Increasing radiology capacity within the lung cancer pathway: centralised work-based support for trainee chest X-ray reporting radiographers

Nick Woznitza, PhD, MASMIRT(AP),1,2 Rebecca Steele, DCR(R),3 Keith Piper, PhD, FCR,2 Stephen Burke, MRCP, FRCR,1 Susan Rowe, MRCP, FRCR,1 Angshu Bhowmik, MD, FRCP,4 Sue Maughn, MA, DCR(R),5 & Kate Springett, PhD2

1Radiology Department, Homerton University Hospital, London, UK
2School of Allied Health Professions, Canterbury Christ Church University, Canterbury, UK
3Radiology Department, University College London Hospital, London, UK
4Department of Respiratory Medicine, Homerton University Hospital, London, UK
5City and Hackney Clinical Commissioning Group, London, UK

Abstract

Introduction: Diagnostic capacity and time to diagnosis are frequently identified as a barrier to improving cancer patient outcomes. Maximising the contribution of the medical imaging workforce, including reporting radiographers, is one way to improve service delivery. Methods: An efficient and effective centralised model of workplace training support was designed for a cohort of trainee chest X-ray (CXR) reporting radiographers. A comprehensive schedule of tutorials was planned and aligned with the curriculum of a post-graduate certificate in CXR reporting. Trainees were supported via a hub and spoke model (centralised training model), with the majority of education provided by a core group of experienced CXR reporting radiographers. Trainee and departmental feedback on the model was obtained using an online survey. Results: Fourteen trainees were recruited from eight National Health Service Trusts across London. Significant efficiencies of scale were possible with centralised support (48 h) compared to traditional workplace support (348 h). Trainee and manager feedback overall was positive. Trainees and managers both reported good trainee support, translation of learning to practice and increased confidence. Logistics, including trainee travel and release, were identified as areas for improvement. Conclusion: Centralised workplace training support is an effective and efficient method to create sustainable diagnostic capacity and support improvements in the lung cancer pathway.

Introduction

Medical imaging has a central role in modern healthcare globally, with imaging needs across all populations and health economies.1 It is used by clinicians to guide diagnostic and prognostic decisions across a broad spectrum of patient pathways, especially for patients with suspected cancer. Early, rapid and accurate diagnosis within a cancer pathway is essential so patients have the widest range of treatment options and to minimise patient anxiety when cancer is not the diagnosis.2 Lung cancer causes a significant burden, and is the leading cause of cancer mortality worldwide.3 There are poorer outcomes for patients with lung cancer in England compared with those internationally, and when compared to other common tumour sites.4,5 Some of this variation may be due to the often vague and non-specific symptoms of lung cancer,6,7 and recent guidance advocates lowering the threshold for investigation in general practice if cancer is suspected to improve early diagnosis.8

Diagnostic capacity is frequently identified as a barrier to improved patient outcomes for cancer patients in England, and to meet this need requires significant
increases in imaging activity. The drive for early diagnosis of cancer and the desire within the new care models to manage more patients in the community suggests that the number of imaging investigations performed will only continue to rise. The diagnostic workforce has failed to increase with rising demands. Chronic shortages of consultant radiologists and, to a lesser extent diagnostic radiographers, exist within many imaging departments within the UK. Workforce shortages have contributed to significant numbers of patients, approaching 250,000, waiting more than 30 days for a clinical report in England.

Radiographer clinical reporting has been used for over 25 years by departments in the UK to assist in the provision of an effective, efficient, accurate and patient focused imaging service. A robust evidence base demonstrates that appropriately trained radiographers provide accurate clinical reports for a range of examinations and modalities. It is estimated that 21% of imaging examinations, including X-rays, magnetic resonance and ultrasound are reported by radiographers who have undertaken appropriate advanced practitioner education and training. However, uptake of radiographer reporting within NHS Trusts is variable, with some departments being exemplars of best practice and others with no or little utilisation of reporting radiographers’ skill set outside of ultrasound imaging.

Maximising the contribution of the existing workforce is key to delivering the new models of care required to implement the Five Year Forward View. All reporting radiographers must complete accredited post-graduate education to ensure they are safe, accurate and competent practitioners prior to reporting in clinical practice.

In this model of medical imaging service development and provision, the trainee’s post-graduate education is supported within the workplace with practice reporting and tutorials, traditionally undertaken by radiologists at each individual site. Acute service pressures mean that release of staff to undergo training and education is often challenging. There are, however, clinical departments where radiographers have completed an accredited post-graduate reporting programme and the practice is established and embedded; such departments are able to use the existing resource of reporting radiographers to support future workforce development. The current medical imaging service development and delivery approach was designed for time-efficiency and effectiveness, centralising the work-based learning and support required to support accredited radiographer post-graduate education. Using established and experienced reporting radiographers in a hub and spoke training support model is one approach to increasing diagnostic capacity while minimising impact on scarce radiologist resource for training.

The aim of this project was to develop and evaluate a novel hub and spoke model to support a cohort of trainee chest X-ray (CXR) reporting radiographers to support the lung cancer pathway, encouraging trainees’ integration theory and practice, as relevant to their workplace.

**Methods**

The project is an evaluation of a new service and as such the requirement for ethical approval was waived by the Research and Development department. For the purposes of this project a district general hospital describes an acute medical hospital with a range of specialist treatments, whereas a tertiary hospital describes an acute hospital that acts as a regional centre for patients requiring highly specialised care.

A hub and spoke model to deliver centralised work-based tutorials and support was developed to support trainee CXR reporting radiographers as they complete an accredited post-graduate certificate in adult CXR reporting at Canterbury Christ Church University. Course content and structure of the post-graduate reporting qualification has been described previously. Targeted recruitment of 14 trainee CXR reporting radiographer was sought across London. Departmental demographics from recruiting centres, including annual activity, number of CXRs performed and existing reporting radiographers was collated. Traditionally, supportive workplace learning would occur within a trainee’s host department and be provided by consultant radiologists. Custom is that recommended engagement and frequency of tutorials is an hour per week with the trainee’s nominated consultant radiologist mentor. However, in our hub and spoke model, to maximise efficiency and minimise impact on scarce consultant radiologist resource a schedule of two-hour, fortnightly tutorials was planned, aligned with the curriculum of the post-graduate programme. Additionally, to improve efficiency within the centralised model the majority of tutorials was delivered by experienced CXR reporting radiographers, drawn from centres across the sector. The hub was responsible for the development and co-ordination of the tutorials, development of the content and delivery of the majority of the workplace tutorials and as required by the accredited post-graduate programme. Additional learning was expected of trainees in addition to university attendance and tutorials supported by the hub and spoke model, including practice reporting. This content was outside of the scope of the current project.

A pilot evaluation of key sections of the education process and overall evaluation of the hub and spoke model was undertaken to support the development of the
evaluation tool, a Bristol Online Survey completed by the 14 CXR post-graduate trainees. A realist evaluation approach was used to construct the evaluation, based on the utilisation focused framework of Patton. Experience of the host Trusts was evaluated using the same survey facilitating comparison between trainees’ and managers’ commentary. Unique responses were coded for trainee (S) and managers (M) for analysis (The evaluation was conducted just prior to final assessment (month 10) of the 12 months post-graduate certificate in adult CXR reporting (Appendix S1).

Results

Trainee recruitment

A cohort of 15 trainee radiographers were recruited from eight Trusts across London, 14 funded centrally (NHS England Diagnostic Capacity Fund) and one department funding an additional trainee. Wide variation in the number of existing CXR reporting radiographers from host Trusts was found. The department demographics are presented in Table 1. One trainee withdrew from the programme due to personal reasons. The trainees recruited to the project had a wide range of radiography experience, summarised in Table 2.

Two centres with established teams of experienced CXR reporting radiographers, Homerton University Hospital and University College London Hospital, formed the hub of the model. Project management was undertaken by a consultant radiographer with experience in CXR reporting and post-graduate clinical reporting education, supported with operational issues by an experienced service manager with further support from the Medical Directors and consultant radiologist mentors.

Table 1. Demographics of participating departments.

| Hospital type | Annual imaging activity (April 2016–March 2017) | Annual volume of CXRs (April 2016–March 2017) | Number of current CXR reporting radiographers | Trainee CXR reporting radiographers |
|---------------|-----------------------------------------------|-----------------------------------------------|-----------------------------------------------|-----------------------------------|
| Tertiary 1    | 291,458                                       | 56,722                                        | 5                                             | 2                                 |
| DGH 1         | 166,108                                       | 29,415                                        | 3                                             | 2                                 |
| Tertiary 2    | 649,615                                       | 108,593                                       | 5                                             | 2                                 |
| Tertiary 3    | 524,100                                       | 114,025                                       | 1                                             | 1                                 |
| DGH 2         | 184,424                                       | 34,718                                        | 1                                             | 1                                 |
| DGH 3         | 236,855                                       | 57,543                                        | 1                                             | 2                                 |
| Tertiary 4    | 638,983                                       | 60,469                                        | 1                                             | 2                                 |
| DGH 4         | 196,846                                       | 49,682                                        | 2                                             | 2                                 |

CXR, chest X-ray; DGH, district general hospital.

Table 2. Trainee radiographer demographics.

| Number of trainees | Radiography experience | Previous Post-graduate Education | Previous reporting qualification |
|--------------------|------------------------|----------------------------------|--------------------------------|
|                    | 2–5 years              | Post-graduate Certificate        | Skeletal reporting |
|                    | 6–10 years             | Post-graduate Diploma            | Other |
|                    | >10 years              | Master of Science                |                                  |
|                    |                        |                                  |                                  |
| 3                  |                        | 1                                | 5                               |
| 8                  |                        | 4                                |                                  |
| 3                  |                        | 1                                |                                  |
| 5                  |                        |                                  |                                  |
| 0                  |                        |                                  |                                  |

Design of the centralised model

The content and timetable for the work-based tutorials is presented in Table 3. The tutorials format was informed by a transmission model and was a blend of practical image viewing sessions, case-based discussions and a small amount of didactic teaching. Tutorial content addressed the fundamental skills of adult CXR interpretation and key pathological areas as relevant to lung cancer. The content and timing of the tutorials was aligned to the post-graduate certificate curriculum (Table 3), timed for maximum benefit coinciding theory learning together with all possible practice experiences and application to their workplace service delivery.

Key topics, such as search strategy and formulation of a differential diagnosis were delivered in the initial period. Common adult pathologies were grouped together, including infection, lobar collapse, malignancy, interstitial lung disease and CXRs performed in an emergency and intensive/critical care setting. Challenging cases and common errors made in clinical practice were included across the programme as a repeating theme with aim of enhancing competencies, through use of cases drawn from local radiology discrepancy meetings and frequent false positive diagnoses from local audits of CXR reporting. Mock examinations and vivas were prepared for the end of the post-graduate certificate programme, modelled on the rapid reporting examination of the Fellow of Royal College of Radiologist (FRCR) part 2B examinations to consolidate learning and as a preparation for the trainees’ final objective structured examination. Emphasis in the tutorial teaching was made not only on the radiographic appearances, but also the role of the CXR and reporting radiographers within the patient pathway and construction of a diagnostic and actionable report.
Impact of the centralised model on service delivery

Delivering the work-based learning in a centralised way across the sector resulted in two hours of 'expert' time lost to clinical practice per fortnight for the cohort, rather than eight hours (14 trainees over eight sites) per week using the traditional model. Over the 12 months duration of the post-graduate certificate this produced a net saving of 300 h (traditional tutorials total of 348 h; centralised model total of 48 h).

To increase efficiency of the centralised model further, the tutorials were led by experienced reporting radiographers (Table 3; \(n = 17\) sessions, 34 h). These radiographer-led sessions were supplemented with targeted teaching delivered by an eminent thoracic radiologist (\(n = 1\) session; 2 h, tertiary hospital based) and a respiratory physician (\(n = 1\); 2 h, DGH based) as well as a senior radiologist registrar (\(n = 2\) sessions; 4 h, DGH based) to ensure a rounded educational experience. As a consequence, only six hours of radiologist time was used to support a cohort of 14 trainee radiographers.

Evaluation of trainee and manager perceptions of the centralised model

Four service managers (from 8 departments, 50%) responded to the survey thus information should be viewed as providing a trend only, nevertheless a number of responses indicate clear common views held by managers. Thirteen trainees (of 14, 93%) took part in the survey and their line managers also responded. Survey questions were the same for both groups allowing view from two lenses: line managers and trainees.

Managers

All managers indicated that:

- Tutorial content prepared them or their trainees for the final assessment
- Provided opportunity to gain experience from a variety of practitioners
- Department capacity will improve consequent to the X-ray reporting training
- Knowledge and skill levels within the department had improved following training
- Centralised model of training was efficacious

Managers appeared to find the centralised model approach helpful for their trainees; 'Regular sessions allow trainees to remain engaged with the course and protected time to attend is vital to ensuring success' (M25851802).

However, some further attention to timetabling would be useful 'Releasing staff in a busy department for tutorials is always going to be a challenge. This would have been easier to facilitate if the tutorials had been scheduled at either end of the day rather than in the middle' (M25850879).

Generally (75%, \(n = 3\)) it was felt confidence in reporting, and training opportunities had increased as a result of having a cohort of peers in the centralised training model. Three managers (75%) agreed that the centralised model of training compared appropriately with other training models, whereas one disagreed and also felt the relevance to the wider context and tutor knowledge was...
not applicable. Two (50%) respondents felt that the centralised model allowed better application of knowledge compared with other models, one felt no change and one respondent stated they did not know. One supporting comment indicated the potential beneficial impact for service '2 additional chest reporting radiographers will ensure that GP and IP chests as well as A and E images are reported within a few days' (M25850879).

Breadth and depth of content covered, and support through the centralised model was considered sufficient compared with other training models by half the respondents (n = 2), whereas others felt not able to comment.

Most managers (n = 3, 75%) considered the centralised training model to be more efficient compared with other approaches, and 'The 2 students seem satisfied at the training provided by the centralised model' (M25850879), but there were caveats. These relate to tutorial delivery in the centralised model compared with other approaches:

- Tutorial timing during the day (1 respondent felt appropriate, 1 less appropriate, others did not know) ‘difficulties have arisen with tutorials in the middle of the day as 2 clinical staff are lost for the majority of the day for a 2 h meeting due to lengthy travel times’ (M25850879)
- Time spent during tutorials (1 respondent recorded appropriate, 1 less appropriate, others did not know)
- Intervals between tutorials (1 appropriate, 1 same, others did not know)
- Location (1 appropriate, 1 less appropriate, others did not know)

**Trainees**

All trainees (n = 13) agreed the centralised model was:

- Appropriate for training compared with other models they had experienced
- Provided opportunity to gain knowledge from a range of practitioners
- Content was sufficiently covered (search strategy and pathologies)

In the five free text comments relevant to this section of the survey, all trainees found the centralised model’s learning environment beneficial compared with other methods.

‘Content has been excellent – provided from a wide range of tutorials on a wide range of topics in intimate learning environments. A much better method of teaching to what I have experienced in the past from courses which don’t offer such a method.’ (S25171724)

A majority of trainees (n = 10, 76%) reported the centralised model compared favourably with other approaches, whereas the two others scored ‘neither agree nor disagree’ and one ‘did not know’. While students (n = 12, 92%) reported learning via this model helped them understand reporting in the wider context and found tutors’ knowledge sufficient, one of seven free-text comments (below) noted some quality variability. Eleven (84%) trainees agreed it was suitable preparation for the final assessment (the remaining two indicated neither agree nor disagree/do not know).

'I would say that some tutorials were very good (e.g. the one that involved the [profession redacted] at [location redacted]). Others were not so good and lacked content'.

‘A wide range of pathologies and normal variants were reviewed during the tutorials. Discussing the physiology helped our understanding of the diseases. Comparing appearances of different pathologies in PA/AP/SUPINE views has prepared us for reporting’.

A majority of trainees (n = 10, 76%) felt increased capacity had been achieved and they had seen increased knowledge and skills within their department subsequent to experiencing the centralised training model.

‘Having two trainees do the course is improving our capacity and general knowledge in the department’.

‘It has developed a much wider understanding of reporting chest X-rays, and also understanding outside the topic as to different clinical details to look for which can cause chest pathologies, etc. this has increased the confidence for reporting as it gives you a greater understanding of the topic’.

Eight of the trainees (61%) felt training and practice opportunities had increased in their department and a free text comment illustrates their perception of the nature of impact for service delivery. ‘The more people who are confident and competent in reporting there are, the greater the quality of service provided across the board.’ (S25171724) Trainees with previous experience of image interpretation included five with previous post-graduate reporting qualifications and those with non-accredited image interpretation education. Despite all trainees finding the centralised model of learning
beneficial compared with other approaches, confidence in CXR reporting shows some variation within the group with around half (53%, \( n = 7 \)) feeling increased confidence and 5 feeling the same level of confidence. Regarding translating learning into practice (application of theory to practice), slightly more trainees (\( n = 8, 61\% \)) found the centralised model helpful, whereas four (31%) respondents found it to be the same as other approaches. Nevertheless 92% (\( n = 12 \)) reported the tutorial pace and tutorial support helped consolidate their learning.

Trainees had varying views about the location and timing of tutorials, but were generally (77%, \( n = 10 \)) positive about tutorial duration. While around half found the location appropriate, three (23%) students were less enthusiastic.

Some of the tutorial locations haven’t been great. One place doesn’t have a projector and we are working off just a small computer screen which makes it difficult to see. (S25181513)

Very flexible and appropriate. I was very happy going to other sites which gave us broad knowledge. Quite unique experience. Well done to course organisers tpb (5172979)

Discussion

The centralised model to support trainee CXR reporting radiographers has been demonstrated to be effective, efficient and generally well rated by trainees and department managers. The fact an additional trainee was funded by a department is evidence of the benefit of the centralised model being perceived by that service. Blended learning, a combination of academic and work-based education, is the established method of reporting radiographer education.34 Leishman highlighted a lack of reporting radiographer online teaching resources relative to other health professions as a possible barrier to training.35 Lack of departmental support has also been found to hamper radiographer reporting education,34 which is particularly relevant given the relative paucity of radiographer CXR reporting in clinical practice when compared to skeletal reporting.25,36 The centralised support model developed addresses these barriers. Online education is often presented as a method of increasing training capacity. The current model provides additional capacity across a sector and ability to upscale the current model is another asset, and should be the preferred alternative to online education as the centralised model maintains engagement with tutors and a peer support network, previously identified as key requirements for reporting education.

Sustainable diagnostic capacity

Diagnostic capacity is frequently highlighted as a barrier to improved patient care and outcomes,2,9 with significant reporting backlogs in England12 identified despite increased spend on outsourced radiology (£47–£53 m) between 2014 and 2015.10 Ongoing use of outsourced reporting is not cost effective or sustainable, as outsourcing does not improve diagnostic capacity, and reporting backlogs will return as drivers have not been addressed. Use of outsourced reporting also has the potential for a decrease in the clinical relevance of reports due to lack of access to previous imaging and knowledge of local pathways. Increasing the number of reporting radiographers will ensure a sustainable workforce, as this facilitates succession planning and reduces risk to service delivery due to staff attrition.

Trainee and manager satisfaction with the centralised model

Centralised tutorials for trainee CXR reporting radiographers was found to be effective in supporting practitioner development from both trainees’ and managers’ perspectives. Trainees with previous reporting experience generally rated the centralised model as effective when compared to their previous experience. Centralised tutorials did produce some logistical challenges, with one clinical trainee site further from the two hubs in the current model. Learning from this initial model would be to concentrate the ‘spoke’ sites within a more closely defined sector or, in addition possibly embrace the use of ‘virtual’ tutorials using tele-medicine facilities. Centralised tutorial support requires fixed and timetabled sessions to enable trainee attendance. The relative inflexibility of this approach was identified by some managers as a negative, although several of the trainees indicated that this was a positive as this gave protected study time and allowed planning of learning. The spectrum of cases and pathologies, as well as access to a range of tutors, were all positive aspects of the centralised model.

Maximising efficiency and support across a sector

Local delivery of the centralised model provides support across an entire sector in an efficient and effective way.

Utilisation of centres with an existing critical mass of experienced reporting radiographers as the ‘hub’ allows training to be provided to support those departments currently without any existing service, including those departments who are challenged with a significant
backlog for reporting. The model could easily be adapted to other regional centres and in fact is already readily transferrable. As demonstrated in this evaluation, this centralised reporting radiographer work-based training model is successful. It can be applied to other regional ‘hubs’ where a critical mass of reporting radiographers exists. To ensure that service delivery at the hub departments is not impacted, appropriate resourcing is required to compensate for lost clinical time used to support other hospitals and for project management of the model. The current model required 0.1 FTE consultant radiographer to manage and co-ordinate the programme and 0.1 FTE reporting radiographer resource to prepare and deliver the tutorials.

Opportunities for patient pathway redesign

By increasing numbers of appropriately trained reporting radiographers to provide reporting for lung cancer, complementing an existing diagnostic imaging service, and additionally releasing radiologists’ capacity for wider service provision within the pathway (such as lung biopsy) the time taken for the entire diagnostic pathway is reduced. Training a sufficient cohort of reporting radiographers across a sector creates a core group to provide an ongoing, stable and sustainable service. The additional diagnostic capacity created when these reporting radiographers enter practice may have a positive impact on patient experience and lung cancer diagnostic capacity, for example implementation of immediate reporting of CXRs referred from general practice by radiographers in line with optimal time target of 28 days from referral from general practice.

The centralised model developed to support radiographer CXR reporting education has the potential to create additional capacity not only support the existing cancer waiting time targets, including 62 days from referral to treatment, but also the new cancer waiting time target of 28 days from referral from general practice to the patient receiving their diagnosis or have cancer ruled out.

Development of the hub and spoke model, with the additional diagnostic capacity that the trainees will bring to departments upon completion, has been used as an opportunity to revisit current pathways. At University College London Hospital a radiographer reporting hot desk has been established with the additional radiographer reporting capacity provided by the newly qualified practitioners. The ‘hot desk’ reporting radiographer acts as a central expert contact point for radiographers who acquire an image and are concerned about a significant abnormality. The reporting radiographer will provide an immediate opinion and report to radiographers, hospital clinicians and general practitioners, and guide patient management such as rapid referral to emergency medicine, respiratory medicine in addition to providing an immediate clinical report. Increasing the number of reporting radiographers who can report CXR is a pathway enabler.

Conclusions

The centralised model to support trainee CXR reporting radiographers is an innovative, novel and efficient way to create additional diagnostic capacity and support pathway redesign within lung cancer. This model of working is directly transferrable to across the NHS, other healthcare providers including the independent sector, to other patient pathways and international health settings acknowledging there will need to be adjustment to fit with local needs.

Conflict of Interest

The authors declare no conflict of interest.

Acknowledgements

The authors wish to acknowledge the support of the radiology departments across London, the trainees for their hard work and dedication and the University College London Hospital Cancer Vanguard. We also thank Ms Allie Tutt for assistance with the trainee and manager satisfaction survey.

References

1. World Health Organization. Diagnostic Imaging. Switzerland: World Health Organization; 2017 [cited 2017 27 June 2017]. Available from: http://www.who.int/diagnostic_imaging/en/.
2. Independent Cancer Taskforce. Achieving world-class cancer outcomes: A strategy for England 2015-2020. 2015 London
3. International Agency for Research on Cancer. GLOBOCAN 2012: Estimated cancer incidence, mortality and prevalence worldwide in 2012. Geneva: World Health Organisation; 2012.
4. Elliss-Brookes L, McPhail S, Ives A, et al. Routes to diagnosis for cancer – determining the patient journey using multiple routine data sets. Br J Cancer 2012; 107: 1220–6.
5. Cancer Research UK. CancerStats key facts – lung cancer. 2011.
6. Iyen-Omofoman B, Tata LJ, Baldwin DR, et al. Using socio-demographic and early clinical features in general practice to identify people with lung cancer earlier. Thorax 2013; 68: 451–9.
1. O’Dowd EL, McKeever TM, Baldwin DR, et al. What characteristics of primary care and patients are associated with early death in patients with lung cancer in the UK? Thorax 2015; 70: 161–8.

2. National Institute for Health and Care Excellence. Suspected cancer: recognition and referral (NG12). National Institute for Health and Care Excellence; 2015.

3. 2020 Delivery. Horizon Scanning: An evaluation of imaging capacity across the NHS in England. Cancer Research UK; 2015.

4. Royal College of Radiologists. Our Patients Are Still Waiting . . . . Royal College of Radiologists, London, 2016.

5. Beardmore C, Woznitza N, Goodman S. The Radiography of Radiographers UK Workforce Report 2014. College of Radiographers, London, 2014.

6. Royal College of Radiologists. Our Patients Are Still Waiting . . . . Royal College of Radiologists, London, 2016.

7. O’Dowd EL, McKeever TM, Baldwin DR, et al. What characteristics of primary care and patients are associated with early death in patients with lung cancer in the UK? Thorax 2015; 70: 161–8.

8. National Institute for Health and Care Excellence. Suspected cancer: recognition and referral (NG12). National Institute for Health and Care Excellence; 2015.

9. 2020 Delivery. Horizon Scanning: An evaluation of imaging capacity across the NHS in England. Cancer Research UK; 2015.

10. Royal College of Radiologists. Clinical radiology UK workforce census 2015 report. London: Royal College of Radiologists; 2016.

11. College of Radiographers. Diagnostic Radiography UK Workforce Report 2014. College of Radiographers, London, 2014.

12. Royal College of Radiologists. Our Patients Are Still Waiting . . . . Royal College of Radiologists, London, 2016.

13. Beardmore C, Woznitza N, Goodman S. The Radiography Workforce Current Challenges and Changing Needs. College of Radiographers, London, 2016.

14. Woznitza N, Piper K, Rowe S, et al. Optimizing patient care in radiology through team-working: A case study from the United Kingdom. Radiography 2014; 20: 258–63.

15. Snaith B, Hardy M, Lewis EF. Radiographer reporting in the UK: A longitudinal analysis. Radiography 2015; 21: 119–23.

16. Snaith B, Milner RC, Harris MA. Beyond image interpretation: Capturing the impact of radiographer advanced practice through activity diaries. Radiography 2016; 22: e233–8.

17. Brealey S, Piper K, King D, et al. Observer agreement in the reporting of knee and lumbar spine magnetic resonance (MR) imaging examinations: Selectively trained MR radiographers and consultant radiologists compared with an index radiologist. Eur J Radiol 2013; 82: e597–605.

18. Piper K, Buscall KL, Thomas N. MRI reporting by radiographers: Findings of an accredited postgraduate programme. Radiography 2010; 16: 136–42.

19. Piper K, Cox S, Paterson A, et al. Chest reporting by radiographers: Findings of an accredited postgraduate programme. Radiography 2014; 20: 94–9.

20. Woznitza N, Piper K, Burke S, et al. Adult chest radiograph reporting by radiographers: Preliminary data from an in-house audit programme. Radiography 2014; 20: 223–9.

21. Brealey S, Scally A, Hahn S, et al. Accuracy of radiographer plain radiograph reporting in clinical practice: A meta-analysis. Clin Radiol 2005; 60: 232–41.

22. Woznitza N, Piper K, Burke S, et al. Agreement between expert thoracic radiologists and the chest radiograph reports provided by consultant radiologists and reporting radiographers in clinical practice: Review of a single clinical site. Radiography 2018; 3: 234–9.

23. Woznitza N, Piper K, Burke S, et al. Chest X-ray interpretation by radiographers is not inferior to radiologists: A multi-reader, multi-case comparison using JAFROC (jack-knife alternative free response receiver-operator characteristics) analysis. Acad Radiol 2018; In Press. https://doi.org/10.1016/j.acra.2018.03.026

24. NHS Benchmarking Network. Radiology Benchmarking 2016 National report. NHS Benchmarking Network, London, 2016.

25. Milner RC, Culpan G, Snaith B. Radiographer reporting in the UK: Is the current scope of practice limiting plain-film reporting capacity? Br J Radiol 2016; 89: 20160228.

26. England NHS. Five Year Forward View. NHS England, London, 2014.

27. College of Radiographers. Preliminary Clinical Evaluation and Clinical Reporting by Radiographers: Policy and Practice Guidance. College of Radiographers, London, 2013.

28. Royal College of Radiologists, Society and College of Radiographers. Team working in clinical imaging. London: Royal College of Radiologists and the Society and College of Radiographers, 2012.

29. British Institute of Radiology, Society & College of Radiographers, Royal College of Radiologists. A guide to understanding the implications of the Ionising Radiation (Medical Exposure) Regulations in diagnostic and interventional radiology. London: Royal College of Radiologists, 2015.

30. Patton Q. M. Utilization Focused Evaluation: The New Century Text, 3rd edn. Sage Publications, London, 1997.

31. Straits W, Wilke R. How constructivist are we? Representations of transmission and participatory models of instruction in the journal of college science teaching. J Coll Sci Teach 2007; 36: 58–61.

32. Piper K, Paterson A, Godfrey R. Accuracy of radiographers’ reports in the interpretation of radiographic examinations of the skeletal system: A review of 6796 cases. Radiography 2005; 11: 27–34.

33. Royal College of Radiologists. Standards For Interpretation and Reporting of Imaging Investigations. Royal College of Radiologists, London, 2018.

34. Hardy M, Snaith B. Radiographer interpretation of trauma radiographs: Issues for radiography education providers. Radiography 2009; 15: 101–5.

35. Leishman L. Can skeletal image reporting be taught online: Perspectives of experienced reporting radiographers? Radiography 2013; 19: 104–12.

36. Price RC, Le Masurier SB. Longitudinal changes in extended roles in radiography: A new perspective. Radiography 2007; 13: 18–29.
37. ACE Lung Cancer Pathway Cluster. Improving diagnostic pathways for patients with suspected lung cancer: Final Report. London: Macmillan, Cancer Research UK & NHS England, 2017.
38. Woznitza N, Piper K, Rowe S, et al. Immediate reporting of chest X-rays referred from general practice by reporting radiographers: A single centre feasibility study. *Clin Radiol* 2018; 73: 507.e501–8.
39. Department of Health. The Handbook to the NHS Constitution for England. Department of Health, London, 2012.

**Supporting Information**

Additional supporting information may be found online in the Supporting Information section at the end of the article:

**Appendix S1.** Evaluation questions – novel radiographer chest X-ray training.