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Original article

How many new cancer patients in Europe will require radiotherapy by 2025? An ESTRO-HERO analysis

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ABSTRACT

Background: The objective of this HERO study was to assess the number of new cancer patients that will require at least one course of radiotherapy by 2025.
Methods: European cancer incidence data by tumor site and country for 2012 and 2025 was extracted from the GLOBOCAN database. The projection of the number of new cases took into account demographic factors (age and size of the population). Population based stages at diagnosis were taken from four European countries. Incidence and stage data were introduced in the Australian Collaboration for Cancer Outcomes Research and Evaluation (CCORE) model.
Results: Among the different tumor sites, the highest expected relative increase by 2025 in treatment courses was prostate cancer (24%) while lymphoma (13%), head and neck (12%) and breast cancer (10%) were below the average. Based on the projected cancer distributions in 2025, a 16% expected increase in the number of radiotherapy treatment courses was estimated. This increase varied across European countries from less than 5% to more than 30%.
Conclusion: With the already existing disparity in radiotherapy resources in mind, the data provided here should act as a leverage point to raise awareness among European health policy makers of the need for investment in radiotherapy.

The number of newly-diagnosed cancer patients that would require radiotherapy treatment using an evidence-based approach was estimated for all European countries for the year 2012 within the framework of the ESTRO-HERO (Health Economics in Radiation Oncology) project [1]. The estimate was based on optimal utilization of radiation oncology according to the CCORE methodological approach [2], using incidence data for European countries as estimated by the International Agency for Research on Cancer (IARC) [3,4], and combined with data on stage at diagnosis from four population-based cancer registries (The Netherlands, Slovenia, Grater Poland region of Poland, and Belgium) available in the categories required [5].

This estimation provides a useful tool for planning the required equipment and staff needs. One of the critical results was the observed gap between the optimal utilization and the actual use of radiotherapy, with most countries covering less than 80% of the evidence-based demand for treatment compared with actual use [1]. This evidence could be immediately applied to improve cancer control planning with respect to placing the necessary investments required to cope with the demand of cancer patients.

Long-term planning is required for radiotherapy facilities as well as for the staff needed, due to the significant interval between the time of making decisions for facility investments and training of personnel and the time when they become a clinical reality. A forecast of the anticipated changes in terms of new cancer patients that would need radiotherapy in the short- to medium-term time horizon seems rational, and fits within the objectives of the ESTRO-HERO project.

The aim of this paper is then to assess the number of new cancer patients by tumor site that will require radiotherapy in 2025 as compared to the 2012 data, using the national cancer incidence estimates based on data from the population-based cancer registries available in each European country together with projections carried out by IARC in GLOBOCAN [6].

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Materials and methods

European country-specific cancer incidence by tumor type was extracted from the GLOBOCAN database [4] for the year 2012. The detailed description of the data and the methods used to compute these estimates is given elsewhere [3]. To summarize, statistical models were developed to predict incidence rates for the year 2012 from recent trends, wherever possible. The country, sex, and site estimated incidence rates in 2012 were then applied to the corresponding population estimates to obtain the estimated numbers of new cancers in each European country in 2012. Projections for the year 2025 were computed using the facility available at the GLOBOCAN website [4]. The projected numbers of new cancer cases have been derived by applying the age-specific incidence rates estimated for 2012 to the corresponding forecast population in 2025. Therefore, the projected incident cases for 2025 took into account the demographic changes (age structure and size), but not the potential impact of the changes in risk factors.

Tumor sites included in the analysis were as follows: bladder, brain, breast, cervix, colon, gallbladder, head and neck (lip, oral cavity, larynx, oropharynx, hypopharynx and nasopharynx), kidney, leukemia, lung, lymphoma (including Hodgkin and non-Hodgkin lymphoma), melanoma, multiple myeloma, esophagus, ovary, pancreas, prostate, rectum, stomach, testis and corpus uteri). It has been necessary to adapt the categories provided by GLOBOCAN to fulfill the requirements of the radiotherapy evidence-based Optimal Utilization Proportion (OUP) [2]. "Colon and rectum" cancer was partitioned into colon and rectal cancers, "lip and oral cavity" into lip and oral cavity and the category "other pharynx" into oropharynx and hypopharynx. In order to do this, we extracted data from population-based cancer registries available in the last volume of Cancer Incidence in Five Continents [7] for as many European countries as possible and computed proportions of each individual category. When no data were available in a particular country (such as Albania, Macedonia or Luxembourg), the data from a neighboring country was used. The same proportions were used in the 2012 and 2025 estimates.

OUP of radiotherapy by tumor site was obtained from the Australian Collaboration for Cancer Outcomes Research and Evaluation (CCORE) review [2], which provided radiotherapy indications for all tumor sites according to the relevant evidence-based clinical guidelines by tumor site and stage at diagnosis, updated to 2012. The stage at diagnosis originally used in the CCORE was from the Australian cancer registry. Four different European cancer registries provided data fitted to the CCORE decision trees structure (Slovenia, Grater Poland region of Poland, Belgium and The Netherlands) in order to estimate the OUP using a range of stage at diagnosis from distinct European countries. The methodological details of this analysis have been provided elsewhere [5]. The same OUPs were used in the 2012 and 2025 estimates. For the correct interpretation of the OUPs it is necessary to know that each patient is counted only once, even if he or she subsequently required further treatment for the particular cancer. Brachytherapy treatments were not considered.

Results

About 4 million new cancer patients are predicted in 2025 in Europe based on demographic changes. This represents a 15.9% increase in the absolute number of cases compared to the 3.4 million diagnosed in 2012, assuming overall cancer rates remain unchanged (Table 1). Using the lowest OUP estimated for each country, the absolute number of patients that would have an indication for radiotherapy at least once during the course of the disease would increase from 1,700,000 patients approximately in 2012 to 2,000,000 in 2025. This represents a 16.1% increase over the entire period.

This increase in the number of expected cases is not distributed evenly across European countries (Table 1 and Fig. 1). Eastern European countries exhibited, broadly speaking, the lowest percentile increases, with Bulgaria, Ukraine, Latvia and Lithuania expecting decreases in the number of new cancer cases, while the incidence burden in many of the rest of Eastern countries is predicted to increase by less than 10%. The exceptions were Poland, the Czech Republic and Slovakia with increases of around 20% or above. However, when the focus is on the absolute in numbers, as shown in Fig. 2, it is clear that the greater increases are estimated in the most densely populated countries.

South-Eastern European countries showed a diversity of estimated changes in the number of patients, from a relative decrease in Bulgaria (−0.8%) to an increase of 33.4% in Albania. The highest relative increases were observed among small countries with no clear geographic pattern (Iceland, Ireland and Cyprus) with increases above 35%, while the incidence rises in more populated countries such as The Netherlands, Switzerland and Norway were between 25% and 31%. The countries of Western Europe, including France, Germany, Italy, Spain or the UK, with the highest volume of population, exhibited increases in the number of new cases from 2012 to 2025 by between 15% and 25%.

Relative changes by tumor site and for all countries combined are presented in Table 2. It is worth noting that prostate cancer produced the highest increase over the period considered with a 24.4% rise followed by bladder cancer and multiple myeloma, while female breast cancer, lymphomas and head and neck cancer were below average. Importantly, cervical cancer only increased by 1.1% while the numbers of patients with a radiotherapy indication for cancer of the testis declined.

The tumors that make up the highest percentage of patients in a radiotherapy department, namely breast, rectum, head and neck, lung and prostate cancers are shown in Table 3 for each European country with their absolute and relative increase. Some relative increases are noteworthy and deserve close analysis at national level. For instance, countries such as Spain, The Netherlands or the Czech Republic show an increase higher than 25% for rectal cancer patients with a radiotherapy indication, while Belgium, UK or Denmark have an estimated increase above 20%. Also, the estimated increase for prostate or lung cancer is very important in many western European countries, higher than 20%; while the observed increases for breast cancer patients are moderate in comparison.

Fig. 3 provides a visual representation of the cancer types with the highest absolute number of radiotherapy indications, projected for the 2025. Interestingly, in several countries bladder cancer ranks among the most frequent cases according to the evidence-based indications, due to its high incidence in these countries. A similar observation can be made for lymphoma (estimates by country for all tumor types can be consulted in the web-based Supplementary material).

Discussion

Projections of the incidence of cancer are helpful in assessing the future burden of cancer and in order to establish appropriate cancer control plans to cope with the challenge posed by a growing number of cancer patients. The projections carried out in GLOBOCAN by IARC, combined with the evidence-based data on radiotherapy indications offer a unique opportunity to undertake long-term radiotherapy resource planning. The obtained data, by tumor site and by country within Europe, give guidance for making the necessary investments in services and equipment and for setting-up training of dedicated personnel, necessary actions to adequately manage the increased radiotherapy demands expected in the near future.

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Table 1
Cancer cases with an evidence based indication for external radiotherapy 2012 and 2025.

Country	Total cancers (n)[a]		OUP (%)[b]		Optimal radiotherapy courses (n)				
					2012		2025		% Var. 2012–25
	2012	2025	Min.	Max.	OUP min.	OUP max.	OUP min.	OUP max.	OUP min./max.
Albania	7143	9,532	52.6	54.3	3758	3879	5014	5177	33.4
Austria	41,117	50,167	49	50.3	20,155	20,698	24,591	25,253	22
Belarus	32,422	33,649	48.5	50.3	15,738	16,293	16,333	16,909	3.8
Belgium	65,345	78,488	53.2	54.8	34,792	35,799	41,790	43,000	20.1
Bosnia Herzegovina	9911	11,538	52.8	54.4	5236	5395	6096	6280	16.4
Bulgaria	32,053	31,792	51.3	53	16,434	16,977	16,301	16,838	−0.8
Croatia	22,890	25,143	51.2	52.7	11,717	12,055	12,870	13,242	9.8
Cyprus	3438	4724	51	52.3	1753	1799	2409	2471	37.4
Czech Republic	57,627	70,553	48.5	50.2	27,943	28,945	34,211	35,437	22.4
Denmark	36,119	43,557	52.8	54.3	19,064	19,600	22,990	23,636	20.6
Estonia	6117	6310	49.1	50.8	3004	3104	3099	3202	3.2
Finland	28,428	34,460	52.1	53.4	14,810	15,189	17,952	18,412	21.2
France	3,71,676	4,46,670	51.9	53.3	1,92,769	1,98,107	2,31,665	2,38,079	20.2
Germany	4,93,780	5,68,892	50.1	51.6	2,47,419	2,54,735	2,85,056	2,93,485	15.2
Greece	40,971	46,621	52.5	54.2	21,523	22,213	24,491	25,276	13.8
Hungary	50,475	54,051	50.3	51.9	25,412	26,209	27,212	28,065	7.1
Iceland	1449	1997	50.7	51.8	734	750	1,012	1,034	37.8
Ireland	20,808	28,432	51.5	52.9	10,714	11,017	14,640	15,053	36.6
Italy	3,54,456	4,11,515	48.2	49.3	1,70,821	1,74,764	1,98,320	2,02,897	16.1
Latvia	10,347	9567	49.9	51.4	5166	5315	4777	4914	−7.5
Lithuania	14,520	13,514	49.9	51.5	7244	7483	6742	6965	−6.9
Luxembourg	2476	3231	50.6	52	1252	1289	1634	1682	30.5
Macedonia	7330	9097	52.6	54.3	3856	3981	4786	4941	24.1
Malta	1902	2563	51.9	53.3	988	1014	1331	1367	34.8
Moldova	9894	10,371	50.2	52.1	4969	5151	5208	5399	4.8
Montenegro	2115	2341	52.2	53.8	1105	1139	1223	1260	10.7
Norway	28,214	36,334	49	50.5	13,818	14,248	17,795	18,349	28.8
Poland	1,52,216	1,81,072	52	53.4	79,139	81,294	94,142	96,705	19
Portugal	49,174	57,436	49.7	51.1	24,438	25,151	28,543	29,377	16.8
Romania	78,760	87,623	50	51.8	39,383	40,805	43,814	45,397	11.3
Russian Federation	4,58,382	4,87,682	47	48.6	2,15,507	2,22,922	2,29,282	2,37,172	6.4
Serbia	42,221	44,392	52.2	53.8	22,050	22,733	23,184	23,901	5.1
Slovakia	24,045	29,911	48.2	50.2	11,599	12,071	14,428	15,016	24.4
Slovenia	11,457	14,207	49.6	51.3	5680	5874	7044	7284	24
Spain	2,15,534	2,68,960	49.7	51.1	1,07,018	1,10,159	1,33,545	1,37,465	24.8
Sweden	50,481	59,410	51.4	52.8	25,928	26,662	30,514	31,378	17.7
Switzerland	42,046	55,088	50.6	52	21,294	21,865	27,900	28,647	31
The Netherlands	93,448	1,17,999	52.3	53.9	48,886	50,324	61,729	63,546	26.3
Ukraine	1,40,999	1,40,928	50.2	52.1	70,811	73,403	70,775	73,366	−0.1
United Kingdom	3,27,812	3,98,471	53	54.4	1,73,612	1,78,405	2,11,034	2,16,860	21.6
Global	34,39,598	39,88,288	50.2	51.7	17,27,538	17,78,816	20,05,480	20,64,739	16.1

[a] All cancers excl. non-melanoma skin cancer. Globocan 2012/2025.
[b] OUP: optimal utilization proportion.

Other groups have performed similar exercises. Datta and colleagues made estimates of the additional number of treatment units and personnel – radiation oncologists, medical physicists and radiation technologists – required in 39 European countries by 2020 [8]. Actual radiotherapy resources were obtained from the DIRAC (Directory of Radiotherapy Centres) database; whereas actual and future needs were computed using actual and projected cancer incidence data from GLOBOCAN, combined with the assumption that 62.5% of all cancer patients would require RT (50% of new cancer patients plus 25% of these for re-irradiation) and with required machine and staffing levels based on ESTRO-QUARTS [9] and IAEA recommendations [10]. In contrast to their approach, our projections are restricted to the number of cancer patients that can be expected to benefit from radiotherapy by 2025, hence courses that should be delivered, without making assumptions – as yet – about the resources that would be required to make this possible. Our previously published HERO-analysis has indeed demonstrated that the available European radiotherapy guidelines do not sufficiently take into account the rapid technology evolution in radiotherapy, hence in our view do not provide sufficiently robust estimates to correctly predict the real resource needs for each individual country [11]. With their activity-based approach using time-based estimates for diverse activities within the radiotherapy treatment process (instead of using average throughput estimates), the Global Task Force on Radiotherapy for Cancer Control has taken an important step in forecasting radiotherapy resource needs for a given patient population, requiring a certain number of radiotherapy courses [12]. The HERO-project is now adopting a similar activity-based approach to develop a productivity and costing model that can be tailored to the specific needs of each European jurisdiction, based on the actual radiotherapy needs down to the level of each cancer type, and accounting for the evolving radiotherapy practice in terms of complexity and fractionation schedules.

The effects taken into account by the methodology used in the projections of cancer incidence are demographic (age structure changes and population size), the major contributor to future increasing number of new cancer cases in Europe [13]. Risk factor changes and their potential consequences on incidence or, more simply, trends-based approaches have however not been considered. All factors taken into account, the projection methodology applied here could be considered conservative, assuming that changes in age-specific rates beyond 2012 were assumed to remain constant through 2025. The uncertainties associated with possible

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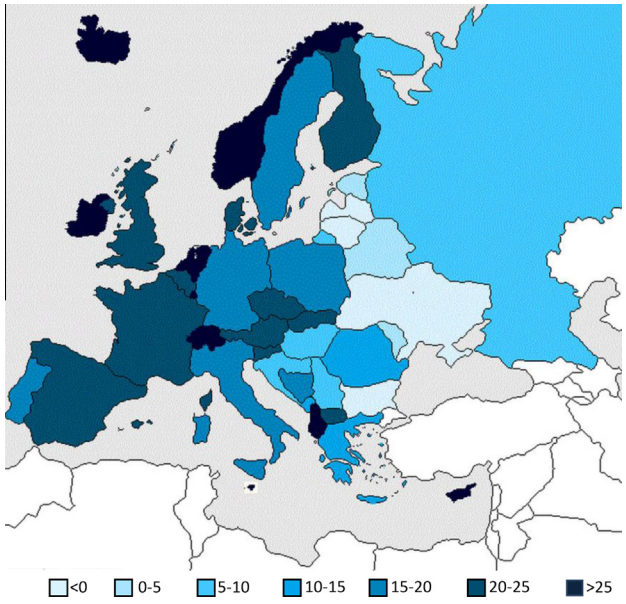

Fig. 1. Increase in new cancer patients that would require radiotherapy by 2025 by country (%).

Table 2
Cancer cases with an evidence based indication for external radiotherapy 2012 and 2025.

Tumor site	Optimal radiotherapy courses (n)		
	2012 (OUP min.)[a]	Increase in number of radiotherapy courses 2025	
		n	%
Bladder	70,679	14,842	21.0
Brain	45,717	4622	10.1
Breast	396,891	40,524	10.2
Cervix	36,384	405	1.1
Colon	9090	1740	19.1
Gall bladder	3490	667	19.1
Head and neck	108,194	13,337	12.3
Kidney	14,242	2139	15.0
Leukemia	2442	366	15.0
Lung	315,197	56,558	17.9
Lymphoma	74,852	9871	13.2
Melanoma	11,725	1340	11.4
Myeloma	17,821	3629	20.4
Esophagus	33,292	5955	17.9
Ovary	1268	124	9.8
Pancreas	40,144	7198	17.9
Prostate	243,669	59,493	24.4
Rectum	99,493	18,314	18.4
Stomach	37,185	5675	15.3
Testis	738	−45	−6.1
Thyroid	2365	107	4.5
Uterus	33,341	4146	12.4

[a] OUP: optimal utilization proportion.

determinants in the future – the risk profile and diagnostic changes – may be considered sufficiently high as to make reliable predictions of their impact on future trends a difficult and potentially misleading exercise [14].

The second source of data used in this study has been the OUP. Any possible change in the evidence-base of the radiotherapy indications in the coming future, and consequently in the OUP for any particular tumor site, will have implications for the expected number of cases for radiotherapy treatment. However, the OUP has been quite robust when considered for all cancers together when the update of 2012 was compared to the evaluation of the clinical guidelines up to the year 2003 [2,15]. In fact, the expansion of conservative approaches to organ preservation, and the increased combination of radiotherapy and chemotherapy in tumor sites such as cervical, rectal or lung cancer [16], related to an earlier stage at diagnosis, will most probably expand the number of candidates for radiotherapy. Moreover, new radiotherapy techniques that involve more precision in the delivery of the dose and less toxic effects on the surrounding tissue jointly with new

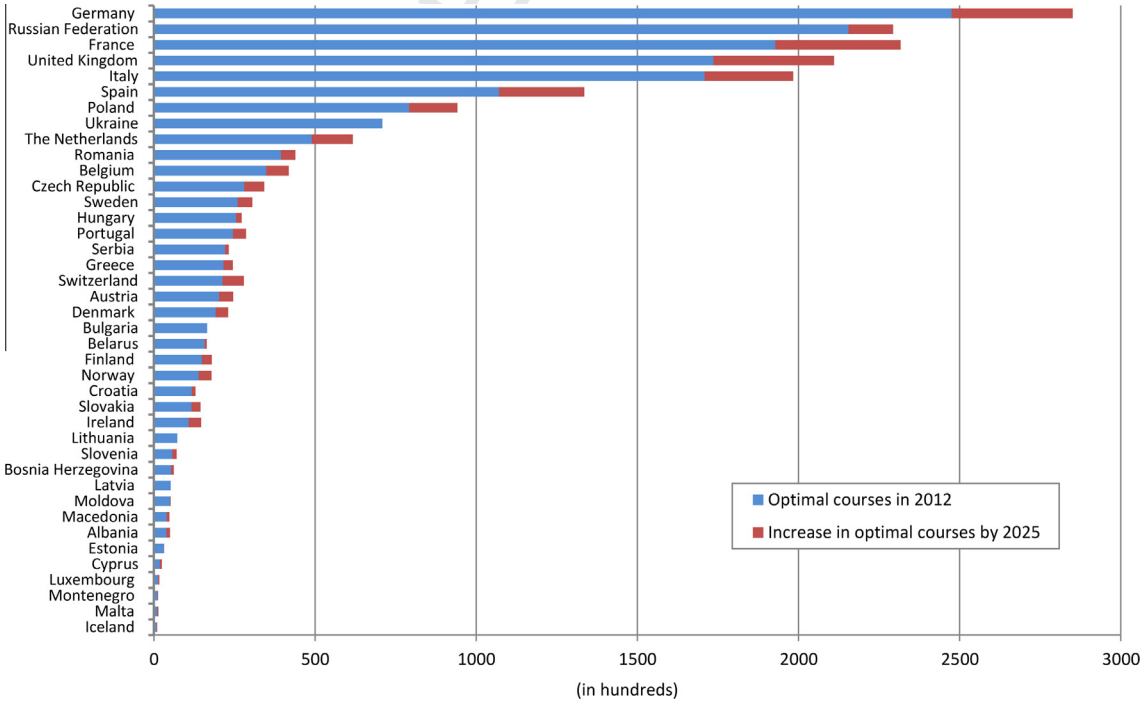

Fig. 2. Optimal number of courses of radiotherapy in 2012 and estimated absolute increase in optimal number of courses by 2025.

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Table 3
Increase in the number of new cancer cases that would require radiotherapy by 2025 and relative percentage increase between 2012 and 2025 for the 5 most frequent indications.

Country	Effects of OFC inactivations Increase		Head and neck Increase		Lung Increase		Prostate Increase		Rectum Increase	
	n	%	*n*	%	*n*	%	*n*	%	*n*	%
Albania	146	16.7	103	39.6	370	43.6	96	49.3	32	37.1
Austria	584	13.0	227	19.9	868	24.7	1019	29.9	248	25.8
Belarus	77	2.4	55	4.0	214	6.9	76	6.1	69	6.6
Belgium	1020	11.5	343	16.5	1401	23.4	1537	28.0	370	22.5
Bosnia Herzegovina	81	8.2	78	17.5	274	20.6	112	27.7	57	19.4
Bulgaria	−125	−3.7	−12	−1.1	0	0.0	42	3.9	20	1.7
Croatia	81	3.6	67	7.9	287	12.2	258	21.8	107	13.1
Cyprus	145	28.1	15	33.4	87	40.9	137	48.8	29	42.1
Czech Republic	815	13.9	252	15.8	1197	23.3	1275	31.8	525	26.7
Denmark	538	12.0	125	13.7	788	22.4	831	27.3	245	24.8
Estonia	−12	−2.1	7	4.5	27	5.5	49	8.2	8	4.4
Finland	313	8.2	73	15.1	506	26.4	836	26.6	160	25.6
France	6253	13.5	1599	13.6	5994	19.5	10,846	25.2	1994	24.2
Germany	5376	8.8	1431	9.5	6775	17.3	9161	23.0	2872	18.0
Greece	395	9.4	132	14.5	880	16.6	319	16.8	119	15.2
Hungary	184	4.2	146	5.2	494	6.9	228	12.3	201	9.6
Iceland	53	27.6	8	38.9	54	43.2	74	46.5	15	39.5
Ireland	744	30.0	146	34.0	714	40.9	905	40.9	155	40.7
Italy	4323	10.0	1303	16.3	5757	20.1	5596	21.5	1763	18.2
Latvia	−92	−9.4	−18	−6.2	−55	−6.1	−47	−5.4	−12	−6.4
Lithuania	−75	−5.9	−14	−3.2	−68	−5.7	−80	−9.0	−23	−6.4
Luxembourg	68	21.9	14	23.5	67	33.3	79	40.2	26	31.9
Macedonia	169	17.2	48	23.0	266	27.3	96	37.6	44	27.7
Malta	50	18.8	23	37.6	67	48.1	63	53.5	19	37.7
Moldova	43	4.5	−6	−1.0	46	4.9	42	16.1	37	9.3
Montenegro	12	5.4	8	9.1	31	11.1	20	22.9	9	13.3
Norway	451	18.3	123	25.6	684	31.3	1179	34.8	245	32.0
Poland	1524	10.3	797	13.4	4442	22.0	2156	33.4	865	23.7
Portugal	521	10.0	340	15.2	621	19.3	803	23.1	325	19.4
Romania	656	8.5	550	12.8	1231	13.7	388	14.7	250	12.9
Russian Federation	2228	4.5	828	5.2	3,425	8.0	2003	12.7	1295	9.1
Serbia	253	5.5	53	3.1	329	5.9	167	9.1	78	6.8
Slovakia	376	16.6	185	18.8	543	27.9	455	40.3	313	30.0
Slovenia	127	11.8	62	18.5	280	26.8	366	39.8	113	28.7
Spain	3678	17.0	1979	27.6	5841	28.4	5021	30.8	2155	26.9
Sweden	623	11.0	133	15.9	542	18.1	1,283	18.9	268	22.2
Switzerland	1091	22.2	301	27.9	1073	32.9	1727	37.6	325	33.8
The Netherlands	1552	13.1	491	22.5	2641	28.7	2825	36.3	862	32.4
Ukraine	−124	−0.9	−5	−0.1	209	1.6	38	1.0	82	1.6
United Kingdom	6401	14.3	1349	18.1	7656	24.7	7419	27.9	2049	24.4
Global	40,524	10.2	13,337	12.3	56,558	17.9	59,493	24.4	18,314	18.4
Range	−9.4 to 30.0		−6.2 to 39.6		−6.1 to 48.1		−9.0 to 53.5		−6.4 to 42.1	

combinations with chemotherapy could also influence the number of candidates for radiotherapy treatments [17]. In summary, a decrease in the number of patients due to a reduction in indications is highly improbable.

The main result of this study is that the absolute number of new cancer patients with a radiotherapy indication will increase in the immediate future in almost all European countries, although there are variations in their relative magnitude between the countries and regions of Europe. As mentioned, the driver of the predictions utilized here are the projected population aging and population growth. Classical drivers of such demographical changes are fertility, mortality and migration. The latter is the least predictable and is more prone to short-term changes. However the impact of migration is usually mainly seen in younger age groups, who have a relatively low cancer risk. From a global viewpoint, EU countries exhibit a very moderate short-term increase in the size of the population (0.8% between 2015 and 2020 and 1.2% between 2020 and 2030). The Nordic and some western countries (e.g. France, the UK), are the only countries to clearly indicate an increase in the size of the population in the mid- and longer-term projections [18] until 2050 or later. Eastern European countries show a decrease in population size in the mid- and longer-term, however the main decrease is predicted beyond 2025 for all these countries, including the Russian Federation and Ukraine [19].

Aging of the European population, due to the increases in longevity and low fertility levels, is a parallel process that explains the increase in number of cases. One consequence of this process is that the very old (80 years or older) are the fastest growing population age group in Europe. Age and cancer incidence are strongly associated, hence the aging process has a strong impact on the cancer incidence in countries with the highest percentage of older age groups, such as Germany, Italy or Spain. The main consequence for radiotherapy as well as for the multidisciplinary management of this aged patient group is the growing prevalence of patients with multi-morbidities including cancer, which influences clinical decision-making. Indeed, one of the most relevant factors that explains lower than expected indications for radiotherapy is the presence of comorbidity and old age [20–22]. These clinically-related factors – coupled with patient preferences – could in part explain the gap between the optimal and actual use of radiotherapy observed in different analyses [1,23]. Other factors are more policy-related and include accessibility problems due to the distance to radiotherapy departments, lengthy waiting lists, a lack of resources and/or old therapeutic technologies [1], which are

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Country	First	Second	Third	Fourth	Fifth
Albania	Lung	Breast	Head&Neck	Brain	Stomach
Austria	Breast	Prostate	Lung	Head&Neck	Bladder
Belarus	Breast	Lung	Head&Neck	Prostate	Rectum
Belgium	Breast	Lung	Prostate	Bladder	Head&Neck
Bosnia Herzegovina	Lung	Breast	Head&Neck	Prostate	Rectum
Bulgaria	Breast	Lung	Rectum	Head&Neck	Prostate
Croatia	Lung	Breast	Prostate	Rectum	Head&Neck
Cyprus	Breast	Prostate	Lung	Bladder	Lymphoma
Czech Republic	Breast	Lung	Prostate	Rectum	Head&Neck
Denmark	Breast	Lung	Prostate	Rectum	Bladder
Estonia	Prostate	Breast	Lung	Rectum	Head&Neck
Finland	Breast	Prostate	Lung	Lymphoma	Rectum
France	Prostate	Breast	Lung	Head&Neck	Lymphoma
Germany	Breast	Prostate	Lung	Rectum	Head&Neck
Greece	Lung	Breast	Prostate	Bladder	Brain
Hungary	Lung	Breast	Head&Neck	Rectum	Prostate
Iceland	Breast	Prostate	Lung	Rectum	Bladder
Ireland	Breast	Prostate	Lung	Lymphoma	Head&Neck
Italy	Breast	Lung	Prostate	Rectum	Lymphoma
Latvia	Breast	Lung	Prostate	Head&Neck	Bladder
Lithuania	Breast	Lung	Prostate	Head&Neck	Rectum
Luxembourg	Breast	Prostate	Lung	Rectum	Head&Neck
Macedonia	Lung	Breast	Prostate	Head&Neck	Bladder
Malta	Breast	Lung	Prostate	Bladder	Head&Neck
Moldova	Lung	Breast	Head&Neck	Rectum	Prostate
Montenegro	Lung	Breast	Prostate	Head&Neck	Rectum
Norway	Prostate	Breast	Lung	Rectum	Bladder
Poland	Lung	Breast	Prostate	Head&Neck	Bladder
Portugal	Breast	Prostate	Lung	Head&Neck	Rectum
Romania	Lung	Breast	Head&Neck	Prostate	Cervix
Russian Federation	Breast	Lung	Prostate	Head&Neck	Rectum
Serbia	Lung	Breast	Prostate	Head&Neck	Rectum
Slovakia	Breast	Lung	Prostate	Rectum	Head&Neck
Slovenia	Lung	Prostate	Breast	Rectum	Head&Neck
Spain	Lung	Breast	Prostate	Rectum	Head&Neck
Sweden	Prostate	Breast	Lung	Rectum	Lymphoma
Switzerland	Prostate	Breast	Lung	Lymphoma	Head&Neck
The Netherlands	Breast	Lung	Prostate	Rectum	Lymphoma
Ukraine	Breast	Lung	Head&Neck	Rectum	Prostate
United Kingdom	Breast	Lung	Prostate	Lymphoma	Rectum
Global	Breast	Lung	Prostate	Head&Neck	Rectum

Fig. 3. Top 5: Ranking by absolute number of cancer patients requiring radiotherapy by 2025 (using min OUP).

all more amenable to health policy efforts. Indeed, differences between evidence-based indications and clinical practice could be observed in the relative importance of bladder cancer or lymphoma as indication, which is not in line with the actual demand for radiotherapy in our clinical departments. These discrepancies may reflect shortcomings of the model or an indication that some patients with indications for radiotherapy are not being treated appropriately [24]. These observations should be the target for health services research in this field in the coming future in order to refine the projections.

The projections of the new cancer patients are useful to assess the expected increase in cancer burden and the related impact for radiotherapy services by country and type of tumor. This analysis has been done under reasonable and conservative assumptions regarding the projections of cancer incidence. Considered globally, the resources required to cope with the challenge posed

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by these projections are important, especially as important differences in the capital resources and staff among European countries have been documented [25,26], as well as the gap between optimal and actual use [1]. The fact that such a gulf has been identified in the majority of European countries and that the need for radiotherapy has been estimated for optimal utilization, could suggest that a more conservative target for planning radiotherapy equipment and staff should be proposed. In this respect, 80% of the optimal demand may be a reasonable first policy target [27]. Additionally, the resources required should be invested within the framework of a national cancer control plan [27,28].

In conclusion, the study has shown that the need for radiotherapy in Europe on average is expected to increase with 16% from 2012 to 2025. The expected changes in demand varied considerably between countries (range 0–35%). With the already existing disparity in radiotherapy resources in mind, the data provided here should act as a leverage point to raise awareness among European health policy makers of the need for investment in radiotherapy.

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Conflicts of interest

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.2016.02.016.

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