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# Professional practice, training, and role development of radiographers in interventional radiology and cardiology: An international survey across Europe

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A B S T R A C T

*Introduction:* Radiographers are now key members of interventional radiology (IR) and interventional cardiology (IC) teams, taking on tasks that go beyond image acquisition. These include radiation protection, assisting in procedures and patient care. However, training and regulation for these expanded roles are variable, leading to differences in practice and raising concerns for safety and mobility.

*Methods:* A cross-sectional survey design was used to investigate radiographers' training, practice scope and technology access in IR and IC across Europe. A 31-item online questionnaire was distributed via professional networks, social media and EFRS research hubs at the European Congress of Radiology (2024–2025). Descriptive statistics were utilised, and open-text comments thematically grouped.

*Results:* Ninety-one radiographers from 12 countries responded, with the majority based in the UK (46 %) and Ireland (19 %). Marked differences were noted in training, with 23 % reporting no formal IR/IC education. Technology access also varied, as nearly half worked with fluoroscopy systems older than five years, limiting dose-saving options. Radiation protection practice was inconsistent; just over half (53 %) used pulsed fluoroscopy routinely, while 27 % reported not removing anti-scatter grids for paediatric cases. Scope of practice showed further fragmentation, with advanced clinical functions only reported by a minority.

*Conclusion:* This study demonstrates wide variations in training, equipment quality, and role scope among radiographers practicing in IR and IC across Europe. Such inconsistencies directly impact radiation safety, patient outcomes and the ability of staff to move freely across borders. Without structured frameworks, radiographers may lack key competences in dose optimisation, paediatric safety and procedural support, exposing patients and staff to avoidable risks.

*Implications of practice:* A harmonised European framework is needed to support safe radiation practice and improve care consistency.



## Introduction

Radiographers are well recognised as integral members of the multidisciplinary interventional team. In more recent years they have expanded their scope of practice and developed their roles to become increasingly involved in delivering interventional radiology (IR) and interventional cardiology (IC) services, these reflecting ongoing developments in imaging technology and procedural demands.[1] These roles now go beyond conventional image acquisition to include responsibilities such as radiation protection, dose monitoring, procedural support, and in some cases, assisting with device deployment and patient care during procedures.[2] The extension in their scope of practice has not always been matched by standardised training or regulatory guidance, leading to variations in how radiographers practise across different countries and institutions.

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Most IR and IC procedures are fluoroscopically-guided, and this inherently involves the use of ionising radiation. In addition to this, the number and complexity of procedures have increased rapidly in recent years in line with advances in technology.[3,4] Hence, recent authors have reported that interventional studies are responsible for some of the highest radiation doses in medical imaging, leading to concerns for both patients and staff.[5,6] Studies have reported instances of deterministic effects in patients undergoing prolonged procedures, including radiation-induced skin injuries and alopecia.[7,8] For staff, occupational exposure may lead to lens opacities, radiation-associated cataract, and possible stochastic effects such as malignancies.[9,10]

Radiographers work at the front-line in these environments and have a duty to advocate for and protect the multidisciplinary team,[11] yet their education and training for managing radiation hazards is not standardised. It has been identified that education, training and role preparation often differ between countries.[12] In some places, radiographers receive formal education in IR or IC during their undergraduate studies or through postgraduate modules. In others, learning is mostly informal and happens "on-the-job" without structured mentorship or assessment.[13] This variation makes it difficult to compare expected competency levels internationally and raises questions on safety and efficacy of practice particularly with staff mobility internationally. This is especially pertinent in higher-risk procedures or subspecialties like neuro or paediatric IR and IC.

Equipment availability and institutional investment may also affect practice in IR and IC. Radiographers working with older fluoroscopic systems may experience higher inherent doses associated with increased screening due to lower image quality, or lack of dose reduction tools such as pulsed fluoroscopy or automatic exposure control.[14] Technological limitations can compromise both patient safety and staff efficiency, and it may also makes cross-centre comparisons of doses unreliable. Additionally, hospitals and centres with resource constraints may not provide adequate shielding or dosimetry, possibly exposing radiographers and patients to unnecessary risks.[15]

In the UK, the Health and Care Professions Council (HCPC) recognises IR and IC competence under its diagnostic radiography standards, and professional bodies like the Society of Radiographers (SoR) have established Special Interest Groups to promote practice development.[13,16,17] However, this level of professional support is not consistent internationally. Variations across countries exist whereby some radiographers are trained and permitted to perform vascular access, assist with embolisations or stenting procedures, whilst others are limited to operating the imaging console, regardless of experience or interest. Role development appears to depend more on local policy and team dynamics than on national frameworks.[1]

The aim of this AERIAL (An international Analysis of the Educational Requirements to practice InterventionAL radiology) study was to investigate the experiences of radiographers currently practicing within IR and IC settings across different European countries. The study focused on their clinical responsibilities, training background, variations in practice between their country of training and their current workplace where migration occurred together with perceived areas of limitations.

## Methods

This study used a cross-sectional descriptive survey design to explore the variations in clinical practice among radiographers working in IR and IC. Data were collected through an online questionnaire, targeting radiographers actively involved in IR or IC Internationally.

The survey was hosted on SurveyMonkey® and circulated primarily via professional social media channels such as X® (fomerly Twitter®) and LinkedIn®, as well as through radiography networks and interest groups including the European Federation of Radiographer Societies Research Hubs (2024 and 2025) at the European Congress of Radiology in Vienna. Data collection continued until March 2025. Purposive sampling was used to recruit radiographers with direct experience in IR and IC practice, ensuring the respondents could provide relevant information on their clinical roles and responsibilities. Participation was voluntary, and informed consent was assumed when respondents completed and submitted the questionnaire.

The questionnaire included 31 questions designed to capture a broad range of information including practice patterns, institutional characteristics, available equipment, professional roles and responsibilities, radiation protection measures, subspecialty practice, cross-border mobility, role development, and perceived gaps in training. This wide scope was intended to identify practice variations across different countries and settings. Before distribution, the questionnaire was piloted with five radiographers experienced in IR and IC practice from diverse clinical settings. Feedback from this pilot study helped improve clarity, removed ambiguous phrasing, and fixed formatting issues, which improved the overall user experience and content validity.

Ethical approval was granted by the Nursing and Health Research Ethics Filter Committee at Ulster University and the NHS Research Ethics Committee, reference number 18/7/3.x. Informed consent was obtained from each participant before they completed the questionnaire. Participant anonymity was preserved throughout the study, and data were securely stored according to General Data Protection Regulation (2018) requirements.

### Data analysis

Collected data were analysed using IBM Statistical Package for the Social Sciences version 27. Descriptive statistics, including frequencies and percentages, summarised participant responses. Additionally, a comparative analysis across countries was performed to highlight practice similarities and differences. Responses from the open-ended question were categorised and tabulated to show frequencies and representative quotes. The study followed the Checklist for Reporting Results of Internet E-Surveys (CHERRIES) for survey design and reporting, as recommended by Eysenbach.[18]

## Results

A total of 91 radiographers working in IR or IC across 12 countries responded to the survey. Due to low response rates (1 participant each), six countries (Austria, Croatia, France, Greece, Netherlands and Slovenia) were classified under one category as other countries (Fig. 1).

Training-practice migration pattern (Fig. 1) show that 11 respondents (12 %) currently work in a different country from where they received their training, indicating professional mobility within the European IR and IC workforce. The geographic distribution of the respondents reveals a predominance of UK-based practitioners (46 % of current sample; $n = 42$), followed by Ireland (19 %; $n = 17$).

The institutional characteristics indicated that most of the respondents worked in university teaching hospitals (59 %; $n = 54$), with large public hospitals providing most remaining employment (29 %; $n = 26$). Equipment age distribution shows significant

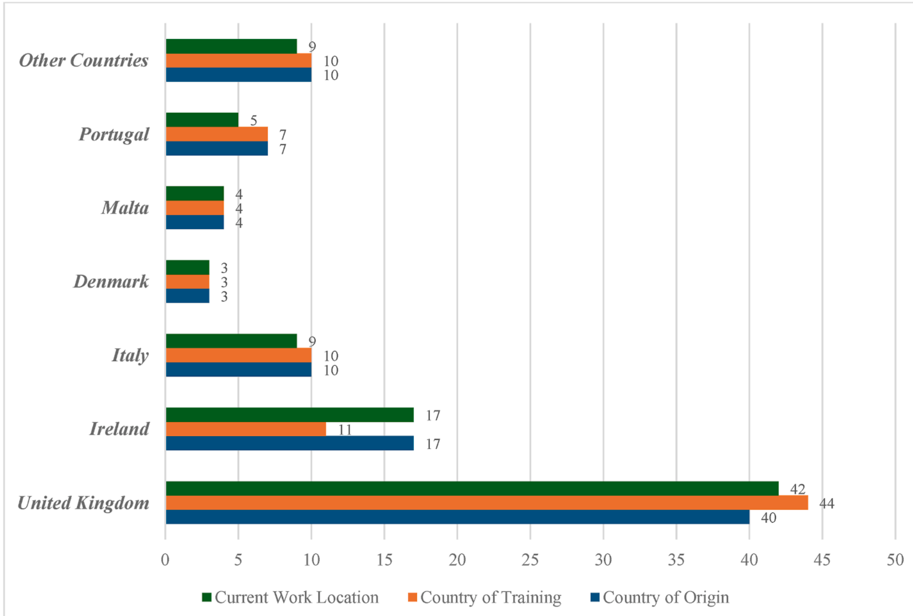


**Figure 1.** Training-practice migration pattern of the respondents.

**Table 1**
Institutional characteristics and equipment infrastructure.

| | | n | % |
|---|---|---|---|
| Hospital type | University Teaching Hospital | 54 | 59 % |
| | Large Public Hospital (>400 beds) | 26 | 29 % |
| | Medium Public Hospital (150–400 beds) | 9 | 10 % |
| | Private Hospital | 10 | 11 % |
| | Other/Specialised | 6 | 7 % |
| Equipment age category | ≤2 years | 20 | 22 % |
| | 3–5 years | 14 | 15 % |
| | 6–10 years | 24 | 26 % |
| | >10 years | 19 | 21 % |
| | Unspecified ranges | 14 | 15 % |

variation, with 47 % ($n = 43$) of facilities operating equipment older than 5 years (Table 1).

There was marked variation in professional responsibilities among respondents. Core technical functions were undertaken by most radiographers (71–89 %), whereas advanced practice functions were less frequently reported (27–44 %). Clinical assessment functions were performed by 55–70 % of respondents across facilities (Table 2).

The results showed heterogeneous adoption of technology across countries, with flat panel detectors and rotational angiography reported by all participating Danish departments while remaining prevalent in the UK (Table 3), compared to other countries.

When asked about practices in radiation protection (Fig. 2), the results revealed significant variation, with application of pulsed fluoroscopy adoption reported by 48 respondents (53 %) and continuous fluoroscopy reported by 10 respondents (11 %), indicating incomplete implementation of dose reduction strategies. The practice of removing the anti-scatter grid showed further inconsistency with 27 % ($n = 25$) reporting no removal for paediatric patients while 73 % ($n = 66$) reported the same for adult patients. Similar variations in practice were also noted on filtration implementation and patient detector positioning.

Subspecialty distribution of the respondents shows vascular interventions as the predominant focus (57 %; $n = 52$), with significant overlap in cardiac (41 %; $n = 37$) and oncology (40 %; $n = 36$) procedures (Table 4). Most practitioners serve adult-only populations (54 %; $n = 49$), with 40 % ($n = 36$) providing comprehensive age-range services. When asked about personal motivation factors that attracted respondents to IR/IC the majority reported skill development (78 %; $n = 71$), new challenges (74 %; $n = 67$) and collaborative practice (70 %; $n = 64$) over monetary incentives (21 %; $n = 19$).

The professional migration analysis indicates that 12 % ($n = 11$) of internationally mobile radiographers (Fig. 1) required role adaptation, with patient care and clinical assessment functions representing the most common new responsibilities (Table 5). Of these, 82 % ($n = 9$) reported acquiring 1–2 new roles in their host country of practice while 18 % ($n = 2$) acquired 3+ new roles.

Respondents reported substantial heterogeneity in IR or IC undergraduate training across Europe (Table 6), with 23 % of the respondents reporting a complete absence of training. Equipment knowledge gaps (19 %) and procedural understanding deficits (19 %) were prominent themes. Limited clinical exposure (16 %) plus training in radiation safety and dosimetry (11 %) were reported as missing but to a lesser extent.

## Discussion

The survey results highlight significant variations in IR and IC practices across Europe, particularly regarding technology, safety practices, professional roles, and education. Many respondents reported centres using imaging equipment that exceeded five years of service life, often including older image intensifier units. Additionally, newer imaging modalities and radiation dose monitoring capabilities were unevenly distributed.

### *Radiation protection practice*

The survey indicates that more than 40 % of the respondents reported that they work in centres lacking current dose recording software and modern pulsed fluoroscopy modes. This inconsistency undermines safe practice and may raise both occupational

**Table 2**
Professional role scope and clinical responsibilities.

| | | n | % |
|---|---|---|---|
| Core technical functions | Patient positioning | 81 | 89 % |
| | Radiation protection | 81 | 89 % |
| | Image manipulation | 78 | 86 % |
| | Image acquisition | 74 | 81 % |
| | Image archiving/storage | 72 | 79 % |
| | Selection/Manipulation of exposures | 68 | 75 % |
| | Patient care | 65 | 71 % |
| Clinical assessment functions | Select projections | 67 | 70 % |
| | Image measurements/volumetric analysis | 64 | 74 % |
| | Data storage/electronic records | 63 | 67 % |
| | Quality assurance/control | 61 | 69 % |
| | Dose monitoring | 61 | 67 % |
| | Explanation of procedures to patients | 57 | 63 % |
| | Confirm procedural checklist | 53 | 58 % |
| | Check for allergies | 50 | 55 % |
| Advanced practice functions | Audit | 40 | 44 % |
| | Review referral requests | 39 | 43 % |
| | Justify examinations | 31 | 34 % |
| | Research | 25 | 27 % |

**Table 3**
IR and IC equipment characteristics.

| Equipment Type | Countries Reporting Use |
|---|---|
| Flat panel detector | UK (29; 69 %), Ireland (11; 65 %), Italy (7; 78 %), Denmark (3; 100 %), other (7; 78 %), Portugal (3; 60 %) |
| Bi-plane systems | UK (5; 12 %), Ireland (5; 29 %), Denmark (2; 67 %), Italy (1; 11 %), other (3; 33 %) |
| Single plane systems | UK (29; 69 %), Ireland (8; 47 %), Italy (8; 89 %), other (7; 78 %) |
| Both single and Bi-plane | UK (8; 19 %), Ireland (5; 29 %), Denmark (3; 100 %), other (1; 11 %) |
| Rotational angiography | UK (27; 64 %), Ireland (9; 53 %), Denmark (3; 100 %), Italy (5; 56 %), other (6; 67 %) |
| Image fusion techniques | UK (17; 40 %), Ireland (5; 29 %), Denmark (1; 33 %), Italy (5; 56 %), other (5; 56 %) |
| Mobile C-arm | UK (26; 62 %), Ireland (7; 41 %), Denmark (2; 67 %), Italy (4; 44 %), other (6; 67 %) |
| Cone beam CT | UK (23; 55 %), Ireland (5; 29 %), Italy (6; 67 %), other (5; 56 %) |
| Image intensifier | UK (26; 62 %), Ireland (8; 47 %), Denmark (1; 33 %), Italy (2; 22 %), other (3; 33 %) |


**Figure 2.** Radiation protection and image quality optimisation practices.

**Table 4**
Subspecialty practice patterns and patient demographics.

| | | n | % |
|---|---|---|---|
| Interventional subspecialty | Vascular | 52 | 57 % |
| | Cardiac | 37 | 41 % |
| | Oncology | 36 | 40 % |
| | Neuro | 27 | 30 % |
| | Other subspecialties | 17 | 19 % |
| Patient population | Adults only | 49 | 54 % |
| | Paediatric and adults | 36 | 40 % |
| | Paediatric only | 3 | 3 % |
| Professional motivation factors | Increase knowledge and skills | 71 | 78 % |
| | Enjoy new challenges | 67 | 74 % |
| | Working in a team | 64 | 70 % |
| | Job satisfaction | 54 | 59 % |
| | Further training opportunities | 43 | 47 % |
| | Higher salary/promotion | 19 | 21 % |
| | Closer patient contact | 19 | 21 % |
| | Better job prospects | 17 | 19 % |

**Table 5**
New roles adopted post migration.

| New roles acquired after international migration | Country of current practice |
|---|---|
| Patient care responsibilities | Ireland (1), Italy (2), Portugal (1) |
| Procedural explanation/ Consent | Ireland (1), Italy (3), Portugal (1) |
| Quality assurance functions | Ireland (1), UK (1) |
| Audit responsibilities | Ireland (1), Italy (1), Portugal (1) |
| Radiation protection coordination | Italy (2) |
| Clinical justification | Ireland (1), UK (2) Portugal (1) |
| Dose monitoring | Croatia (1), Italy (1) |
| Audit | UK (1) others (1) |
| Research | UK (1) other (1) |

and patient exposure levels. It may also reflect inadequacy in staff training on effective utilisation of available equipment for dose management. The recent 19th report by the Committee on Medical Aspects of Radiation in the Environment (COMARE) in the UK issued recommendations for safe interventional radiology practice, which are reinforced by a review from the European Heart Rhythm Association. Both reports strongly recommend using collimation, low frame rates, source-to-detector distance optimisation, and real-time electronic personal dosemeters, approaches that have been shown to reduce radiation exposure in electrophysiology interventions by factors of six to eight.[5,19] In scenarios where outdated C-arms are utilised in high-radiation contexts without real-time dose meters, practitioners are unable to adjust parameters effectively to optimise radiation exposure.[20] In contrast,

**Table 6**
Missing IR or IC training elements in undergraduate training.

| Category | Examples of direct quotes by country |
|---|---|
| **Complete absence of IR an IC training** ($n = 21$; 23 %) | “All of it, I was not taught IR procedures or IR equipment” (UK)<br>“I never received any training in this specialty” (UK)<br>“No IR training was performed” (Italy)<br>“Next to no skills received during schooling” (Slovenia)<br>“No formal training was available then or now here in UK” (UK) |
| **Equipment and technical knowledge gaps** ($n = 17$; 19 %) | “Lacking the knowledge about IR equipment, like types of guidewires, sheaths and other equipment. In Portugal nurses are responsible for that” (Portugal)<br>“We don’t know the devices when we start, and the understanding of the navigation comes after a few months/ years” (France)<br>“More practice in IC unit. Knowing more about stents and other equipment in IC” (Croatia)<br>“No training in projections or equipment” (Ireland) |
| **Procedural and clinical application deficits** ($n = 17$; 19 %) | “Knowledge of the procedures, rad role, understanding set up of the room, are skills required” (Ireland)<br>“All the cardiac and interventional procedures knowledge. The positioning and what really happens” (other)<br>“Different IR procedures” (UK)<br>“Neuro IR- stroke and thrombectomy” (Ireland) |
| **Patient care and clinical pathway understanding** ($n = 12$; 13 %) | “ multidisciplinary team working, patient care assessment and planning, pathways, audit, safety, human factors, quality improvement” (UK)<br>“Ideally more exposure to the different facets of IR would be beneficial with a focus on patient pathways” (UK)<br>“Scrubbing, understanding clinical applications and IR patient pathway, IV cannulation” (UK) |
| **Limited clinical exposure** ($n = 15$; 16 %) | “As a student I did not feel as though I spent a lot of time in IR and when placed in IR I didn’t get a lot of practical experience as a radiographer” (Ireland)<br>“More practice” (Portugal)<br>“Only saw IR in 1 hospital for 1 week during my third year. Very basic information gained through university” (UK)<br>“We only spent 1 week in IR/IC so never had good exposure. Never learnt about different angulations and how to operate the machines” (UK) |
| **Radiation safety and dosimetry** ($n = 10$; 11 %) | “ the practical aspect was missing” (Ireland)<br>“I need training in determining the dose, doing research on the accuracy of dose delivery and how to care for patients” (other)<br>“Detailed radiation safety in cath lab or IR” (UK) |

modern systems equipped with real-time dose feedback have demonstrated a significant reduction in staff exposure during various angiographic examinations, yielding a 36 % reduction in dose when compared to those without real time feedback (3.67 μSv–2.36 μSv; $p = 0.032$).[21] Research indicates that older equipment is associated with higher entrance skin doses, particularly during paediatric interventions, as these systems often lack adequate beam collimation and low pulse capabilities.[22,23] However, these technical safeguards cannot be effectively implemented without standardising IR and IC practice across Europe.

There was also significant variation in radiation protection protocols as 11 % of the respondents were still using continuous fluoroscopy while 27 % did not remove grids in paediatric IR or IC cases. While there might be procedural variations due to different subspecialities and patient groups, these deficiencies generally contradict international guidelines, which emphasise the importance of using pulsed fluoroscopy, in both adult and paediatric fluoroscopy procedures to reduce dose.[20,23] While the use of grids improves image quality through scatter reduction, their use is associated with increased patient dose and their removal is recommended when imaging small or paediatric patients.[5] Thus the consequences of the reported practices are concerning, as entrance doses in paediatric interventions can be ten times higher per unit area, and effective dose per minute varies widely by projection and age.[24] Without standard protocols in place, each procedure poses an uncontrolled risk, increasing the cumulative radiation burden for vulnerable patients as noted in the literature.[25] Minor variations in frame rate or grid use can significantly reduce patient doses, with dose reductions of up to 20 % reported from paediatric patients and 28–49 % from phantom studies focusing on cardiac catheterisation.[26,27]

### Training and staff mobility

The differences in IR and IC extend beyond technology and protocols to include workforce training. Twenty-three percent of the respondents reported receiving no formal training in these fields. Qualitative feedback indicated minimal exposure to critical areas such as radiation safety, equipment operation, anatomy in fluoroscopic contexts, and procedural confidence. This situation reflects broader patterns in Europe, where training is inconsistent in IR and IC even among radiologists, despite the existence of guiding curricula.[28] Recent UK surveys found that radiologist training in IR varies widely among member states and often lacks sufficient clinical placements, specialty modules and radiation awareness.[29,30] This trend appears similar to radiographer training showcasing the critical need to define training standards and harmonise regulations in these high dose procedures.

In radiotherapy, variations in training across Europe and their implications for clinical competencies that may impact patient safety have been reported previously.[31] As noted by Couto et al., staff mobility is hindered by factors such as the characteristics of educational programs, which may, in turn, affect patient care and safety.[31] This constraint is not unique to radiography and radiotherapy; it is a reported phenomenon affecting other allied health practitioners, nurses, and doctors in the UK, negatively impacting staff and student mobility as well as patient care.[32,33] The skill deficit was recognised as particularly significant for internationally trained nurses in countries such as Australia, Canada, and Sweden, leading to the subsequent rollout of bridging programs to improve skills, confidence, and language proficiency.[34–36] In the current study, some radiographers who reported country–country mobility were required to train in 1–3 key skills for their new work environment, which may pose a significant barrier to future staff mobility and present risks to patient care when this training is not offered.[31]

Adequate training, whether through simulation, virtual reality, or supervised practice, is directly linked to the development of key IR and IC skills such as dose optimisation.[37,38] Without structured training pathways, radiographers may miss essential competencies such as optimum collimation practice, pulse rate adjustment, or emergency radiation management. These tasks are fundamental in high-dose procedures and have been recognised by the HCPC and SoR as essential professional responsibilities for optimum patient care which could be reinforced through harmonised training.[39,40]

### Scope of practice

The professional scope of practice was also poorly defined in this study. While most radiographers perform basic imaging tasks; duties such as clinical justification, quality assurance, research and auditing were only carried out by a minority, with notable country to country inconsistencies. This fragmentation hampers workforce mobility across Europe, as responsibilities and competencies differ significantly, in relation to on-the-job training.[13] Inconsistent role definitions hinder team integration and mutual accountability, both essential during complex IR and IC interventions, thereby compromising the quality of care and patient safety.[41] Furthermore, this may also affect the radiographer's ability to carry out the expected role of advocating for and protecting multidisciplinary teams from radiation hazards. Standardising professional scopes would facilitate harmonised workflows, shared responsibility, and regulatory consistency.

The reported infrastructural, educational, and role-based discrepancies have direct implications for both practitioners and patients. This gap may raise legal and ethical concerns, particularly regarding training validation and accountability for radiation doses where it is mandated. For patients, this may result in a form of "population risk," where treatment outcomes, radiation burden, and reassurance are heavily influenced by geographic location and institutional investment.[42] Ultimately, the quality of service may be affected by inconsistencies in dose management, skills, and protocols, which may lead to unnecessary complications in image quality and patient diagnosis and treatment.[43] Procedural efficiency may also suffer, as inadequate training can prolong fluoroscopy time, while older equipment may necessitate repeated screening or produce suboptimal results.[14,44]

### Limitation

The study's sample size and geographic distribution may not capture all international contexts equally. The response distribution was highly uneven, with a high response rate from the UK and Ireland, which may over-represent the perspectives of these countries and limit the generalisability of findings to nations with fewer respondents. However, the multi-country perspective provides valuable insights into universal gaps and offers a strong foundation for policy harmonisation and workforce development across Europe.

## Conclusion

This study reveals substantial variation in IR and IC practices across Europe, particularly in equipment quality, radiation protection, role scope, and training. The lack of standardisation undermines both practitioner competency and patient safety, especially in high-radiation settings such as complex vascular procedures including paediatrics. To address these gaps, a harmonised European framework is needed, incorporating modern equipment benchmarks, mandatory DRL application, structured IR and IC training curricula for radiographers, and clear role definitions supported by the relevant national regulators. Investment in simulation-based training and cross-border accreditation systems should also be considered. This will improve radiation safety and procedural consistency while enhancing professional mobility and care quality across the European interventional radiography and cardiology workforce.

## Ethics approval and consent to participate

Ethical approval for this study was obtained from the Nursing and Health Research Ethics Filter Committee in Ulster University and the NHS Research Ethics Committee; reference number 18/7/3.x. Written informed consent was obtained from each study participant.

## Availability of data

Data required for this study may be made available by the author(s) upon reasonable request.

## Author contributions

SM: Conceptualisation, Methodology, Writing - Review & Editing, Supervision.

JMcN: Conceptualisation, Methodology, Writing - Review & Editing.

AK: Data curation, Formal Analysis, Writing - Original Draft, Writing - Review & Editing.

CR: Methodology, Investigation, Writing - Review & Editing.

EG: Methodology, Visualisation, Writing - Review & Editing.

LM: Methodology, Investigation, Writing - Review & Editing.

## Generative AI use

Not applicable.

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## Conflict of interest statement

JMcN is the current Editor in Chief at *Radiography*, however, as an author of this submission he had no role in or visibility of the handling of the manuscript through the editorial or peer review process.

The remaining authors declare that they have no competing interests.

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## Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.radi.2025.103315.

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