World Journal of Radiology

Submit a Manuscript: http://www.wjgnet.com/esps/ *World J Radiol* 2017 February 28; 9(2): 55-62

DOI: 10.4329/wjr.v9.i2.55 ISSN 1949-8470 (online)

ORIGINAL ARTICLE

Basic Study

Radiology education in Europe: Analysis of results from 22 European countries

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Author contributions: Rehani B, Zhang YC and Dillon WP made substantial contributions to conception and design of the study and acquisition of data, and the remaining authors made substantial contributions to acquisition of data, or analysis and interpretation of data; all authors made substantial contributions to drafting the article or making critical revisions related to important intellectual content of the manuscript; all authors gave final approval of the version of the article to be published.

Institutional review board statement: The University of California San Francisco IRB does not consider this project as human subject research.

Conflict-of-interest statement: Bhavya Rehani is the recipient of a RSNA Education Scholar grant for development of RISEMed.org. All other authors have no conflict of interest to disclose.

Data sharing statement: Technical appendix, statistical code, and dataset available from the corresponding author at bhavya.rehani@ucsf.edu. Consent was not obtained but the potential benefits of sharing these data outweigh the potential harms because the data does not contain any personal information. The data only pertains to radiology education infrastructure on a national level.

Manuscript source: Unsolicited manuscript

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Received: July 30, 2016
Peer-review started: July 31, 2016
First decision: September 2, 2016
Revised: October 25, 2016
Accepted: December 1, 2016
Article in press: December 2, 2016
Published online: February 28, 2017

Abstract

AIM

To assess the state of radiology education across Europe by means of a survey study.

METHODS

A comprehensive 23-item radiology survey was distributed *via* email to the International Society of Radiology members, national radiological societies, radiologists and medical physicists. Reminders to complete the survey were sent and the results were analyzed over a period of 4 mo (January-April 2016). Survey questions include length of medical school and residency training;

availability of fellowship and subspecialty training; number of residency programs in each country; accreditation pathways; research training; and medical physics education. Descriptive statistics were used to analyze and summarize data.

RESULTS

Radiology residency training ranges from 2-6 years with a median of 5 years, and follows 1 year of internship training in 55% (12 out of 22) European countries. Subspecialty fellowship training is offered in 55% (12 out of 22) European countries. Availability for specialization training by national societies is limited to eight countries. For nearly all respondents, less than fifty percent of radiologists travel abroad for specialization. Nine of 22 (41%) European countries have research requirements during residency. The types of certifying exam show variation where 64% (14 out of 22) European countries require both written and oral boards, 23% (5 out of 22) require oral examinations only, and 5% (1 out of 22) require written examinations only. A degree in medical physics is offered in 59% (13 out of 22) European countries and is predominantly taught by medical physicists. Nearly all respondents report that formal examinations in medical physics are required.

CONCLUSION

Comparative learning experiences across the continent will help guide the development of comprehensive yet pragmatic infrastructures for radiology education and collaborations in radiology education worldwide.

Key words: Radiology education; European radiology survey; Radiology training; Residency; Radiology research

Core tip: The authers report survey results of radiology education across 22 European countries with respect to length of training, subspecialty fellowship availability, research opportunities, and national certification and credentialing. Given the diversity in training requirements and its impact on cross-border training recognition, our results provide important insights to understand radiology education and its potential on portability across different countries in Europe.

Rehani B, Zhang YC, Rehani MM, Palkó A, Lau L, Lette MNM, Dillon WP. Radiology education in Europe: Analysis of results from 22 European countries. *World J Radiol* 2017; 9(2): 55-62 Available from: URL: http://www.wjgnet.com/1949-8470/full/v9/i2/55.htm DOI: http://dx.doi.org/10.4329/wjr.v9.i2.55

INTRODUCTION

Radiology provides cutting-edge imaging information that guides clinical decision-making. As our understanding of disease processes has grown more complex, radiology itself has branched into increasingly subspecialized fields. The number of distinct subspecialties in the broader scope of the discipline has significant implications for radiology teaching. Radiology training programs around the world face a challenging task in both teaching a common knowledge base across all the imaging modalities and in imparting deep subspecialty knowledge within each specialty domain.

A paucity of literature exists regarding the radiology education infrastructure worldwide[1]. This gap in the literature can be challenging for radiologists who would like to collaborate, contribute and learn from differences, similarities and challenges in radiology education systems outside their country. Highlighting the variations in residency training may encourage exchange of best practices and experiences to better prepare trainees for an ever-evolving practice environment. There is a wide range of training infrastructure and assessment methods across the globe with respect to pre-clinical qualifications, radiology residency structure, on-call requirements, access to teaching, and certifying national or board examinations[2].

The goal of this paper is to understand the radiology education infrastructure across the European continent, share common practices and explore different perspectives to better prepare the next generation of radiologists leaders.

MATERIALS AND METHODS

Medical school, internship, radiology residency

A comprehensive radiology survey (Table 1) was created to analyze the state of Radiology education worldwide. Each survey consisted of questions assessing medical school, radiology residency, internship, fellowships and subspecialties, medical physics, research, and accreditation, along with supplemental questions specifically targeted to their specific audience.

Subspecialty training

Apart from the overall infrastructure of radiology residency and subspecialty training, we also inquired about the number of radiology residency programs in the country, availability and type of subspecialty fellowship programs and the percentage of radiologists who have to travel outside the country for further training. We surveyed fellowship availability in the following subspecialities: Neuroradiology, Interventional Radiology, Musculoskeletal Radiology, Chest Radiology, Abdominal Radiology, Interventional Neuroradiology, Nuclear Medicine, Ultrasound, Breast Imaging, Cardiovascular Imaging, and Pediatric Radiology.

National or university based board certifying exam and research

The type of national or university based board certifying exam was questioned. Research requirements to finish

Table 1 List of survey questions

	Survey questions
A	How long is medical school in your country excluding internship?
B	Is internship required in your country?
C	How long is the radiology residency/post-graduate training in your country including internship in number of years?
D	Please provide the number of radiology residency programs in your country (rough estimate if exact figure is not known)
E	Is subspecialty radiology fellowship training available in your country?
F	Which subspecialty fellowship trainings are available in your country?
G	What percentage of radiology residents travel outside your country for subspecialized radiology training?
H	Approximately how many radiologists are there in your country?
I	If subspecialty training is not present in your country, are week- or month-long courses for advanced training and credentialing in a particular subspecialty available from your national societies?
J	Are there research requirements for radiology residents/trainees to finish training?
K	If there is a research requirement to finish training, please explain. Otherwise, please skip this question
L	What kind of national certifying exam or university based exam is required for residents to be certified in radiology?
M	How many MRI scanners are available in your country?
N	What percentage of radiology/medical imaging procedures is done by non-radiologists?
O	Is there a degree option like MSc in medical physics in your country?
P	Who teaches medical physics to radiology residents in your country?
Q	Are radiology residents formally examined for medical physics?

Table 2 Medical school, internship, and residency responses

Country	Length of medical school (excluding internship)	Internship requirement	Length of radiology residency (internship included)	Number of radiology residency programs
Armenia	6	No	2	1-5
Austria	6	Yes	6	6-10
Bulgaria	6	No	4	1-5
Croatia	6	Yes	5	6-10
Denmark	6	Yes	5	41-50
Estonia	5	No	4	1-5
Greece	6	No	5	11-20
Hungary	6	No	5	6-10
Italy	6	Yes	4	31-40
Lithuania	5	No	5	1-5
Malta	5	Yes	5	1-5
Norway	6	No	5	--
Poland	6	Yes	5	41-50
Portugal	6	Yes	5	> 80
Romania	5	Yes	4	21-30
Serbia	6	Yes	4	> 80
Slovakia	6	No	5	6-10
Slovenia	6	Yes	5	1-5
Spain	6	No	4	> 80
Sweden	6	Yes	7	51-100
Switzerland	6	No	5	21-30
United Kingdom	5	Yes	5	41-50

residency training were assessed.

Medical physics

Availability of masters programs in medical physics, medical physicists for education, and national radiation safety programs was queried.

The 23-item survey was distributed *via* email to the International Society of Radiology members, national radiological societies, radiologists and medical physicists. Reminders to complete the survey were sent and the results were analyzed over a period of 4 mo (January-April 2016).

To check the accuracy of information submitted we contacted radiologists, representatives of national radiology and neuroradiology societies by email who validated the responses and answered specific discordant questions. Descriptive statistics were used to analyze and summarize data.

RESULTS

Medical school, internship, radiology residency (Table 2)

We gathered data for 22 European countries based upon responses from national radiological society representatives or radiologists (Figure 1). Seventy-seven percent (17 out of 22) respondents report six-year medical school training. Radiology residency training ranges from 2-6 years with a median of 5 years, and follows 1 year of internship training in 55% (12 out of 22) European countries.

Subspecialty training (Table 3)

Subspecialty fellowship training is offered in 55% (12 out of 22) European countries. Within those countries, interventional radiology fellowship is the most common subspecialty followed by neuroradiology, pediatrics, and nuclear medicine fellowships. Switzerland offers the greatest variety of fellowship opportunities including neuroradiology, interventional, neuro-interventional, musculoskeletal, nuclear medicine, and pediatrics training. In contrast, Austria, Estonia and Sweden offer only one fellowship subspecialty. Availability for specialization training by national societies is limited to eight countries. For nearly all respondents, less than fifty percent of radiologists travel abroad for specialization.

Research opportunities (Table 4)

Nine of 22 (41%) European countries have research requirements during residency, which range from 1-mo to 9-mo research blocks, or at least one publication

Figure 1 Survey responses representing countries (place markers) across the European continent.

during residency with an open time frame of research commitment.

National or university based board certifying exam (Table 4)

The types of certifying exam show variation where 64% (14 out of 22) European countries require both written and oral boards, 23% (5 out of 22) require oral examinations only, and 5% (1 out of 22) require written examinations only.

Medical physics education (Table 5)

A degree in medical physics is offered in 59% (13 out of 22) European countries and is predominantly taught by medical physicists. Nearly all respondents report that formal examinations in medical physics are required.

DISCUSSION

Europe is the third most populous continent after Asia and Africa with a wide diversity of cultures and languages. Similarly, there is diversity in radiology education systems. Although medical school training is six years long in the majority of European countries included in our study, there are differences in clinical internship requirement and length of residency training, which may vary by up to two years[3]. Given the diversity in training requirements and its impact on cross-border training recognition, our results provide important insights to understand radiology education and its potential on portability across different countries in Europe.

While some countries have greater than eighty radiology residency programs, others like Armenia, Bulgaria, Estonia, Lithuania, Malta and Slovenia have only one to five radiology residency programs in the entire country. It is unclear if the number of residency programs is sufficient, given the size and population of these countries.

Fellowship training is available in 50% of the respondent countries in our study. The countries that offer at least one fellowship include Austria, Croatia, Estonia, Greece, Hungary, Romania, Serbia, Slovakia, Sweden, Switzerland, and United Kingdom. The most common fellowship offered is interventional radiology. Ultrasound fellowship is only available in one respondent country (Croatia), while none of the respondent countries have chest radiology fellowships.

Compared to the 2004 EAR Education Survey[3], there has been an increase in both the number of

Table 3 Subspecialty fellowship responses

Country	Subspecialty	Types of available subspecialties										Percent radiologists traveling abroad for specialization	Approx. number of radiologists	Specialization training by national society
		Neuro	IR	MSK	Chest	Abd	Neuro-IR	NM	US	Breast	CV	Ped			
Armenia	N												< 50%	201-400	Y
Austria	Y	Y											< 50%	> 400	Y
Bulgaria	N												< 50%	Difficult to estimate	N
Croatia	Y	Y	Y						Y				< 50%	201-400	N
Denmark	N												< 50%	> 400	N
Estonia	Y		Y										< 50%	--	N
Greece	Y		Y	Y		Y						Y	< 50%	--	--
Hungary	Y	Y	Y				Y			Y		Y	< 50%	> 400	Y
Italy	N												< 50%	> 400	Y
Lithuania	N												< 50%	201-400	Y
Malta	N												> 50%	< 50	Y
Norway	---												< 50%	> 400	--
Poland	N												< 50%	> 400	N
Portugal	N												< 50%	> 400	N
Romania	Y	Y				Y		Y					< 50%	> 400	N
Serbia	Y		Y			Y							< 50%	101-200	N
Slovakia	Y		Y							Y	Y	Y	--	> 400	N
Slovenia	N												< 50%	101-200	N
Spain	N												< 50%	> 400	N
Sweden	Y							Y					0%	--	--
Switzerland	Y	Y	Y	Y			Y	Y				Y	< 50%	> 400	--
United Kingdom	Y	Y	Y				Y	Y					< 50%	> 400	N

Neuro: Neuroradiology; IR: Interventional radiology; MSK: Musculoskeletal radiology; Chest: Chest radiology; Abd: Abdominal radiology; Neuro-IR: Interventional neuroradiology; NM: Nuclear medicine; US: Ultrasound; Breast: Breast imaging; CV: Cardiovascular imaging; Ped: Pediatric radiology; Y: Yes; N: No.

countries that offer fellowship training as well as in the variety of available subspecialties. For example, fellowship training in Switzerland now encompasses interventional radiology (IR), musculoskeletal (MSK), Neurointerventional, and Nuclear Medicine. Similarly, Slovakia increased fellowship training to include Interventional Radiology, Breast, Cardiovascular, and Pediatrics. Estonia, Greece, Hungary, and Romania are additional examples of countries that expanded subspecialty training.

Given rapid innovation across many imaging modalities, increasing exposure to fellowship training is fast becoming a priority to ensure that residents learn up-to-date subspecialty knowledge worldwide. Our results show that less than 50% of radiologists travel outside their respective countries for training. It has been discussed that practicing radiologists understandably face the challenge of meeting clinical demands while maintaining teaching responsibilities[4]. Individual didactic teaching sessions may not be feasible in a high-volume work environment[5].

This creates a potential role for interactive e-learning teaching modules[6-9] and virtual education[10] to supplement education in a particular subspecialty for self-motivated learners. Accessible electronic modules have served as useful extensions to radiology teaching[11,12]. The European Society of Radiology (ESR) offers accredited electronic modules categorized by subspecialty content with optional self assessments[13]. The ESR has also implemented and continuously updated the European Training Curriculum, a subspecialty-specific framework organized by training level that enhances the quality of radiology education throughout Europe[14].

The European Society of Radiology offers courses to help prepare trainees for the European Diploma in Radiology (EDiR)[15]. The EDiR, a certificate of excellence, helps standardize radiology training in the setting of varied certification methods across Europe as demonstrated in our survey results.

Basic and translational research exposure form a significant component of radiology education and should be made widely available[16]. Residents can make considerable contributions to the field because they have a unique perspective on the day-to-day practice from an "in-the-trenches" point of view, ranging from image interpretation to workflow management and on-call demands. Residents also have first hand experiences with different technology platforms and thus can bring new ideas that drive innovation in radiology. In our surveyed European countries, fewer than half of European countries have dedicated research blocks during residency. Challenges in promoting research include limited finances, lack of incentives for researchers, issues of career planning, and gender

Table 4 Certification and research responses

Country	Research requirement for residency	If yes, describe research requirement	Type of certifying exam required	Number of MRI scanners	Percentage of radiology procedures by non-radiologists
Armenia	No	---	Oral	6-10	---
Austria	Yes	9-mo research	Written and oral	> 100	15%-20%
Bulgaria	No	---	Oral	10-50	> 20%
Croatia	Yes	Indexed publication	Written and oral	10-50	---
Denmark	Yes	1-mo research	Oral	10-50	0%-5%
Estonia	No	---	Oral	---	---
Greece	Yes	---	Written and oral	---	---
Hungary	No	---	Written and oral	5-10	---
Italy	Yes	At least one research project	Written and oral	> 100	0%-5%
Lithuania	Yes	Research presentation	Written and oral	10-50	---
Malta	No	---	Written and oral	6-10	---
Norway	---	---	---	> 100	---
Poland	No	---	Written and oral	> 100	15%-20%
Portugal	No	---	Oral	51-100	> 20%
Romania	No	---	Written and oral	< 5	---
Serbia	No	---	Written and oral	10-50	5%-10%
Slovakia	No	---	Written and oral	10-50	---
Slovenia	Yes	At least one publication during residency	Written and oral	10-50	10%-15%
Spain	No	---	Written	> 100	10%-15%
Sweden	Yes	---	---	---	---
Switzerland	No	---	Written and oral	51-100	> 20%
United Kingdom	Yes	Basic research competency	Written and oral	> 100	> 20%

Table 5 Medical physics responses

Country	Medical physics degree	Medical physics taught by	Formal examination of medical physics
Armenia	Yes	Radiologist	Yes, there is a question paper combined with another subject Only oral test
Austria	No	Radiologist	Only written test
Bulgaria	No	Radiologist	Yes, there is a separate question paper on this subject Radiologists review the answer sheets for medical physics portion
Croatia	No	Radiologist	Radiologists review the answer sheets for medical physics part Radiologists conduct oral exam in medical physics and radiation safety
Denmark	Yes	Medical physicist	Yes, there is a separate question paper on this subject Only written test Radiologists review the answer sheets for medical physics portion
Estonia	Yes	---	---
Greece	Yes	Medical physicist	Only oral test
Hungary	Yes	Medical physicist	There is both oral and written test
Italy	No	Medical physicist	Only oral test
Lithuania	No	Medical physicist	Yes, there is a separate question paper on this subject Yes, there is a question paper combined with another subject
Malta	Yes	Medical physicist	Yes, there is a question paper combined with another subject Only written test
Norway	No	Medical physicist	Yes, there is a question paper combined with another subject
Poland	Yes	Radiologist	Only written test
Portugal	No	Other	---
Romania	No	Medical physicist	Yes there is a question paper along combined with another subject Radiologists review the answer sheets for medical physics part
Serbia	Yes	Medical physicist	Yes, there is a separate question paper on this subject Yes, there is a question paper combined with another subject
Slovakia	Yes	Medical physicist	Yes, there is a question paper combined with another subject There is both oral and written test
Slovenia	No	Medical physicist	Radiologists review the answer sheets for medical physics portion
Spain	Yes	Medical physicist	Only written test
Sweden	Yes	Medical physicist	Yes, there is a separate question paper on this subject
Switzerland	Yes	Medical physicist	Yes, there is a separate question paper on this subject Only written test Radiologists review the answer sheets for medical physics portion
United Kingdom	Yes	Medical physicist	Yes, there is a separate question paper on this subject Radiologists review the answer sheets for medical physics portion

issues[16]. This also seems to be a challenge worldwide and increased emphasis on research during residency has been encouraged[17-19]. Increasing time and mentorship resources for research will help establish radiology innovation early in the career pathway. Radiologists around the world could assist in mentoring trainees in research outside their programs to encourage future world leaders in radiology.

Medical physics and radiation safety is particularly important given the reported radiation injuries due to imaging[20-22]. The ESR recently noted an increase in inappropriate exposure to ionizing radiation along with significant variations in dosimetry for the same examination[23]. To reduce patient exposure to unnecessary radiation, the ESR plans to implement individual patient dose tracking, mobile dose information for physicians, and radiation protection training with certification[23]. Nearly all survey respondents reported that formal examination in medical physics is required in Europe. In addition, 70% had medical physics training from medical physicist rather than a radiologist. Medical physics degree programs are also offered by majority of respondent European countries.

Each European country included in our study offers a unique perspective on radiology education based on what is feasible for resident teaching, subspecialty training, and research. Comparative learning experiences across the continent will help guide the development of comprehensive yet pragmatic infrastructures for radiology education and collaborations in radiology education worldwide.

Limitations of our study include a sample size of twenty out of a total of forty-eight European countries. As such, our data may not be representative of the radiologic education landscape across all of Europe. In addition, our survey response rate indicates that our results represent only a fraction of all countries in Europe, likely due to the approach in questionnaire distribution and collection. Our survey channels through the International Society of Radiology also may have introduced bias in selecting for countries that are its participating members.

Future research may involve potential collaboration with the European Society of Radiology to gain insight into the radiology infrastructure across a greater number of European countries. E-learning modules may help augment the variety of fellowship training and increase resident engagement with real time communication and feedback. Innovative technology platforms that offer indexed and searchable didactic content will contribute to a sustainable solution for international radiology education.

ACKNOWLEDGMENTS

We would like to profoundly thank International Society of Radiology for collaboration and radiologists in Europe who participated in this survey.

COMMENTS

Background

The status of radiology education in Europe, particularly in specialty fellowship training and research, merits an in-depth study in order to gain an understanding of challenges and potential collaborations among the regional training programs.

Research frontiers

Recent advances in technology platforms for web-based applications and mobile tools have enabled trainees to gain access to specialty training that may supplement availability of radiology education at their home institutions.

Innovations and breakthroughs

This study demonstrates that subspecialty fellowship training is offered in approximately half of European countries and the availability for specialization training by national societies is limited to eight countries. Other differences in board certifications and medical physics curricula differ among the regional training programs. The European Training Curriculum serves as a reference for the establishment and revision of national training programs and sets the basis for the European Diploma in Radiology exam.

Applications

Practical applications of this study include the use of country-specific training availability data to augment radiology education and in providing access to online teaching curricula to supplement radiology education.

Peer-review

This is a well-written paper regarding radiology education in Europe.

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P- Reviewer: Boffano P, Gao BL, Pinto A, Quattrocchi CC, Wan YL
S- Editor: Kong JX **L- Editor**: A **E- Editor**: Wu HL

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