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Review article

Radiographer reporting: A literature review to support cancer workforce planning in England

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ABSTRACT

Objective: Clinical Imaging contributes to screening, diagnosis, planning and monitoring of treatment and surveillance in cancer care. This literature review summarises evidence about radiographer reporting to help imaging service providers respond to Health Education England's 2017 Cancer Workforce Plan project to expand radiographer reporting in clinical service provision.

Key findings: Papers published between 1992 and 2018 were reviewed (n = 148). Evidence related to dynamic examinations (fluoroscopy, ultrasound) and mammography was excluded. Content was analysed and summarised using the following headings: clinical scope of practice, responsibilities, training, assessment, impact in practice and barriers to expansion.

Radiographer reporting is well established in the United Kingdom. Scope of practice varies individually and geographically. Deployment of appropriately trained reporting radiographers is helping the NHS maintain high quality clinical imaging service provision and deliver a cost-effective increase in diagnostic capacity.

Conclusion: Working within multiprofessional clinical imaging teams, within a defined scope of practice and with access to medical input when required, reporting radiographers augment capacity in diagnostic pathways and release radiologist time for other complex clinical imaging responsibilities.

Introduction

In 2015 the Independent Cancer Taskforce set out a strategy to improve the lives of people affected by cancer in England through better prevention, earlier diagnosis and transforming the care and support of people living with and beyond cancer.[1] In its subsequent 2017 Cancer Workforce Plan,[2] Health Education England (HEE) identified the vital contribution of Clinical Imaging across cancer care pathways and highlighted the key role of clinical radiologists and diagnostic radiographers in screening, diagnosis, planning and monitoring treatment and surveillance of people affected by cancer.

With the radiology workforce suffering continued shortages[3] and having a lead time of at least five years (speciality training) to increase supply, the 2017 Phase 1 Cancer Workforce Plan included a project to support 300 senior radiographers to undertake nationally approved postgraduate training which would enable them to move into advanced and consultant practice roles incorporating image reporting by 2021.

This literature review outlines the evidence base supporting radiographer reporting and was undertaken to help service providers promote expansion in the number and scope of practice of reporting radiographers.

Background

The traditional role of a radiographer was to acquire images for interpretation and reporting by a (medically qualified) radiologist. Over time, as demand for imaging in England increased at a greater rate than radiologist supply[4] the role of radiographers evolved to encompass interpreting images working alongside their medical colleagues in multiprofessional imaging teams. Image interpretation and reporting by non-medically qualified healthcare professionals was not supported initially by the Royal College of

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Radiologists (RCR)[5] but on-going pressures in the National Health Service (NHS) have led to acceptance of the role.[6]

The basic elements of image interpretation and reporting have been recognised formally in radiographers' professional regulatory standards[7] in the United Kingdom (UK) since 2013 and are included in the Society and College of Radiographers' (SCoR) curriculum for diagnostic radiography practitioner training programmes.[8] Pre-registration radiography programmes in the UK have a long history of including pattern recognition, abnormality detection and/or preliminary clinical evaluation (commenting) in their curricula with determination of first-post competence at this level of practice lying with employing clinical departments.[9]

Since the 1990's UK Higher Education Institutions (HEI) have offered formal postgraduate programmes in image interpretation and reporting. These Masters level programmes develop a deeper understanding of the image review process and cultivate the higher level skills needed to go beyond pattern recognition and preliminary clinical evaluation. Such programmes prepare radiographers to undertake definitive image interpretation and construct their own interpretive, actionable reports. NHS England's national strategy to develop the role of allied health professionals (AHP) emphasises the increasing value of 'advanced practice' roles and notably includes exemplar case studies of radiographers undertaking formal image interpretation and reporting roles.[10]

In 2017 NHS Benchmarking[11] stated that 35% of imaging reports in the UK were generated by appropriately educated and trained radiographers (or sonographers) and the RCR estimated that 78% of imaging departments nationally utilised radiographer reporting.[3] Although radiographer reporting is well established in some NHS trusts, the volume and scope of practice varies from trust to trust with some not employing reporting radiographers at all.[12] In at least one trust up to 80% of musculoskeletal (MSK) plain film and visceral (chest and abdomen) radiograph reports are authored by radiographers.[13] NHS Benchmarking[14] advocate growth in radiographer reporting as an important response to the continuous growth in demand for clinical imaging, not least because the largest component of reporting backlog (59%) is general (plain film) radiography examinations.

The Cancer Workforce Plan[2] recognised that increasing the number of reporting radiographers has the potential to relieve pressure on radiologists and increase capacity for early diagnosis. Expansion of radiographer reporting should enable NHS services to make more efficient use of radiologists, freeing them up to use their specialist skills in complex cases and for attendance at multidisciplinary team (MDT) meeting case discussions. Use of more reporting radiographers could also reduce the number of imaging examinations that do not get a formal clinical report.[15]

This review considers the current scope of practice of reporting radiographers, their underlying training, assessment of their competence, the impact of their practice and how trusts might harness support for, and overcome barriers to, expansion of radiographer reporting at local level.

Methods

This review summarises evidence about reporting radiographers published between 1992 and 2018. Studies relating to radiographer reporting of dynamic examinations, such as fluoroscopy and ultrasound, were excluded as outside the scope of the Cancer Workforce Plan reporting radiographer project. Studies relating to radiographer reporting of mammography images were excluded in view of the 2016 systematic review published by Moran & Warren-Forward.[16]

The literature search was performed on 13th November 2017 using search terms, key words and databases as outlined in Table 1. In contrast to formal systematic review methodology the search strategy was iterative and inclusive and not limited by pre-specified eligibility or quality criteria. The analytical approach adopted was exploratory and descriptive to generate a basic exposition of issues pertinent to providers considering how to develop their radiographer reporting service.

The initial evidence search was conducted by a professional information specialist at Surrey and Sussex Library and Knowledge Services, Redhill, UK. Additional material for the review was identified by searching the reference lists of retrieved papers and through citation tracking. After the initial evidence search, emerging literature for inclusion was identified using key author and citation alerts and both informal and official peer review processes. Assessment of relevance and thematic categorisation was performed by the second and third authors; first and second authors undertook initial detailed analysis and wrote the first draft of the paper; all authors contributed to subsequent drafts and the final review report.

Findings and discussion

Search results

The initial search identified 148 papers: two national guidance documents, 36 institutional publications, two systematic reviews and 108 original research papers.

Brealey et al.[17] point out a range of biases and methodological factors that influence the validity of image interpretation research and variation in fulfilment of methodological standards across empirical studies of radiographer performance. They acknowledge that investigators are invariably bound by resource constraints and the need to seek a balanced trade-off between study objectives and methodology in order to give policy makers and service providers confidence in their findings.

In view of the diversity of methodological approaches in the papers in this review, we did not undertake formal quality assessment. We describe studies which identify limitations in radiographer diagnostic accuracy and acknowledge potential for over-representation of favourable studies due to publication bias.

Table 1
Literature review search terms and notes.

§ NICE Evidence Search: "reporting radiographer"; "advanced practice radiographer"; "CT reporting radiographer"; "radiographer image analysis"; "advanced practice"
§ SCOR: "reporting radiographer"; "advanced practitioner"; "education"; "reporting radiographer standards"
§ NHS England: "reporting radiographer"; "advanced practitioner"
§ Ethos: radiographer reporting
§ Google: "reporting radiographer" [limited to results from 2013 due to high number of results].
§ Google Scholar: "radiography reporting"; "radiographer reporting"; radiographer reporting standards"
§ Forward citation tracking of key articles and authors in Google Scholar
§ Medline and EMBASE were searched using OVID. AMED and HMIC were searched using HDAS. Please note that thesaurus terms vary between databases.
§ ClinicalKey: "reporting radiographer"
§ ISRCTN: "reporting radiographer"; "radiologic technician"; "radiologic technologist"
§ Key authors: Brealey, Woznitza, Snaith, Hardy

Clinical scope of practice

From early practice limited to general musculoskeletal cases in trauma, accident and emergency settings[15,18,19] the current scope of practice of reporting radiographers in England covers a wide range of examinations and referral sources (Tables 2 and 3). Practice usually develops in response to local service demand and the need to maintain service provision in the absence of an adequate and equally distributed supply of radiologists; as such significant geographic variation exists.[18]

Reporting responsibility

International papers confirm that radiographer reporting is not well established outside the UK. The most recent non-UK papers describe developments in 'red dot' schemes,[37] commenting[38] and pattern recognition[39] with overseas institutional guidance still advocating for the role and advising on setting up legal and good practice standards and developing robust education frameworks.[40,41] This illustrates a time lag of some 27 years since Berman et al.[42] first described radiographers interpreting images in 'red dot' schemes in England in 1985.

The practice of radiographers in England evolved over time to encompass 'hierarchical' double reporting. This involves radiographers 'first reporting' prior to a definitive (second) report by a radiologist; definitive (single) reporting by radiographers emerged following pilot projects in the 1990s.[43] In the papers reviewed the former practice is variously described as commenting,[44] preliminary clinical evaluation,[32] initial reporting[44] or concurrent reading,[36] the latter as definitive reporting,[45] clinical reporting,[29] reporting in clinical practice[35] or single formal written reporting.[31] The remainder of this review focuses predominantly on the practise of definitive single reporting by radiographers in the UK.

Responsibility of contemporary reporting radiographers in England now also encompasses provision of second opinions and supervision for less experienced colleagues, both medical and non-medical[13] and responding to queries from referring clinicians.[15] In some schemes of work reporting radiographers have autonomous clinical decision-making responsibilities, for example removing malpositioned naso-gastric tubes,[13] onward referral to further imaging or specialist opinion,[13,21] making recommendations for treatment[21] or discharging patients independent of further medical intervention.[46] When considering the role of reporting radiographers in service delivery the ability to provide cross-cover and to attend and participate in clinical decision making at multidisciplinary meetings are also important.[15,47]

Table 2
Technical and anatomical scope of practice.

Scope of practice	Sources of evidence
General/musculoskeletal system	Snaith et al. 2016[13] Woznitza et al. 2014[15] Snaith et al. 2015[18] Milner & Snaith 2017[19] Milner et al. 2016[20] Stevens 2019[21]
Chest * studies limit to adult chest	Snaith et al. 2016[13] Woznitza et al. 2014[15] Milner et al. 2016[20] * Stevens 2019[21] * Woznitza et al. 2014[22] Bajre et al. 2017[23] * Piper et al. 2014[24] * Woznitza et al. 2018[25] * Woznitza et al. 2018[26] * Woznitza et al. 2018[27]
Abdomen	Snaith et al. 2016[13] Woznitza et al. 2014[15] Milner et al. 2016[20]
CT Head	Woznitza et al. 2014[15] Lockwood et al. 2015[28]
CT sinus and facial bones	Lockwood 2017[29]
CT colonography	Moore et al. 2012[30] Meertens et al. 2013[31] Rimes et al. 2015[32]
Contrast enhanced chest CT for Pulmonary Embolus	Kilburn et al. 2017[33]
MRI head	Bolton 2016[34]
MRI Knee and lumbar spine	Woznitza et al. 2014[15] Brealey et al. 2013[35]

Table 3
Referral sources.

Referral service	Sources of evidence
Trauma/accident/emergency	Woznitza et al. 2014[15] Milner et al. 2016[18] Berman et al. 1985[19] Stevens 2019[21] Snaith et al. 2015[22]
In patients	Snaith et al. 2016[13] Woznitza et al. 2014[15] Milner et al. 2016[20]
Orthopaedics Out patients	Brealey et al. 2013[35] Woznitza et al. 2014[15] Milner et al. 2016[20]
Rheumatology Paediatrics	Milner and Snaith 2017[19] Stevens 2019[21] Milner and Snaith 2017[19]
General Practitioners/Primary care	Snaith et al. 2016[13] Milner et al. 2016[20] Stevens 2019[21]
Cancer – lung	Woznitza et al. 2018[25] Woznitza et al. 2014[22] Bajre et al. 2017[23] Nair et al. 2018[36]
Cancer – bowel	Moore et al. 2012[30], Meertens et al. 2013[31] Rimes et al. 2015[32]
Stroke Pulmonary Embolus screening	Bolton 2016[34] Kilburn et al. 2017[33]

Training radiographers to interpret and report clinical images

In both training and practice, the performance of reporting radiographers is usually assessed against the 'gold standard' diagnostic opinion of the radiologist. This review did not consider evidence about the education, training and assessment of radiologists. Review findings related to training and assessment are summarised in Box 1 and discussed below.

Early training programmes were delivered in-house and recruited participants with substantial clinical experience. Loughran's early (1994) study[48] demonstrated the effectiveness of an in-house six-month programme of weekly tutorials and written assignments on accuracy of fracture detection. Following training the three participant radiographers' sensitivity improved to a similar level to that of the local radiologists (95.9%, 96.8% respectively). Training was also shown to improve the radiographers' specificity, however it remained significantly lower than radiologist specificity (96.6%, 99.6%, respectively; $p < 0.001$).

Brealey et al.'s 2005[49] meta-analysis of this and 11 other studies of radiographer reporting published between 1994 and 2002 calculated pooled sensitivity of 92.6% (95% CI: 92.0–93.2) and specificity 97.7% (95% CI: 97.5–97.9). Although the number of participant radiographers is not stated, across almost 30,000 imaging examinations the authors concluded that there was no evidence of any difference in the accuracy of selectively trained

Box 1
Training and assessment summary

- ➢ Formal structured courses develop deeper understanding of image interpretation.
- ➢ Higher level education postgraduate programmes are required for development of skills to the level required for definitive image interpretation and report construction.
- ➢ A national accreditation process upholds training quality by assuring performance standards and allows transferability of skills.
- ➢ Intensive (hot housing, simulation, off line cases, academic study) and non-intensive (in practice, over time, workplace-based learning) approaches are used to suit learner preference, a combination of training techniques being most effective.
- ➢ Online delivery, virtual classrooms and e-learning can be used to develop theoretic understanding but learning under clinical practice conditions and interaction with experts is required for development of practical clinical skills.
- ➢ Assessment of competence includes both construction of text comments and calculation of diagnostic accuracy - defined in terms of ability to identify normal cases and to detect, interpret and report abnormality.
- ➢ Competence is defined as safe practice and practice equivalent to that of a medical consultant.
- ➢ Development of confidence, readiness to participate in clinical decision-making and communication skills are further important components of image interpretation and reporting in clinical practice.
- ➢ In the academic setting the OSE can measure diagnostic accuracy and report construction competence.
- ➢ Using an abnormality enriched OSE image test bank might not represent performance in the clinical environment; improved validity might be achieved with customised test banks representative of local case mix.
- ➢ Performance improves with experience, number of cases read and reflective practice with continual feedback; audit, error and discrepancy review and MDT meetings can be used to identify individual on-going learning needs.
- ➢ Electronic software tools have potential to benchmark performance across individuals and professional or geographically defined populations of reporters.
- ➢ Within a defined scope of practice the diagnostic accuracy of appropriately trained and educated radiographers is comparable to that of radiologists and is higher than that of other medical practitioners.

radiographers and radiologists reporting general radiography examinations.

In a 2017 systematic review, McLaughlin et al.[50] considered 13 primary studies that used structured training programmes to improve radiographers' ability to interpret chest radiographs. Their selection of papers covers radiographer participant sample sizes of one to 148 and a variety of training approaches including local in-house support, digital short courses through to formal post-graduate programmes of at least six months duration. The reviewers conclude there is strong evidence from high quality studies to demonstrate that accuracy is high, and improved, regardless of training approach. They recommended that a combination of training techniques has the potential to maximise learning across trainees with different learning styles.

The majority of current radiographer reporting education in the UK is delivered on extended (now 9–12 month) formal post-graduate programmes provided by Higher Education Institutions. Learning methods often include a blend of intensive classroom-based teaching in the academic environment and use of simulation and off-line case libraries. This is combined with non-intensive (supernumerary) workplace based learning in clinical practice where students engage with experienced radiologists and reporting radiographers. Most recently, Woznitza et al.[51] described an innovative 'hub and spoke' approach to providing centralised tutorial support for 14 radiographers training to report chest radiographs across a pan-London geography. Significant efficiencies in expert supervision/mentorship time (48 h) were achieved in comparison to traditional one-to-one based workplace support (348 h). Similar centralised 'academy-style' group learning and peer support systems for trainee reporting radiographers, as described by Harcus and Snaith[52] are beginning to emerge, with the potential for multiprofessional learning being encouraged.[53]

As HEI based courses incur direct and indirect costs for staff development, economic viability and provision is subject to 'minimum numbers'. Face-to-face teaching requires students to be away from the workplace, and sometimes from home, adding travel and subsistence expenses, over and above course fees, to the cost of training. Distance, online or 'e' learning in healthcare has evolved as an alternative approach to overcome some of the limitations of the traditional classroom approach. However, in a 2013 survey, Leishman[54] explored the perceptions of 86 experienced reporting radiographers across the UK and concluded that total online delivery of skeletal image interpretation education was not an appropriate pedagogic approach. Whilst the participants in Leishman's study appreciated the potential benefits of online delivery, the majority said they preferred the traditional blended approach (block release, n = 76, 88%; day release, n = 9, 11%) they had experienced. However, ten (12%) considered that use of a virtual classroom could be combined with workplace based learning for teaching practical skills which they believed required interaction with experts in the field so that learning was enhanced by experience.

Increasingly UK image interpretation and reporting programmes are being incorporated into multiprofessional advanced practice programmes with learning covering all four pillars of such practice. Area specific competence in image interpretation and reporting fulfils the criteria for expert clinical practice, with such programmes also developing Masters' level skills in leadership and management, education and research.

Assessment of competence

Assessment strategies in HEI programmes mirror teaching styles and include a range of methods such as written case studies, objective structured examinations (OSE) which involve case viewing and reporting, and portfolio-based clinical case audit over the duration of study.

Studies such as that of Piper et al.[24] demonstrate how UK accredited postgraduate programmes use a summative assessment OSE to enable students to demonstrate the ability to identify correctly normal chest radiographs, including anatomical variants, and provide a report on abnormal appearances, including incidental findings. Piper's institution used an abnormality enriched (abnormality prevalence 50%) 100-image test set and the consensus agreement of three consultant radiologists as the 'gold standard' opinion. Although the test set contained a predefined and comprehensive clinical (cardiac, pulmonary, pleural, interstitial,

inflammatory, neoplastic and trauma) and referral (inpatient, outpatient, primary care and acute) case mix, the authors acknowledged that further work was required to confirm the application of their results, obtained under controlled academic conditions, in clinical practice. Subsequent studies by Woznitza and colleagues compared radiographers with radiologists interpreting and reporting images in routine service provision and demonstrated similar performance in terms of diagnostic accuracy and discrepancy rates.[15,21,26,27]

McLaughlin et al.[50] noted the importance of prevalence rate when assessing ability to interpret radiographs. Three of the studies[55–57] in their meta-analysis had evaluated 'first reporting' performance over a 'natural' case series encountered in clinical practice, with abnormality prevalence calculated retrospectively. Usefully, the review cites the paper of Pusic et al.[58] showing how junior doctors tested using a high number of abnormal images demonstrate high sensitivity (0.69 ± 0.24) in comparison to those trained with medium (0.63 ± 0.21) and low (0.51 ± 0.24) numbers of abnormal images. Conversely, the study also showed high specificity when participants trained using a low number of abnormal images (0.83 ± 0.10) compared to those tested with medium (0.70 ± 0.15) and high (0.66 ± 0.17) numbers of abnormal images.

In 2017 Neep et al.[59] demonstrated how a locally derived test set reflecting one institution's typical anatomical region case-mix of adult trauma radiographs produced high reliability (inter-rater, intra-rater, internal consistency) and validity (concurrent) across 41 radiographers categorising cases as either normal or abnormal. Going further, in their 2016 paper, Hardy et al.[60] concluded that image test banks reflecting local clinical practice can be used to establish the competence level of individual practitioners and identify bespoke learning development needs.

In 2016 Wright & Reeves[61] developed a software programme, RadBench, as an objective assessment tool for image interpretation skills and tested it at one NHS Trust. The programme calculated sensitivity, specificity and accuracy across two sets of 20 MSK images and generated a decision-making map for each respondent. The programme discriminated reporting radiographers and radiologists (accuracy 95% or above) from general radiographers (accuracy 60–95%). The 'benchmarking' option enabled participants to compare their score with the highest, lowest and mean score of other participants. The authors conclude that the Radbench tool could underpin development of radiographer reporting by benchmarking measures of image interpretation accuracy and identifying training needs across different populations of healthcare professionals.

New clinical applications

Since the turn of the century evidence has begun to emerge about radiographers interpreting and reporting CT and MR images. As radiographer reporting emerges into new clinical applications, responsibility is invariably limited until training standards and minimum experience to demonstrate competence are determined. This is illustrated in the following selected papers.

Computed tomography

Lockwood et al.[28] reported on the use of a standardised test set of cases to assess the performance of 24 radiographers following *CT head* reporting training on an accredited nine-month postgraduate programme delivered by distanced learning. In the academic setting, with an enriched limited case series and tripartite radiologist agreement as the gold standard, they conclude that the radiographers reached high levels of diagnostic performance and accuracy. In a later study Lockwood reported similar methods for demonstrating accurate and a 'high standard' of radiographer reporting of *CT sinus and facial bone* examinations.[29]

Meertens et al.'s[31] 2013 systematic review of eight studies of radiographer reporting of *computed tomography colonography* (CTC) examinations concluded that there was insufficient evidence to support autonomous practice at the time. Their review papers had an average sample size of 10 participants (range 2–49) and performance was assessed over samples of between 10 and 300 cases. The reviewers suggest that following sufficient training autonomous reporting might be developed as performance was observed to improve with number of cases read. Rimes et al.[32] explained how audit tools that measure accuracy can be used to monitor practice.

Most recently Nair et al.[36] demonstrated that training two radiographers experienced in thoracic CT scan image acquisition to detect *lung nodules* could improve sensitivity and reduce reading time despite a small increase in false positive calls. The radiographers in this study (double) read 369 consecutive baseline CT examinations performed in the UK lung cancer screening trial concurrently alongside two experienced and specialist consultant thoracic radiologists.

Magnetic resonance imaging

Using a random sample of 326 MRI cases Brealey et al.[35] demonstrated postgraduate education and training enabled two MR radiographers to report sample cases of specific examinations of the *knee and lumbar spine* with similar levels of agreement to two non-MSK consultant radiologists.

Bolton's recent (2016) conference paper on radiographer reporting of *MR head* examinations in stroke services suggested that following 'training and qualifications' (not further specified) radiographers can produce 'safe and accurate' reports in line with those of consultant radiologists.[34]

Introducing radiographer reporting into clinical practice

Safe adoption of radiographer reporting into routine clinical practice requires demonstration of individual competence. Robinson et al.'s[62] early case review of over 11,000 accident and emergency skeletal radiography cases reported by two trained and experienced radiographers who participated on the 'radiologists' rota' was seminal in demonstrating that, within a defined scope of practice, appropriately trained and supervised radiographers can undertake diagnostic reporting successfully.

All current UK HEI programmes are subject to quality assurance within their host institutions and from external agencies including the Quality Assurance Agency for Higher Education (QAA) and the SCoR. Use of external quality assured HEI delivered programmes of study has helped improve recognition of radiographer advanced practice skills across NHS Trust employers. Quality assurance of radiographer reporting in clinical practice is informed by national occupational standards[47] and best practice recommendations relating to (radiologist) support, viewing equipment and session scheduling[47,63] (Box 2).

Over and above demonstrating similar diagnostic accuracy to radiologists across a range of clinical applications and referral routes, since 2012 an emerging body of evidence illustrates a wider range of positive consequences of introducing radiographer reporting into routine clinical practice. Examples of these are illustrated below and summarised in Box 3.

Improvements to radiology service delivery

Respondents in Milner et al.'s 2016 survey[20] claimed that radiographer reporting can *increase reporting capacity* and *reduce backlogs* where radiographers and radiologists work collaboratively in a multiprofessional reporting team. Similar service

Box 2
Deployment of reporting radiographers

- ➢ Deployment of reporting radiographers in England is informed by national occupational standards and best practice recommendations related to:
  - o medical support;
  - o equipment used;
  - o scheduled sessions - minimum half day/maximum all week;
  - o audit mechanisms & tools - practical, easy to use and reliable for recording, monitoring and evaluating performance accuracy;
  - o cross-cover and attendance at multidisciplinary meetings;
  - o local and national geographical need and support for the role.

improvements were demonstrated by Woznitza et al.[15] with a multiprofessional team of radiographers reporting alongside radiologists. In the context of an overall workload increase of over 13% from 2010 to 2013, their review of imaging examinations at a single hospital demonstrated an increase of 10% (49%–59%) in the proportion of general radiographic images reported by radiographers, a rise largely driven by increases in in-patient chest and abdomen radiography reporting. Although general radiography report turnaround times increased over their study period, *significant reductions in CT and MR patient waiting and report turnaround times* were evident despite 22.8% and 43.7% caseload increases, respectively. This evidence illustrates both the value of radiographer reporting in releasing radiologist capacity for CT and MRI work and also the need to be mindful of monitoring for potential (unintended) consequences of a service change beyond the immediate area of intended impact.

Box 3
Consequences of introducing reporting radiographers into service provision

- ➢ Radiographer opinions (in the absence of a radiologist opinion, e.g. out of hours or remote locations) can improve junior doctor clinical decision making.
- ➢ There is no difference in the clinical impact of the reports of appropriately trained and educated radiographers in comparison to those of radiologists.
- ➢ More research is needed to assess the implications of radiographer/radiologist discrepancies and errors and assess their impact on patient clinical outcomes.
- ➢ Concurrent (double/pre) reading by radiographers can improve radiologist performance, e.g. increase their sensitivity, reduce reading time per case.
- ➢ Radiographer reporting can improve service delivery, service quality and patient outcomes by:
  - o addressing reporting backlogs and/or adding reporting capacity;
  - o reducing patient waiting time & report turnaround times;
  - o reducing immediate treatment errors and avoiding the need for repeat attendance;
  - o reducing time to instigation of treatment (patient pathway redesign).
- ➢ There is evidence that radiographer reporting is cost-effective, generates economic cost savings and increases productivity within budget constraints.
- ➢ When adequately trained and supported, enhanced responsibility and contribution to patient care increases radiographer job satisfaction.

Benefits for patients

Henderson et al.[46] reviewed radiographer-led discharge for minor injuries in a prospective two-year audit of 639 cases that met the inclusion criteria for potential discharge by one of two radiographers. In comparison to the 'usual' emergency nurse practitioner led discharge system, they evidenced *reduced waiting times* and *reduced re-attendance rates* in their new radiographer-led discharge service, alongside improved diagnostic accuracy.

Emerging new practises that incorporate early initial review of images by radiographers demonstrate further benefits for *reducing patient pathway transit times*. Kilburn et al.[33] assessed effectiveness of a radiographer-led service for detection of unsuspected pulmonary emboli on routine contrast-enhanced CT. They established diagnostic accuracy for the 32 participating radiographers and demonstrated an effective *reduction in gap between scan and anticoagulant prescription clinical consultation* for patients from 1.5 days (average) to 26 min. Moore et al.[30] showed how real-time radiographer review of CTC examinations could *expedite same day full-body staging* for patients on a cancer clinical care pathway. Woznitza et al.[25] demonstrated that introduction of immediate radiographer reporting of primary care chest radiograph referrals streamlined their lung cancer pathway by *reducing both time to CT examination and time to MDT discussion*.

Using decision tree modelling, Woznitza's team[23] estimated that radiographer reporting of initial chest radiographs in a lung cancer pathway was *more effective* than radiologist reporting (10.3 more lung cancers detected at initial chest radiography presentation) and could offer patients 1.4 *additional quality-adjusted life years* in the five years after diagnosis.

Improved cost effectiveness

Since 2013, evidence demonstrating the cost, alongside clinical, effectiveness of radiographer reporting has begun to emerge. This emerging evidence suggests that radiographer reporting offers the potential to make a significant contribution to increasing clinical imaging service productivity within a climate of financial constraint.

Hardy et al.'s[45] multicentre study randomising over 1500 emergency department patients to either immediate (radiographer) or delayed reporting demonstrated a significant reduction in interpretive errors along with no adverse impact on patient health status (eight week follow up). In addition radiographer-led immediate reporting was associated with an *average saving of £23.40* per *patient*.

Referencing previous RCR guidelines on consultant radiologist workload,[64] Woznitza et al.[15] estimated that effective multiprofessional team working had generated *cost savings equivalent to three consultant radiologist posts* by reducing demand on radiologist time from 15,595 to 11,834 h in the final year of their study. As above, in their decision tree modelling paper, Woznitza's team[23] estimated that radiographer reporting of initial chest radiographs in a lung cancer pathway was *cheaper than radiologist reporting* (detection costs reduced by £8500 over 1000 cases).

Lockwood[65,66] undertook economic evaluations of both CT and MRI reporting by radiographers and predicted *substantial potential yearly cost savings*. Over an annual workload of more than 7200 CT head scans, Lockwood[65] suggested a £299,359-£124,514 per annum

saving and for 3500 non-complex MRI examinations a £145,230-£60,524 per annum potential saving.

Benefits for imaging professionals

In addition to the service and patient benefits described above, radiographer reporting appears to have a positive effect on the working lives of radiographers[33,44] and the work and working lives of their multidisciplinary healthcare team medical colleagues.[36] Radiographers involved in image interpretation and reporting contribute to clinical decision making in patient care pathways when they offer an opinion and report their findings. In these roles radiographers describe high levels (84%) of job *satisfaction*[33] and feelings of *contentment, pride, motivation, confidence and value* within clinical teams.[33,44]

In the current NHS climate, improved morale associated with the opportunity to upskill into an image interpretation and reporting role could have a positive impact on the recruitment, retention and return to practice ambitions for radiographers, and radiologists, in the Cancer Workforce Plan.[2]

Overcoming barriers to expansion of radiographer reporting

Professional workforce surveys[67] and the empirical research collated for this review illustrate the issues relating to integration and development of radiographer reporting roles into routine clinical practice from a variety of stakeholder perspectives. These are illustrated below with the full range of drivers for, and barriers to, radiographer reporting identified in the literature summarised in Box 4.

Radiology managers and clinical directors are required to maintain service provision despite fluctuations in availability of professional staff groups. Radiographer image interpretation and reporting is often promoted where there are shortages of radiologists, either overall or out of hours, with adequate radiologist supply and availability of teleradiology[21] impeding implementation elsewhere. Clarke et al.'s[68] survey of postgraduate radiography students and managers also highlighted how professional protectionism can impede skill mix change. Radiographer shortages alongside increases in radiologist numbers bolstered radiologist resistance, despite perceptible benefits to implementation of radiographer CT head reporting being acknowledged where introduced. Snaith et al.[18] and Henderson[69] in 2015 and 2017 respectively, conclude that cultural opposition from the radiologist community remains a significant barrier to the development of reporting radiographers.

Radiologists are also concerned about the potential adverse impact on speciality training and consultant de-skilling (competition for cases) associated with the expansion of radiographer reporting. The latter can be mitigated using a multiprofessional shared learning approach - increased demand for imaging and opportunities to increase the number of cases that get a formal radiology department generated report[15] suggest there should be plenty of cases for both radiography and radiology trainees. There is a body of appropriately skilled radiographers who are now supporting radiologists in training.[53]

Multiprofessional team working is an important component of modern clinical imaging service delivery.[15] The overall scope of practice of reporting radiographers (both individually and as a community) is narrower[20,21] than that of radiologists and is currently agreed and defined at organisational and individual level. Radiologist/radiographer reporting skill mix, to make the best use of the respective skills and knowledge of both professions, enables the redesign of care pathways and has demonstrable clinical benefits for patients and logistic and economic benefits for service providers.[23,25,30,33,46]

Box 4
Drivers and barriers for expansion of radiographer reporting

- ➢ Innovation and technological change, such as developments in digital communication methods, are driving increases in number and capability of imaging examinations such that demand now outstrips radiologist capacity.
- ➢ Use of reporting radiographers helps to maintain service provision, overall or out of hours for example, where there is a shortage of medical cover.
- ➢ Redesign (optimisation and streamlining) of (rapid access cancer) patient pathways provides opportunities to reconfigure workforce teams to make the best use of skill mix.
- ➢ Radiographers are optimistic and enthusiastic about the reporting role because they believe it improves their professional profile and increases their contribution to clinical decision making.
- ➢ In the UK radiographers have access to several SCoR accredited Masters level image interpretation training courses.
- ➢ Successful implementation of radiographer reporting requires the support of local radiologists and an effective team working culture.
- ➢ Development of radiographer reporting is restricted if access to structured training opportunities are not available.
- ➢ Progress with implementing radiographer reporting is impeded where there is lack of funding, e.g. for course fees, release from normal (image acquisition) duties (backfill) or where recurrent uplift funding for subsequent advanced practitioner grading and function is not available.
- ➢ Slow progress with training, and thus delayed achievement of competence, occurs if radiographers do not have adequate time allocated for study or do not have access to appropriate technology & resources (reporting grade workstations) in the clinical environment.
- ➢ Development of radiographer reporting may be less likely to occur in departments with a pre-existing radiographic workforce shortage or when adequately staffed with radiologists such that there is no local capacity/demand mismatch.
- ➢ Cultural barriers to expansion of radiographer reporting include professional protectionism, resistance from individual radiologists, failure to reconfigure radiologist job plans to reduce reporting content and lack of effective teamworking.
- ➢ Successful implementation of radiographer reporting may be compromised where practitioners lack confidence or support in their new role or in a new anatomical area of practice.

The accuracy of radiographer reporting is well established and any concern over clinical 'error' can be mitigated with the development of national standards, collaborative teamworking and ensuring reporting audit frameworks and governance are multiprofessional and inclusive of all staff who undertake reporting, regardless of profession. HEE is working with the professional colleges (RCR and SCoR) to develop national multiprofessional

standards for image interpretation and reporting to support service provision and governance structures for multiprofessional clinical imaging team skill mix. Nationally defined and agreed specialist clinical competencies for image interpretation and reporting should further strengthen confidence in radiographer reporting and underpin patient safety.

Lack of adequate funding for training and to enable backfill for image acquisition can also impede expansion of radiographer reporting.[70] Problems with backfilling image acquisition roles can be mitigated by further restructuring the workforce team and upskilling suitably capable and motivated support workers into assistant practitioner roles. The support worker supply pipeline is typically easier to recruit to and with radiographers on the Migratory Advisory Committee shortage occupation list, international recruitment into practitioner posts is also a viable source of supply.

Funding for practitioner upskilling in England has traditionally been locally driven and inconsistent across geographies. Fully funded initiatives, such as the 2017 NHS Cancer Workforce Plan project, provide services with the resources to overcome financial barriers to training and backfill.

Without support and investment in career development for the existing workforce, radiographers may not be motivated to work, or continue to work in this demanding discipline leading to continued or increased attrition from the profession, further reducing service capacity. There is the risk that reporting radiographers might be attracted to work for independent sector report providers and this would be less likely if they were supported during training and appropriately rewarded for their advanced skill and greater responsibility in service provision.

Conclusion

Failure to support and invest in initiatives to increase clinical image interpretation and reporting capacity puts delivery of the recommendations of the Independent Cancer Taskforce in jeopardy. Limited image reporting capacity increases report turnaround times, may increase the number of cases that do not get a formal radiology report and can delay diagnosis and initiation of treatment. Lack of reporting capacity will perpetuate or increase the need for costly subcontracting of NHS reporting to the independent sector.

Comparing training time, employment costs and sessional availability, it is likely that supplying new radiologists to cover general radiography and less-complex image interpretation and reporting would take longer and cost more than upskilling some of the current radiographic workforce. The evidence from this literature review confirms that the UK has pioneered radiographer reporting and that the reporting radiographer role is well established in many NHS clinical imaging departments. The studies reviewed demonstrate how radiographer reporting is helping modern NHS providers maintain high quality clinical imaging service provision and deliver cost-effective increases in diagnostic capacity.

Working within multiprofessional clinical imaging teams within a defined scope of practice and with access to medical input when required, expanding the number and scope of practice of reporting radiographers can make a direct contribution to cancer screening and diagnosis and release radiologist capacity for other complex clinical imaging responsibilities. Transforming imaging service skill mix, to make better use of the respective specialist knowledge and skills of clinical radiologists and diagnostic radiographers, will help improve access to imaging not only for people suspected to have or affected by cancer, but also other patients referred to the service.

Declaration of interest

None

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Appendix A. Supplementary data

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