SoR 100 YEARS
THE SOCIETY OF RADIOGRAPHERS

Artificial Intelligence: Guidance for clinical imaging and therapeutic radiography workforce professionals

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Executive Summary

Artificial intelligence: Guidance for clinical imaging and therapeutic radiography workforce professionals

The Society of Radiographers (SoR) is a professional body and membership organisation with approximately 30,000 members across the UK. In January 2020, the Society and College of Radiographers (SCoR) issued a policy statement with regards to artificial intelligence (AI). That short strategy statement focused on AI, including machine learning (ML) and deep learning (DL). It outlined that the professional body would continue to support radiography professionals to champion person-centred care and quality services in diagnostic and radiotherapy services when considering AI, with all its subsets.

An SoR working group was established following the publication of the AI guidance statement. This was initially convened in September 2020 with a six-month horizon. The broad purpose of the group was to represent the voices of the radiographic workforce in the development of AI technology, with aims to strengthen and support care for patients in clinical imaging and radiotherapy. Further, the group intended to act as a point of contact and to provide clinical, educational and research-related radiography advice. In addition, the group would forge, strengthen and expand partnerships for and with stakeholders who seek to collectively develop healthcare technology. A working recommendations document was deemed an appropriate vehicle to convey the voice of the radiography workforce on AI in the UK. Many other ideas and suggestions, including a UK-wide survey, and opportunities to connect with other AI groups within the National Health Service (NHS), but also independent of the NHS, were also highlighted as part of the working group.

The recommendations provided in this guidance document are focused on the different areas of radiographic practice in both clinical imaging and therapeutic services:

- Clinical practice
- Education
- Research
- Stakeholder partnerships

The recommendations were compiled using evidence from research literature, patient publications and healthcare professional policy and practice. The recommendations have been subject to a rapid period of peer, professional and patient assessment and review. Feedback was sought from a range of SoR members and advisory groups, including the SoR informatics group, the College of Radiographers (CoR) patient advisory group, the SoR research advisory group, and the CoR Education and Career Framework (ECF) review writing groups. It is hoped that these guidelines will be of value to: people who are developing, testing, validating and implementing AI for radiography in clinical practice; patients and carers; individual practitioners; service managers; and academic institutions.

Glossary of Terms

Accelerated Access Collaborative (AAC)

artificial intelligence (AI)

artificial intelligence emerging technology (AIET)

Association of Healthcare Technology Providers (AXREM)

Care Quality Commission (CQC)

College of Radiographers (CoR)

deep learning (DL)

Education and Career Framework (ECF)

education institution (EIs)

European Congress of Radiology (ECR)

European Federation of Radiographer Societies (EFRS)

European Society for Radiotherapy and Oncology (ESTRO)

European Society of Radiology (ESR)

Global Partnership on Artificial Intelligence (GPAI)

Health Education England (HEE)

Institute of Physics and Engineering in Medicine (IPEM)

International Society of Radiographers and Radiological Technologists (ISRRT)

machine learning (ML)

Medicines and Healthcare products Regulatory Agency (MHRA)

National Consortium of Intelligent Medical Imaging (NCIMI)

National Health Service (NHS)

National Imaging Academy Wales (NIAW)

National Institute for Health and Care Excellence (NICE)

National Institute for Health Research (NIHR)

quality assurance and quality control (QA and QC)

Quality Standard for Imaging (QSI)

Royal College of Radiologists (RCR)

Scottish Radiology Transformation Programme (SRTP)

Society and College of Radiographers (SCoR)

Society of Radiographers (SoR)

Society of Radiographers Artificial Intelligence Working Party (AIWP)

British Standards Institution (BSI)

East Midlands Imaging Network (EMRAD)

UK Imaging and Oncology (UKIO) Congress

UK Research and Innovation (UKRI)

United Kingdom (UK)

World Health Organization (WHO)

Acknowledgements

Background

Artificial intelligence (AI), including its subsets of machine learning (ML) and deep learning (DL), has the potential to make a profound impact on clinical practice and patient care. For brevity, this document will use the abbreviation AI to refer to these terms collectively.

In the UK, the language used in AI is evolving, with widely cited acronyms, abbreviations and glossaries available; an accessible example of these is contained in the appendices of a UK all-party parliamentary group report from the House of Lords [1].

Research is taking place across the world to investigate the use and development of AI. AI technology is seen as a way of managing growing demand and activity in healthcare but also as a means of improving patient outcomes. It is important to consider how the clinical imaging and radiotherapy workforces will use AI and technology to provide better quality services, while meeting the needs of those who use our services. It is crucial that patients and service users inform all development and are partners in research.

Introduction

A working group for AI was established following the publication of a SCoR AI guidance statement in January 2020 [2]. The broad purpose of convening the working group was to represent the voices of the radiographic workforce in the development of technology, with aims to strengthen or improve care in clinical imaging and radiotherapy. Further, the group was intended to act as a point of contact and to provide clinical, educational and research-related radiography advice and partnerships for stakeholders who sought to collectively develop healthcare technology.

It was expected that the outputs of the working party could inform a number of SCoR documents under review in 2021: the CoR Education and Career Framework, the CoR Research Strategy 2021–2026 and the joint SCoR/Royal College of Radiologists (RCR) Quality Standard for Imaging (QSI). Therefore, it was important that the first edition of the guidance would be completed in time to inform these 2021 reviews.

Healthcare policy in the UK requires that all healthcare professionals, including those in radiography, provide person-centred care [3]. The publication of a values-based practice training template in diagnostic and therapeutic radiography [4] has been used to highlight that each person brings unique values, preferences and opinions to clinical imaging and radiotherapy services. Accordingly, the SoR and the CoR work with patients and the public to develop and publish guidance to support partnership working for patients, the public and practitioners [5]. More widely, radiography practitioners may use a number of UK publications that support the development of person-centred health and care, highlighting that additional time spent with patients/service users/other people will enable care to be strengthened. The development of AI is important for radiography because it has the potential to further support clinical decision making, enhance radiography education, extend the scope of radiography-led research and provide more time for practitioners to personalise care for patients in clinical imaging and radiotherapy services [6].

Scope and Purpose

The aim of the working party was to provide baseline guidance for education, research, clinical practice and stakeholder partnerships, which will require regular updating given the rapidly evolving nature and evidence of AI. The guidance presented in this document is intended for use by multi-professional clinical imaging and radiotherapy teams, including all staff, volunteers, students and learners. This includes clinical and non-clinical, registered and other practitioners, service managers, educators, and researchers. In addition to staff members, the guidance covers family members, parents/carers or supporters who may accompany patients in clinical imaging or radiotherapy services. The setting for the guidance is clinical imaging and radiotherapy services in the United Kingdom.

The working party systematically identified, reviewed and synthesised the available evidence from research and expert opinion, including from service users, and subjected that evidence to peer professional discussion and debate.

To enable that work, the working party met regularly online via video conferencing, and collaborated by email, a Synapse Group platform hosted by the SoR, and a google workspace to collect feedback and peer review. Smaller meetings were organised between the chair, vice-chair and a SCoR professional officer to consolidate the groups discussions. The group agreed the following terms of reference:

- To collaborate proactively with stakeholders in the informatics and health and life sciences/medical technology fields, patients and professional advisory groups to facilitate the development of innovative, safe, effective and sustainable services

- To promote and facilitate radiography-led and radiography-specific research and help to grow the radiographic evidence base in the field of AI

- To facilitate the development of radiography professional body standards for practice when using AI

- To work in cooperation with a range of organisations and key stakeholders to promote and facilitate the implementation of AI once unequivocal benefits have been demonstrated

- To contribute to the work of the SoR and the CoR document reviews

Working Process and Methods

The SoR has approximately 30,000 members who were informed of the intention to facilitate a working party. This was communicated via SoR's monthly professional publication, *Synergy News*, and via social media platforms. A call for members with an interest in AI was placed in *Synergy News* in August 2020, with expressions of interest to join the work received during August and early September. A total of 15 members, gathered from all four nations of the UK, were invited to be part of the group, representing a range of clinical modalities with backgrounds in clinical practice, research, academia and industry. The working party members are listed in Appendix One.

A SCoR professional officer was appointed to the group. The working party commenced their work in September 2020 and terms of reference were agreed,

as outlined in the previous subsection of this document: Scope and purpose. The group nominated a chair and vice-chair and met regularly via online video conferencing software. Members also had their own online workspace on a Synapse platform. The group planned to collaborate proactively with stakeholders in the informatics and health and life sciences/medical technology fields, to aid the development of innovative, safe, effective and sustainable services. It was considered important that this and future work should be in partnership with patients and the public in line with both the SoR and CoR strategies. This was vital to ensure the quality, clinical relevance and holistic approach of this work, and to promote and facilitate the research and development of radiography professional body standards for safe and effective practice of, and with, AI.

The focus of the working party was to inform initial clinical imaging and radiotherapy practice and policy. It was evident that the development of AI technology is ongoing, with extensive philosophical, ethical, professional and legal debate from a range of fields. The group was therefore mindful that a range of evidence should be considered when attempting to review the guidance in the future. The guidance must be reviewed regularly to ensure currency.

The group members submitted a short note of their specific interests to the chair and were then divided into appropriate subgroups. Four subgroups for education, research, clinical practice, and stakeholder partnerships were each led by a subgroup leader. The subgroups worked toward completion of the draft guidance. It was circulated for consultation with SoR advisory groups in early April 2021. The working party reviewed the advisory groups' comments. Amendments were then made in line with available evidence and a final consensus was reached by the group. The resulting guidance was submitted to the SoR UK Council to seek their approval in May 2021.

It was recognised that work around AI will require SoR members' long-term cooperation with a range of organisations to promote and facilitate the implementation of AI and health technologies where appropriate. It was recommended that, beyond the duration of the working party, the SoR UK Council may consider the establishment of an AI advisory group to lead further work. The field of AI is moving and developing at a fast pace, therefore regular updates will be required to ensure that the recommendations remain current.

Funding Arrangements

No external funding was sought to assist with guidance development. All working group members gave their time and expertise voluntarily. The SCoR professional officer was a member of staff in a full-time role, spending time on the working party as SCoR time and resource allowed.

Declaration of Conflict

The SoR policy and procedure for managing conflicts of interest were adhered to. Individual members of the working party (Appendix One) were asked to declare conflicts of interest verbally or to inform the professional officer via email.

Unrelated to the working party project, Dr Nicholas Woznitza is a clinical advisor to InHealth and clinical director of the Health Education England London radiographer reporting programme. Ms Yasmin McQuinlan is an employee of Mirada Medical. Collaborative work for the AI working party was done in her personal time and neither she nor the company received any reimbursement or benefits as a result. The processes of the working party and the appointment of a chair and vice-chair were intended to ensure that the views and interests of the SoR and the CoR did not unduly influence the recommendations.

SoR Approval Process

The SoR, a trade union and professional body for the radiographic workforce, offers professional leadership, and guides and supports professional development in the interests of patients and high-quality health and care services. The SoR sponsors the development of practice guidelines and guidance. The final draft of this guidance was submitted for the approval of the UK Council of the SoR in May 2021.

Limits of the Guidance

The evidence base around the development and use of AI in diagnostic and therapeutic radiography, clinical imaging and therapeutic services, is sparse and early in development. The EQUATOR (Enhancing the QUAlity and Transparency Of health Research) Network has provided guidance on the conduct and reporting of AI research for clinical protocols and for randomised controlled trials [7, 8], which will be useful in the future.

Although there is minimal evidence of AI-specific research that is related to diagnostic radiography, there are numerous papers on the development of radiology/clinical reporting. Therapeutic radiography research is concentrated on radiotherapy treatment planning, therapeutic pathways and optimisation of workflows. Radiography papers remain largely opinion or review based. Despite this gap, a strength of the recommendations contained within this guidance was the perceived strong level of agreement between all members with respect to the priorities for the development of AI in healthcare across clinical practice, education and research.

Members of the working party were conscious of the complexity and diversity of AI within medical imaging and radiotherapy. This includes: the different rates at which AI has been implemented in different imaging modalities; the varied experiences of practitioners depending on the clinical, education or research setting in which they are based; the changing experiences and needs of the people present within clinical imaging and radiotherapy departments; and the rapid rate of change as part of the digitalisation of healthcare. The working party members remained cognisant of these wider issues, while the main focus of the work was to examine the developing evidence base and to develop recommendations for radiographers and healthcare professionals in these settings.

Summary of AI Working Party Actions

During the six-month duration of the SoR AI working party, the group have achieved the completion of a range of actions. Their achievements include the following.

The initial production of a draft AI guidance document was followed by: document consultation with stakeholders; amendments that addressed points from stakeholders and external reviewer; the guidance being shared with the SoR Council; and the Council's approval to publish SoR AI guidance recommendations.

An article updating SoR members about the working party, the AI group members and progress report of the AI working party was printed in *Synergy News* and made available online in May 2021.

A related summary of the SoR AI guidance was submitted to *Radiography* – the official journal of SCoR and the European Federation of Radiographer Societies – for peer review process and intended publication.

A UK-wide online survey explored the knowledge, perceptions and expectations of diagnostic and therapeutic radiographers and pre-registration students (417 responses) in relation to AI. A resulting abstract was submitted to International Society of Radiographers and Radiological Technologists (ISRRT) and accepted for oral presentation at the 2021 ISRRT Congress in Dublin.

Members of the working party have been invited to represent SoR with respect to AI on: the NHSX AI Lab Imaging Programme board; the British Institute of Radiology (BIR) Clinical Intelligence and Informatics Special Interest Group; the British Standards Institution (BSI) AI standards for healthcare; the Scottish Radiology Transformation Programme AI group; the Royal College of Radiologists and Society of Radiographers Quality Standard for Imaging (QSI) 2021 review; and the Health Education England Digital, Artificial Intelligence and Robotics Technologies in Education (DART-Ed) Innovation, Digital and Transformation Directorate AI and digital healthcare technologies capability framework workshop.

A representative of the SoR AI working party will meet with the Association of Healthcare Technology Providers (AXREM) AI Special Focus Group to present the SoR guidance in August 2021.

This SoR AI guidance document has been shared with the SoR steering group for consideration during the update of CoR's Education and Career Framework 2021. The CoR Research Strategy 2021–2026 also now includes a recommendation with respect to AI research.

Context

The Implementation of Technology

Radiography has been at the forefront of the implementation of technological innovation for clinical imaging [9]. The radiography workforce, including registered diagnostic and therapeutic radiographers, are among the most technology-enabled professions in healthcare. As a consequence, the workforce

has learned to adapt to, and engage with, technological advancements [10]. It has been suggested that the disciplines of diagnostic and therapeutic radiography are now poised to experience a groundbreaking transformation in clinical practice because of AI [6, 11]. The Topol Review has recommended the need for readiness and relevant training of all healthcare practitioners in AI technologies to be able to contribute to a digital future in healthcare [12].

With the advancement of AI technology, there is currently a pressing need to explore how SoR members can further influence, innovate and use the development of technology in practice [13]. In order to understand the concepts associated with the development of AI in radiography, it is important for people to understand the language and terms in use. There are widely cited glossaries available; an accessible and comprehensive example is contained in a UK all-party parliamentary group report from the House of Lords [1]. Also in the UK, Health Education England (HEE) commissioned a review of areas for the development of the healthcare workforce's technological capabilities, including AI [12]. An American paper reminds us of the need to also educate patients and the public about the capabilities and limitations of AI [14].

AI Strategy and Policies

With respect to global policy, the Global Partnership on Artificial Intelligence (GPAI) is an international multi-stakeholder initiative to guide the responsible development and use of AI that is grounded in human rights, inclusion, diversity, innovation and economic growth [15]. A UK partner of the GPAI is the Office for Artificial Intelligence, which is part of the Department for Digital, Culture, Media and Sport and also of the Department for Business, Energy and Industrial Strategy. This reflects just a small part of the areas across which AI is poised to revolutionise ways of working.

The Office for Artificial Intelligence has a number of independent reports and guidelines, including a roadmap for UK AI strategy as well as guidelines for AI procurement and its use of in the public sector [16–18]. With respect to ethics, the UK Ada Lovelace Institute works to ensure that data and AI policy will work for the benefit of people and society. The Ada Lovelace Institute was established by the Nuffield Foundation in collaboration with the Alan Turing Institute, the Royal Society, the British Academy, the Royal Statistical Society, the Wellcome Trust, Luminate, techUK and the Nuffield Council on Bioethics. With respect to national funding for AI research, UK Research and Innovation (UKRI) provides government funding for research projects in the UK, including seven research councils, Innovate UK and Research England.

A growing number of national and international policies and plans consider the use of AI in healthcare. The International Society of Radiographers and Radiological Technologists (ISRRT) considers radiographers essential in elevating patient care with AI [13]. The World Health Organization (WHO) made a commitment to address the ethics, governance and regulation of AI for health in 2019, establishing an expert group who aim to develop a global framework for ethics and governance in AI [19]. A goal of the WHO was to ensure that technologies are aligned with overarching aims of promoting fair and equitable global health, meeting human rights standards, and supporting member states' commitments to achieve universal health coverage.

The SCoR published a policy statement for AI for SoR members in January 2020 [2]. The underpinning principle of that publication was that patients, the public and professionals must work in partnership to inform and direct the advancement of quality services and the development and implementation of AI. In May 2020, a joint statement was issued by ISRRT and the European Federation of Radiographer Societies (EFRS), which commenced by making the point that

radiographers, both diagnostic and therapeutic, are working in the interface between technology and patients [13]. The joint statement outlined firstly, the uses of AI in radiography, and secondly, radiographer roles in optimising the use of AI.

The Development of AI in UK Healthcare

The National Institute for Health and Care Excellence (NICE) evidence standards framework for digital health technologies states that digital healthcare technologies must meet the needs of the health and care system, patients and users [20]. It is imperative that concept development, design, testing, implementation and governance of AI are designed in partnership with patients, radiographers, radiologists, oncologists and physicists. AI is developing with the clear potential to aid people, healthcare and radiography services, across a range of areas, to support and improve systems. The use of AI will therefore necessitate new skill sets and teams with a range of stakeholders [13, 21, 22].

There are issues relating to the generalisability and external validity of the algorithms and ecosystems that enable AI. Systems are generally proving to be limited (biased) by constraints of the data sets that are used in training in them [23]. Variations in local data, populations, and imaging and radiotherapy equipment will be a key consideration and currently present challenges to the widespread implementation of AI in clinical practice. NHSX was set up in July 2019 to lead digital transformation of the NHS as a whole [24]. One such intended transformation includes the deployment of AI in clinical imaging and radiotherapy. NHSX has developed an online hub for clinicians, innovators and wider stakeholders to collaborate via discussion boards and learning resources. SoR members seeking further information are encouraged to access the FutureNHS collaboration platform that hosts the workspace for the NHS AI Virtual Hub.

Person-Centred Care and AI in the UK Healthcare System

To understand and work to mitigate risks for patients and staff, it is essential for radiography teams to understand key terminologies and issues around the use of AI. Included in a discussion of nine ethical principles to guide professional and practice standards for research and deployment of AI is a reminder that tools should reflect the needs of patients [22]. A recent white paper for radiologists discussed AI and concurs that tools must benefit patients [25]. It is important to remember though, that the needs of patients vary according to each individual person, with their unique values and preferences [4, 5].

A number of radiology papers have considered the 'value chain' and 'radiology workflow', but authors must also consider the importance of person-centred, customised care in diagnostic and therapeutic radiography. Patients, families and carers are at the centre of services. They are supported by frontline radiographers and clinical imaging/radiotherapy workforces, including assistant practitioners, volunteers [26] and students; all of them collectively care for, examine and treat thousands of people each day, and millions of people each year.

Different applications of AI in radiography have been suggested, with authors outlining possibilities for the priority of clinical adoption [6, 10, 11, 27–30]. Accordingly, the role and functions of staff will need to evolve if they are to enable the delivery of immediate results, support and onward referral of patients to appropriate pathways and treatment.

This type of redesign requires enhanced teamwork between radiography, oncology and radiology teams [10]. If the proposed use of technology to

improve the time required to get diagnostic results and commence treatment comes to fruition, then this could truly make a difference to the lives of all the people who use our collective services [9]. It is the view of the SoR AI working party that AI has the potential to support radiographers to collectively transform and innovate those services.

Recommendations and Priorities for Clinical Practice

Clinicians need to be involved in the co-construction and development of AI; this will ensure the suitability and clinical relevance of AI solutions. Many AI tools have already been developed, but the challenge is for them to be fully internally validated (do methods work?) and externally validated (do they work on unseen data?) to be able to implement these solutions in clinical practice. Furthermore, standardisation of regulations and the creation of universally agreed auditable standards for AI healthcare solutions are vital for the safe integration of AI in clinical imaging and therapeutic radiography services.

Clinical Practice Priorities Summary Table

Strategic priorities for research (vision)	Recommendations for practice (actions)	Responsibility for implementation (people or groups)	Status: Pending – work not commenced. Emerging – work commenced but not established. Ongoing – work established and continuing
1) Engagement of clinical professionals in research to develop solutions in areas of clinical need (use cases)	Perform clinically relevant AI research that addresses real life challenges with the input of all key stakeholders: clinicians, academics, researchers and service users. This could be facilitated through strong clinical academic partnerships and patient and public involvement (PPI) initiatives.	Researchers, clinicians, academics Patient, public, professional and industry partners SoR, CoR, healthcare professional bodies	**Pending** Examples include: NHSX, NHS Digital and NHSX AI Lab Skunkworks initiatives
2) Validation of AI tools	Clinicians need to be included in the clinical validation processes of AI tools to be assured of the safety and efficacy of algorithm decision support prior to deployment as part of routine clinical practice. The Medicines and Healthcare products Regulatory Agency (MHRA), CE marking (and its successor scheme) and software standards committees need to be consulted as well, given their expertise.	Researchers, clinicians, academics Industry	**Ongoing** Examples include SoR work with regards to: • Development of NHSX/NHS AI Lab, SRTP and NIAW national imaging resources • NHS AI Lab AI Ethics Initiative research project: empowering staff to make the most of AI through a skills and capabilities framework

Strategic priorities for research (vision)	Recommendations for practice (actions)	Responsibility for implementation (people or groups)	Status: Pending – work not commenced Emerging – work commenced but not established Ongoing – work established and continuing
3) Ensure equitable and fair use of AI in clinical practice	AI users highlight the limitations and biases in the performance of AI tools and promote equitable use of AI software and hardware. This will enable clinician awareness of inequities in the AI technology of concern. This is vital so that AI implementation will not exacerbate health inequalities (e.g., appointment prioritisation, case triage, image interpretation).	Clinicians, researchers, academics, industry partners	**Emerging** Examples include: Publication of allied health professional (AHP) framework on tackling health inequalities; joint work from Public Health England, the King's Fund, SoR and AHP professional bodies HEE AHP digital inclusion agenda
4) Ensure AI tools are being audited, validated and evaluated over time (QA/QC)	Clinical practitioners ensure there are robust post-implementation auditing and QA/QC frameworks in place to ensure consistent and reliable algorithm performance, following national/international regulatory frameworks for post-marketing surveillance of medical devices.	Healthcare organisations, clinical professionals, industry partners	**Emerging** The British Standards Institution (BSI) AI auditable standards for healthcare NHSX, NICE, CQC, HEE, NHS Digital and MHRA collaboration with the Ada Lovelace Institute: AI Ethics Initiative
5) Continuing professional development (CPD) and ongoing training	Clinical imaging and radiotherapy professionals to seek out appropriate education in the use of algorithmic implementation, safety, clinical decision support and effective communication of decisions to patients and other health professionals.	Clinical imaging and radiotherapy professionals, academics, EIs, industry partners, CoR, SoR	**Pending**
6) Patient, public and professional partnerships and co-production of clinical AI tools	Clinicians engage patients as partners in the development of algorithms, their privacy is maintained and appropriate informed consent is obtained.	Clinicians, researchers, patients, industry, CoR, SoR	**Pending**

Recommendations and Priorities For Education

Radiography is one of the most technology enabled professions. The Topol Review has outlined the urgency for healthcare practitioner training to facilitate a safe and efficient digitalised healthcare system and enable improved patient outcomes and personalised care [12]. Opinion statements and white papers for radiologists and other medical specialties have outlined the need for an update in educational curricula to include more AI training, such as terminology, statistics, AI applications, patient-centred care and validation techniques [2, 11, 13, 25].

In the UK this priority is supported in the Topol Review, recommending that HEE develop an NHS digital education strategy to improve digital literacy. Organisations employing and retaining staff should ensure that clinical staff are supported to maintain an appropriate level of digital literacy [12]. The HEE technology enhanced e-learning platform for clinical imaging and one for radiotherapy, supported by CoR, deliver learning in a virtual environment; the ongoing addition of new content is planned, which should include learning about AI. To further support the goals of this AI guidance, programmes should be developed in collaboration with the CoR, SoR, education institute (EI) leaders and industry colleagues.

More generally, HEE, in collaboration with the University of Manchester, has developed a free e-learning course, AI for Healthcare: Equipping the Workforce for Digital Transformation. The radiography community and educators need to consider these examples, the required changes and new technological developments, and accordingly update the pre-registration and post-registration/ postgraduate educational curricula to enable the safe and efficient contribution of the radiography workforce to the digital future. The CoR Education and Career Framework (ECF), currently under review (2021), should also embrace these changing practice requirements.

Education Priorities Summary Table

Strategic priorities for research (vision)	Recommendations for practice (actions)	Responsibility for implementation (people or groups)	Status: Pending – work not commenced; Emerging – work commenced but not established; Ongoing – work established and continuing
7) Promote collaborative learning between educators, clinical practitioners, researchers, SoR, CoR and industry	Create opportunities for co-construction of AI educational tools and of the AI curriculum by facilitating synergies between these partners. Highlight these priorities in the CoR Education and Career Framework (ECF).	EIs, academics, practice educators, industry partners, CoR, SoR, SCoR ECF working group	**Pending**

Strategic priorities for research (vision)	Recommendations for practice (actions)	Responsibility for implementation (people or groups)	**Status:** Pending – work not commenced Emerging – work commenced but not established Ongoing – work established and continuing
8) Engage with appropriate stakeholders, including professional bodies, patient and service user groups, and regulators to ensure academic curricula are person and patient centred	Create undergraduate, postgraduate and CPD educational provisions on patient and person-centred care in medical imaging and radiotherapy.	Els, academics, CoR ECF working group, professional bodies, patient and public involvement groups, appropriate charities	**Ongoing** CoR Patient public and practitioner partnerships within imaging and radiotherapy: Guiding principles CoR Education and Career Framework
9) Ensure training on AI, progressive technology, data science and healthcare informatics in education programmes is aligned to scope of practice of professionals	Liaise with practice educators and practitioners to ensure education delivers what practice needs.	Els, practice educators	**Pending**
10) Create training opportunities related to clinical audit, service evaluation and validation of AI systems integrated within clinical imaging and radiotherapy practices	Liaise with practice educators and practitioners to devise optimal clinical audit/ service evaluation and validation pathways with evidence-based standards.	Radiography professionals, industry partners, Els, academics	**Pending** The British Standards Institution (BSI) AI auditable standards for healthcare
11) Promote continuity of education in AI, progressive technology, data science and healthcare informatics from pre-registration to postgraduate education, lifelong learning and CPD	Bring pre-registration and postgraduate academics together. Harmonise AI training standards in CoR ECF document.	Els, practice educators, CoR ECF working group, national healthcare systems' e-learning management, CPD platforms (e.g., CoR's CPD Now)	**Emerging** AI is included in CoR's Research Strategy 2021–2026 A standard for AI to be included in the revised CoR/ RCR Quality Standard for Imaging AI to be included in CoR's ECF

Strategic priorities for research (vision)	Recommendations for practice (actions)	Responsibility for implementation (people or groups)	Status: Pending – work not commenced Emerging – work commenced but not established Ongoing – work established and continuing
12) Consider appropriate inclusion of AI within pre-registration and postgraduate training curricula. AI topics to include the following: A) Overview of AI and its potential roles within clinical imaging/ radiotherapy. B) Basic knowledge of terminology, and of development processes of AI algorithms. C) Testing, validation, standardisation, and governance arrangements. D) AI implementation techniques. E) Patient-centred and person-centred care in the context of AI; F) Critical appraisal of research literature related to emerging technologies. G) Ethics of AI, accountability in the AI ecosystem, and principles of innovation and entrepreneurship.	Organise a task force of radiographer academics and clinical practitioners/ educators.	Academics, EIs, industry partners, AIWG, patient and public/service user groups	**Pending**

Strategic priorities for research (vision)	Recommendations for practice (actions)	Responsibility for implementation (people or groups)	Status: Pending – work not commenced	Emerging – work commenced but not established	Ongoing – work established and continuing
13) Incorporate learning for all practitioners and operators on risk management of AI use in clinical practice, including: patient safety, justification, interpretation and communication of using AI/ algorithms to contribute to clinical management, diagnosis and/or staging	Organise short courses, and develop CPD resources and signposting towards further information in these areas.	Els, industry partners, academics, practice educators	**Pending**		
14) Evaluate the correct clinical usage of AI systems within clinical competency assessment tools	Review pre-registration and postgraduate clinical competency assessment tools and methods.	Els, academics, clinical professionals	**Pending**		
15) Facilitate educational research activities to evaluate and monitor the introduction of modules in AI, progressive technology, data science and healthcare informatics, and best practices for education and learning	Organise educational research projects and initiatives in relation to AI curriculum design, delivery and evaluation.	Els, academics, radiography students	**Emerging** For example, the evaluation of Radiography AI postgraduate modules at City, University of London is underway (2021)		
16) Enable involvement of educators/ students of suitable academic/ clinical expertise to develop AI within clinical imaging, radiotherapy and radiographic education	Organise student–academic focus groups to brainstorm and discuss the proposed changes in the curriculum, with pre-registration and postgraduate students actively involved in their learning.	Els, academics, radiography pre-registration and postgraduate students	**Pending**		

Strategic priorities for research (vision)	Recommendations for practice (actions)	Responsibility for implementation (people or groups)	Status: Pending – work not commenced Emerging – work commenced but not established Ongoing – work established and continuing
17) Teach not just about AI principles but with AI-enabled educational tools Teach not just about AI but with AI	Ensure that appropriate focus is given to developing/ co-constructing AI solutions with an educational focus for delivery of the academic curriculum within clinical imaging and radiotherapy.	EIs, patients/ public, professionals, academics, industry partners	**Ongoing**
18) Provide opportunities for scoping events and networking around prospective developments	Organise educational conferences around AI, its use and future work.	EIs, academics, industry partners, pre-registration and postgraduate students	**Ongoing** UK Imaging and Oncology (UKIO) Congress EFRS and ISRRT Congress European Society of Radiology (ESR) European Congress of Radiology (ECR) European Society for Radiotherapy and Oncology (ESTRO) Congress SCoR Achieving Excellence in Radiography Education and Research conference Focused international AI conferences; for example, AI conference by City, University of London in July 2020 SoR online Synapse workspaces

Recommendations and Priorities for Research

As highlighted by Hardy and Harvey (2020), there is a lack of information on the impact of AI on the radiographer's role [11]. As healthcare professionals, radiographers are accustomed to the development of evidence-based practice with increasing technological advances. However, AI is being rapidly integrated into imaging equipment with arguably little consideration as to how it influences radiography practice and frontline services. Current regulatory frameworks stipulate that all AI systems that are deployed clinically require human oversight of their implementation [31]. This is adding to the radiographer's role and increasing the need for a high level of digital fluency among radiography staff as they must learn to evaluate, interact and oversee the actions of AI driven tools within their workflow. It is recommended that research is required to investigate the impact of AI on: the quality of services; patient care; and radiographers' roles and their working practices. There is also a need for prospective high-quality 'real world' clinical validation of AI interventions, the reporting of which should adhere to the appropriate guidelines (e.g. SPIRIT-AI and CONSORT-AI guidelines) [7, 8].

Research Priorities Summary Table

Strategic priorities for research (vision)	Recommendations for practice (actions)	Responsibility for implementation (people or groups)	Status: Pending – work not commenced Emerging – work commenced but not established Ongoing – work established and continuing
19) Explore and map out radiography baseline theoretical knowledge, clinical practice, technical skills and perceptions/expectations of the use of AI	Conduct research on the current knowledge, technical skills/competences, and attitudes and expectations of radiographers towards AI. This could take the form of surveys or other type of mixed-methods research.	SoR AIWP, EIs, CoR, academics	**Ongoing** For example: UK-wide AI survey, with similar surveys running in Africa, Ireland, Saudi Arabia and Greece EFRS and ISRRT running pilot studies in 2021 HEE AHP digital skills project
20) Investigate the impact of emerging AI technologies on the patient experience, patient safety and quality of care	Conduct undergraduate and postgraduate/doctoral and postdoctoral research in this area	AIWP, EIs, SoR, radiography service managers, academics	**Emerging**
21) Investigate how the radiographer's role, career opportunities, role extension and career progression will develop and change with the increased use of AI	Carry out baseline search, but also ongoing research required.	AIWG, HEIs, SoR, research-active professionals, academics, radiography service managers, consultant practitioners, advanced practitioners, team leaders	**Pending**
22) Develop transparent AI working practices and protocols Strive for explainable AI that practitioners and patients will be able to trust but also query and assess its quality	Create auditable standards. Cross-disciplinary, multi-site research projects are needed.	SoR, industry, higher education institutions (HEIs), academics, clinical practitioners, British Standards Institution	**Pending** SoR sits on [NHSX](#) AI Lab AI Imaging Programme board Further work is ongoing at: [NHS Digital](#), [NHSX](#) and [NHS AI Lab](#) in England; [Scottish Radiology Transformation Programme](#) (SRTP) for Scotland; and [National Imaging Academy Wales](#) (NIAW) for Wales
23) Identify what AI metrics/interface influence clinical decision making	Conduct research projects e.g., by clinical imaging and therapeutic radiography professionals, doctoral students, postdoctoral researchers.	SoR AIWP, EIs, SoR, clinical professionals, academics, colleagues from industry	**Ongoing** For example: Ultrasound scan and surgical innovations in pregnancy services

Strategic priorities for research (vision)	Recommendations for practice (actions)	Responsibility for implementation (people or groups)	Status: Pending – work not commenced Emerging – work commenced but not established Ongoing – work established and continuing
24) Make radiography researchers in AI visible to editors, publishers, journals, and conferences as autonomous researchers who can add value within multidisciplinary teams but also as distinct to radiologists and other medical imaging colleagues	Organise conferences, arrange sessions in conferences, webinars, seminars etc. on radiography and AI. Invite multiprofessional key stakeholders to increase visibility and understanding of capability and impact of clinical imaging and therapeutic radiography professionals.	AIWP, EIs, SoR, clinical professionals, academics	**Emerging**. Promote existing papers and further publication of articles in *Radiography* journal
25) Support, fund and advocate for AI research in radiographic practice and education	Highlight funding routes that are available within devolved nation research programmes. Explore the development of industry-funded grants and partnerships. Approach research funders to advocate for the role of radiography research in AI implementation and healthcare practice.	SoR professionals, industry professional partners, AIWG, research funders (NIHR, Medical Research Council, Economic and Social Research Council)	**Emerging** Explore the possibility of CoR Industry Partnership Scheme themed calls for AI research grants
26) Forge partnerships between AI researchers and clinical practitioners to support collaboration on areas of mutual interest.	Create multidisciplinary teams.	AIWP, EIs, SoR, clinical professionals, academics.	**Emerging** for example, a range of sites where AI is being used in collaborations between NHS sites/NHSX/ academic partnerships NHS Accelerated Access Collaborative (AAC) awards, e.g. Mirada Medical FutureNHS Collaboration Platform resources: NHSX AI Virtual Hub National Consortium of Intelligent Medical Imaging (NCIMI) The East Midlands Imaging Network (EMRAD)

Recommendations and Priorities For Stakeholder Partnerships

Due to the complexity of healthcare systems, the development, testing, validation, implementation and auditing of AI tools need to involve multidisciplinary teams. The teams must have key stakeholders from all areas of practice. Clinicians, scientists, engineers, researchers, educators, patients, trainees and industry are just a few of the different groups that need to work in partnership to deliver AI solutions. These partnerships, vitally, must extend to and include the full context and scope of practice of the radiography workforce. Key partners must ensure: radiography clinical practitioners are included in decision making; radiography researchers are supported and able to apply for funding; and radiography students and trainees get the education they need to safely navigate a digital future. It is therefore essential that industry partners and key collaborators recognise the whole range of professionals involved in the medical and clinical imaging workflows; the distinct bodies of knowledge that can work with them to develop solutions. In this process it is also essential that patients hold a central place in highlighting clinical necessities and personalisation and humanisation priorities.

Stakeholder Partnership Priorities Summary Table

Strategic priorities for research (vision)	Recommendations for practice (actions)	Responsibility for implementation (people or groups)	Status: Pending – work not commenced Emerging – work commenced but not established Ongoing – work established and continuing
27) Collaboration between industry/ AI companies, clinical practitioners, universities, researchers and the whole range of multidisciplinary professionals working in clinical sites	Develop partnership between industry, radiography researchers and early adopter clinical sites to establish AI health transformation pathways and develop validation documentation for AI healthcare adoption. Also establish early accountability pathways for AI products.	Academics, industry, clinical practitioners, UK regulatory bodies and professional bodies, including SoR, IPEM, RCR professionals, and NHS trust leadership	**Ongoing** For example: NHSX AI in Health and Care Award for the conceptualisation, development, testing and validation of AI technologies in the NHS. London Medical Imaging & AI Centre for Value-Based Healthcare collaboration between NHS trusts, small to medium-sized enterprises (SMEs) and King's College London to develop, validate and implement AI technologies for the benefit of the NHS
28) Collaboration between industry and educators/ academics	Partnerships between industry and educators/academics and practice educators are important to ensure radiography pre-registration and postgraduate training is up to date with current technologies and clinical needs. Forge partnerships to run conferences/ webinars on AI in radiography.	Academics/ educators, industry, CoR, professional bodies	**Ongoing** For example: AI symposium at City, University of London Association of Healthcare Technology Providers (AXREM) AI Special Focus Group manifesto City University of London Radiography 2020 conference European Society for Radiation Oncology (ESTRO) and American Society for Radiation Oncology (ASTRO) congresses.

Strategic priorities for research (vision)	Recommendations for practice (actions)	Responsibility for implementation (people or groups)	Status: Pending – work not commenced Emerging – work commenced but not established Ongoing – work established and continuing
29) Development of AI health lead radiographers/ clinical imaging and therapeutic radiography professional ambassadors to facilitate clinical digital transformation	Ensure radiographers, clinical imaging and therapeutic service professionals participate in/apply for the NHS Topol Programme for Digital Fellowships in Healthcare and other AI leadership positions with the NHS, EIs and industry.	SoR members, EIs, professional bodies, AIWG	**Ongoing**
30) Advocate and work with industry to establish a common language in AI terminology for consistency	Ensure a common AI language is understood between industry, academia and clinical practice.	Industry, academic, clinical	**Pending**
31) Coordinate a seamless multidisciplinary framework of AI implementation, where every team member is valued and their input is heard	Collaboration between clinical practitioners, academics, researchers, professional bodies and regulatory bodies.	All stakeholders	**Pending**

Opportunities For Partnerships

This list represents some of the available opportunities for partnership; it is not exhaustive and will continue to expand.

Opportunity	Description	Status
CRUK RadNet	CRUK RadNet is a radiotherapy research network with seven centres, each driving its own research priorities.	**Emerging**
CTRad	CTRad is the Clinical and Translational Radiotherapy Research Working Group of the National Cancer Research Institute (NCRI).	**Emerging**
The London Medical Imaging & AI Centre for Value-Based Healthcare	The London Medical Imaging & AI Centre for Value-Based Healthcare is a consortium of academic, NHS and industry partners led by King's College London and based at St Thomas' Hospital. It aims to bring together clinical, research and industry minds to develop innovative technologies using NHS medical images and data. Work is also being done to develop a platform for validation of these technologies.	**Emerging**

Opportunity	Description	Status
[NCIMI](#)	The National Consortium of Intelligent Medical Imaging (NCIMI) is a network of NHS hospitals, clinical leaders, industry experts in the fields of AI and medical imaging, and world-leading academic researchers, plus patient groups and charities. NCIMI's mission is to computer vision with artificial intelligence and apply it to clinical problems within imaging and diagnostics through research.	**Emerging**
[NHSX](#)	NHSX is partnering with the NHS Accelerated Access Collaborative (AAC) and NIHR to [award funding for evaluation and validation of progressive technologies in the clinic](#). The first winners were announced on 8 September 2020. Work is being done to match the award winners with clinical sites and to ensure the right evidence is collected for validation of new technologies.	**Emerging**
[Topol Programme for Digital Fellowships in Healthcare](#)	A range of clinical candidates, including those with an allied health professional (AHP) background, have been admitted to the Topol Programme. If you have an idea or clinical problem you would like to solve, you can [apply for a fellowship](#). NHS candidates and banding restrictions apply.	**Emerging**
Vendor or professional body meetings and conferences	Vendor or professional body organised user meetings and conferences provide many opportunities. There is the activation of a product feedback loop when industry and clinic engage. Networking between academia, clinic and industry can encourage research collaborations for the betterment of clinical practice. The establishment of an AI emerging technology (AIET) conference track at established conferences such as the congresses of UKIO, British Institute of Radiology (BIR), ECR/EFRS and ESTRO may further the publication of AIET research.	**Ongoing**

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Recommended Reading and Resources

1. Government

Secretary of State for Business, Energy and Industry Strategy – [Government response to House of Lords Artificial Intelligence Select Committee's report on AI in the UK: Ready, willing and able?](#) (2018)

2. Professional Regulatory Requirements

Health and Care Professions Council – [Standards of proficiency for radiographers](#) (2013)

Health and Care Professions Council – [Standards of continuing professional development](#) (2018)

Health and Care Professions Council – [Standards of education and training](#) (2017)

3. Journal Articles

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4. Stakeholder Partnerships

Advanced Radiotherapy programme – e-Learning for Healthcare

AI for Healthcare and Digital Transformation course – FutureLearn

Topol Digital Fellowships programme – Health Education England

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National Consortium of Intelligent Medical Imaging (NCIMI)

National COVID-19 Chest Imaging Database (NCCID) – NHSX

NHS Accelerated Access Collaborative

The London Medical Imaging & AI Centre for Value-Based Healthcare: Our partners

Cancer Research UK: RadNet – our radiation research network

National Cancer Research Institute: Workstreams

Appendix One

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