national societies within ESTRO and to promote high standards of quality and accessibility for all European cancer patients, in an environment of shrinking budgets, a strong argument could be made for the continuing development of templates to guide the planning of radiotherapy facilities in the European nations. To be useful in the medium to long term, such templates would have to accommodate the dynamic technological environment in which radiotherapy is delivered. The IAEA initiative to develop a staffing estimator based on performed activities and time estimates would be an appropriate starting point [18]. The knowledge base created through other components of the HERO project complement the development of such templates by facilitating the prediction of evidence based demand for radiotherapy services.

Conclusions

There have been no major changes in the availability or specificity of equipment and staffing guidelines in the European countries in the last ten years with the exception of those for RTT staffing. In the nations which could be evaluated here, actual staffing for radiation oncologists, physicists and particularly RTTs mostly exceed those in current guidelines. While it is acknowledged that the development of human and capital resource guidelines in a rapidly changing technological environment is challenging, the provision of sustainable, safe, high quality radiotherapy services to the population of Europe would benefit from progress in this regard. A consensus developed template, using consistent terminology and metrics, for the planning of radiotherapy resources could facilitate the availability of this pillar of cancer management.

Conflict of interest statement

The authors have no conflict of interest.

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.radonc.2014.08.032.

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