Basic Study

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

Bhavya Rehani, Yi C Zhang, Madan M Rehani, András Palkó, Lawrence Lau, Miriam N Mikhail Lette, William P Dillon

Bhavya Rehani, Yi C Zhang, William P Dillon, Department of Radiology and Biomedical Imaging, University of California, San Francisco, CA 94110, United States
Madan M Rehani, Department of Radiology, Massachusetts General Hospital, Harvard Medical School, Boston, MA 02115, United States
András Palkó, Department of Radiology, University of Szeged, H-6720 Szeged, Hungary
Lawrence Lau, Consultant Radiologist, Melbourne, 3103 Victoria, Australia
Miriam N Mikhail Lette, Consultant Diagnostic Radiologist, RAD-AID International, 1110 Geneva, Switzerland

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.

Open-Access: This article is an open-access article which was selected by an in-house editor and fully peer-reviewed by external reviewers. It is distributed in accordance with the Creative Commons Attribution Non Commercial (CC BY-NC 4.0) license, which permits others to distribute, remix, adapt, build upon this work non-commercially, and license their derivative works on different terms, provided the original work is properly cited and the use is non-commercial. See: http://creativecommons.org/licenses/by-nc/4.0/

Manuscript source: Unsolicited manuscript

Correspondence to: Bhavya Rehani, MD, Assistant Professor, Department of Radiology and Biomedical Imaging, University of California, 1001 Potrero Ave, San Francisco, CA 94110, United States. bhavya.rehani@ucsf.edu
Telephone: +1-415-2068024
Fax: +1-415-4760616

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

© The Author(s) 2017. Published by Baishideng Publishing Group Inc. All rights reserved.

Core tip: The authors 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.

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. 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.

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 subspecialties: 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...
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
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
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), Interventional neuroradiology, and Nuclear Medicine. Similarly, Slovakia increased fellowship training to include Interventional Radiology, Breast, Cardiovascular, and Pediatric radiology. 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\(^\text{[4]}\). Individual didactic teaching sessions may not be feasible in a high-volume work environment\(^\text{[5]}\).

This creates a potential role for interactive e-learning teaching modules\(^\text{[6-9]}\) and virtual education\(^\text{[10]}\) to supplement education in a particular subspecialty for self-motivated learners. Accessible electronic modules have served as useful extensions to radiology teaching\(^\text{[11,12]}\). The European Society of Radiology (ESR) offers accredited electronic modules categorized by subspecialty content with optional self assessments\(^\text{[13]}\). 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\(^\text{[14]}\).

The European Society of Radiology offers courses to help prepare trainees for the European Diploma in Radiology (EDiR)\(^\text{[15]}\). 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\(^\text{[16]}\). 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 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 |
|---------|--------------|----------------------------------|-------------------------------------------------------|---------------------------------|--------------------------------------------|
| 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                            | <50%                                                  | --                              | --                                         |
| Hungary | Y            | Y Y Y Y Y                        | <50%                                                  | >400                            | N                                          |
| 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 Y Y |                                  | <50%                                                  | >400                            | N                                          |
| Serbia  | Y            | Y                                | <50%                                                  | 101-200                         | N                                          |
| Slovakia| Y            | Y Y Y Y                          | <50%                                                  | --                              | >400                                       |
| Slovenia| N            |                                  | <50%                                                  | 101-200                         | N                                          |
| Spain   | N            |                                  | <50%                                                  | >400                            | N                                          |
| Sweden  | Y            |                                  | 0%                                                    | --                              | --                                         |
| Switzerland| Y Y Y Y Y |                                  | <50%                                                  | >400                            | --                                         |
| United  | Y Y Y Y Y Y |                                  | <50%                                                  | >400                            | N                                          |
| Kingdom |              |                                  |                                                       |                                 |                                            |

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.
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    | No                                | ---                                   | ---                             | ---                    | ---                                                   |
| Poland    | No                                | ---                                   | Written and oral                 | >100                   | 15%-20%                                               |
| Portugal  | No                                | ---                                   | Oral                            | 5:100                  | >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                 | 5:100                  | >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 |
| 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 |
| Denmark   | Yes                    | Medical physicist                 | Yes, there is a separate question paper on this subject Radiologists conduct oral exam in medical physics and radiation safety |
| 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 |
| Malta     | Yes                    | Medical physicist                 | Yes, there is a question paper combined with another subject Only written test Radiologists review the answer sheets for medical physics portion |
| Norway    | No                     | Medical physicist                 | Yes, there is a question paper combined with another subject Radiologists review the answer sheets for medical physics portion |
| 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 question paper on this subject Radiologists review the answer sheets for medical physics portion |
| 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 Radiologists review the answer sheets for medical physics portion |
| 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                 | Radiologists review the answer sheets for medical physics portion |

Rehani B et al. Radiology education in Europe
issues\textsuperscript{240}. This also seems to be a challenge worldwide and increased emphasis on research during residency has been encouraged\textsuperscript{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\textsuperscript{20-22}. The ESR recently noted an increase in inappropriate exposure to ionizing radiation along with significant variations in dosimetry for the same examination\textsuperscript{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\textsuperscript{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.

**REFERENCES**

1. Di Marco L, Conway WF, Chapin R. Radiology Resident Education in France from Medical School Through Board Certification. *J Am Coll Radiol* 2015; 12: 1097-1102 [PMID: 26435123 DOI: 10.1016/j.jacr.2015.06.030]
2. Willatt JM, Mason AC. Comparison of radiology residency programs in ten countries. *Eur Radiol* 2006; 16: 437-444 [PMID: 15702337 DOI: 10.1007/s00330-004-2635-3]
3. European Society of Radiology. Radiological Training Programmes in Europe: EAR Education Survey - Analysis of Results. 2004 EAR Education Committee. [accessed 2016 May 8]. Available from: URL: https://www.earres.org/html/img/pool/ESR_brochure_05.pdf
4. Gunderman RB, Kang YP, Fraley RE, Williamson KB. Teaching the teachers. *Radiology* 2002; 222: 599-603 [PMID: 11867772 DOI: 10.1148/radiol.2223010285]
5. Cohen MD, Gunderman RB. Academic radiology: sustaining the mission. *Radiology* 2002; 224: 1-4 [PMID: 12091654 DOI: 10.1148/radiol.2241011741]
6. Colucci PG, Kostandy P, Shrauner WR, Arleo E, Fuortes M, Griffin AS, Huang YH, Juluru K, Tsouris AJ. Development and utilization of a web-based application as a robust radiology teaching tool (radtax) for medical student anatomy teaching. *Acad Radiol* 2015; 22: 247-255 [PMID: 25964956]
7. Carriero A, Bonomo L, Calliada F, Campioni P, Colosimo C, Crotoneo A, Cova M, Ettorre GC, Fugazza C, Garlaschi G, Macarini L, Mascalchi M, Meloni GB, Mucelli RP, Rossi C, Sironi S, Torricelli P, Beomonte BZ, Zompatori M, Zanini C. E-learning in radiology: an Italian multicentre experience. *Eur J Radiol* 2012; 81: 3956-3961 [PMID: 22902406 DOI: 10.1016/j.ejrad.2012.07.007]
8. Pinto A, Brunese L, Pinto F, Acampora C, Romano L. E-learning and education in radiology. *Eur J Radiol* 2011; 78: 368-371 [PMID: 21755951 DOI: 10.1016/j.ejrad.2010.12.029]
9. Zafar S, Safdar S, Zafar AN. Evaluation of use of e-Learning in undergraduate radiology education: a review. *Eur J Radiol* 2014; 83: 2277-2287 [PMID: 25242658 DOI: 10.1016/j.ejrad.2014.08.017]
10. RISE: Real-time International Student Education. [accessed 2016 June 27]. Available from: URL: http://www.risemed.org
11 Farkhondeh A, Geist JR. Evaluation of Web-Based Interactive Instruction in Intraoral and Panoramic Radiographic Anatomy. J Mich Dent Assoc 2015; 97: 34-38 [PMID: 26292503]

12 Scherer A, Kröpil P, Heusch P, Buchbender C, Severin P, Blondin D, Lanzman RS, Miese F, Ostendorf B, Bökle E, Mödder U, Antoch G. Case-based interactive PACS learning: introduction of a new concept for radiological education of students. Radiologe 2011; 51: 969-970, 973-977 [PMID: 22033604 DOI: 10.1007/s00117-011-2241-8]

13 eLearning - Education on Demand. [accessed 2016 June 27]. Available from: URL: https://cslide.c4meetingtech.com/library/esr/home

14 European Training Curriculum for Radiology. [accessed 2016 June 27]. Available from: URL: http://www.myesr.org/cms/website.php?d=/en/education_training/european_training_curriculum_for_radiology.htm

15 EDiR - European Diploma in Radiology. [accessed 2016 June 23]. Available from: URL: http://www.myesr.org/cms/website.php?d=/29634/en/education_training/elearning/european_diploma_in_radiology_edir_.htm

16 European Society of Radiology (ESR). Research education in Europe: an opinion paper by the European Society of Radiology. Insights Imaging 2015; 6: 157-162 [PMID: 25763995 DOI: 10.1007/s13244-015-0397-x]

17 Alderson PO, Bresolin LB, Becker GJ, Thrall JH, Dunnick NR, Hillman BJ, Lee JK, Nagy EC. Enhancing research in academic radiology departments: recommendations of the 2003 Consensus Conference. J Am Coll Radiol 2004; 1: 591-596 [PMID: 17411658 DOI: 10.1016/j.jacr.2004.03.011]

18 Barker CF. Making imaging research a part of radiology resident training. Acad Radiol 2013; 20: 135-136 [PMID: 23395241 DOI: 10.1016/j.acra.2012.11.003]

19 Costello JR, Mullins ME, Votaw JR, Karobyi DR, Kalb B, Gonzales P, Fornwalt B, Meltzer CC. Establishing a new radiology residency research track. Acad Radiol 2013; 20: 243-248 [PMID: 23085410 DOI: 10.1016/j.acra.2012.08.011]

20 Valk PE, Dillon WP. Radiation injury of the brain. AJNR Am J Neuroradiol 1991; 12: 45-62 [PMID: 7502957]

21 Sodickson A, Baeyens PF, Andriole KP, Prevedello LM, Nawfel RD, Hanson R, Khorasani R. Recurrent CT, cumulative radiation exposure, and associated radiation-induced cancer risks from CT of adults. Radiology 2009; 251: 175-184 [PMID: 19332852 DOI: 10.1148/radiol.2511081296]

22 Schonfeld SJ, Lee C, Berrington de González A. Medical exposure to radiation and thyroid cancer. Clin Oncol (R Coll Radiol) 2011; 23: 244-250 [PMID: 21296564 DOI: 10.1016/j.clon.2011.01.159]

23 European Society of Radiology. ESR statement on radiation protection: globalisation, personalised medicine and safety (the GPS approach). Insights Imaging 2013; 4: 737-739 [PMID: 24092563 DOI: 10.1007/s13244-013-0287-z]

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