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Introduction

The National Health Service (NHS) England released the Five Year Forward View¹ in 2014 to consider possible future changes that could be implemented to improve patient outcomes and satisfaction, and decrease service delays, with an emphasis on investment for local service changes. The English Cancer Strategy 2015-202 followed in 2015 and embraced the Five Year Forward View¹ three main aims of better prevention, swifter diagnosis and better treatment. The Royal College of Radiologists³ (RCR) endorsed the strategy but insisted the plan to improve access to scans and reports quickly requires a change in diagnostic capacity and increase in radiology staffing.

The Kings Fund Better Value in the NHS 2015⁴ report called on NHS staff to engage in delivering better outcomes by improving value rather than reducing the costs, in the wake of the Five Year Forward View¹ that proposed £22 billion of efficiency savings. The report findings emphasised the need to create an environment for change and the many opportunities to improve outcomes by highlighting major service areas where development and innovation in restructuring diagnostic pathways to deliver cost-effective service improvements, increase the speed of delivery, reduce length of stay in hospital and fast track treatment and management for preventable illness.

Two specific driving factors for change in radiology have been a flexible response to workforce shortages^{5,6,7,8,9,10}, and demand for imaging that outstrips capacity^{11,12,13}. The NHS Imaging and Radiodiagnostic activity 2013/14 report¹¹ assessed the number of Magnetic Resonance Imaging (MRI) examinations from April 2013 to March 2014 to be 2.7 million, with a 12.3% increase in examinations from the previous year¹¹, 71.7% over five years¹⁴, and 220% growth over a 10 year period¹¹ which is a substantial increase in the pattern and trend of imaging demand. Both the RCR¹³ and the Society and College of Radiographers¹³ (SCoR) observe that a future demand in imaging is expected to intensify. The Centre for Workforce Intelligence (CfWI)¹² predict the demand for imaging to escalate driven by multiple factors including growing/aging populations, rise in cancer diagnosis and chronic illness, screening programmes, introduction of 24/7 working hours, and future imaging techniques introduced into clinical practice. The CfWI and the RCR have estimated the total imaging workload could potentially rise from 39 million tests in 2011 to 51 million by 2025, (an increase of all imaging by 76%, with MRI imaging alone raising 87%)¹².

The RCR¹⁵ recommend a formal report for diagnostic examinations within 2 days, but acknowledge through workforce shortages that this is not occurring¹⁴, causing delays in cancer and serious illness diagnosis, hospital stay and the subsequent increased listing of radiology departments to NHS risk registers¹⁵. In October 2014 an RCR survey¹⁶ highlighted a month delay in results (1,697 examinations) in the 25% of NHS trusts surveyed. The survey was repeated in February 2015¹⁵ with 71% of surveyed trusts having delays of more than a month, with over 3,277 unreported MRI scans (estimated for all trusts in England to be up to 4,268¹⁵).

Methodology

In order to define the perspective of the review, and the key drivers of cost effectiveness (capacity and demand, benefits and risks) a PICO framework¹⁷ was adopted. Consisting P=the patient sample group defined by the MRI imaging pathway. I=Intervention of radiographers reporting MRI examinations; C=comparison to existing intervention of radiologists reporting MRI examinations; O=outcome comparison of current and alternative service provision through costs, savings, and risk.

This review received university research ethical and governance approval to calculate a deterministic scenario based evaluation of costs of the current and new intervention. The study used data from a retrospective audit of MRI examination attendance at an acute NHS district general hospital (DGH).

A defined time horizon of 12 months (August 2014 to July 2015; Table 1 and 2) was used to identify the key resource demand for MRI examinations (n=12,958).

Using decision tree modelling to illustrate the process mapping of the current intervention, (Table 3) allowed evaluation of costs and outcomes from each intervention for internal validity. Employing the audit data allowed external validation of the model as an example of expected workflow demand in a generic DGH. A decision tree was chosen over conventional Markov models as data for chronic returning patients was not available to consider all feasible transitions of patient's health states or cohorts of particular disease categorised patients.

Patient group

The sample size from the data collection identified n=3,525 non-complex MRI scans (Table 2), the inclusion criteria included knee, lumbar, internal auditory meatus (IAMs), scaphoid and breast. The non-complex examination criteria limitations were due to the restricted literature evidence available on reported diagnostic thresholds of reporting radiographers and radiologists in MRI reporting.

The current Intervention

The NHS currently employs radiologists to report MRI examinations, but drivers for change include the low workforce numbers of UK registered radiologists¹⁴. The fifth RCR workforce report 2012¹⁴, recorded the number of United Kingdom (UK) registered radiologists as 2,997 (4.7 radiologists per 100,000 population); with a current deficit of 421 vacant posts³. To reach comparable radiologist levels with the rest of the European Union countries, the RCR estimated it would require an 82% increase of radiologists¹².

The CfWI report on Clinical Radiology¹² commissioned by the Department of Health (DoH) with multiple stakeholders including the RCR and SCoR, reviewed the RCR 2012¹³ report for the Medical Programme Board and the Joint Working Group on Speciality Training Numbers. Recommendations included a proposed but not implemented increase of 60 trainees radiology registrars per year, with the use of radiographers to effectively support the future expansion of radiology.

Unit costs and discounting

To ascertain an average hourly price for radiologists, Netten et al's Ready Reckoner for staff costs in the NHS¹⁸ and the Personal Social Services Research Unit (PSSRU) Unit Costs of Health and Social Care 2014¹⁹ were adopted for the basis of the calculations. The salary was based on a full time equivalent (FTE) mean of NHS medical consultant wages¹⁹. An additional 33.5% was added for overtime, shift work and geographic allowances¹⁹, National Insurance (NI) contributions²⁰, and employer's contribution to superannuation²¹. The costs for education and training used PSSRU¹⁹ standard estimation approaches for the components of training, tuition fees, clinical placement costs, infrastructure (books, journals, computers), and lost production costs of staff training days.

The costs incorporated the discounting system used by PSSRU¹⁹ and HM Treasury²² to transfer all costs and benefits to 'present values' to compare, using a 3.5% discount rate. This allowed a net present value of the intervention to be calculated, which is the primary indicator used by the UK government to justify action. Furthermore this is the approved system in use by the National Institute for Health and Care Excellence²³ (NICE) for all DoH²⁴ assessment and appraisals of health technologies, techniques, and screening programmes. The hourly unit cost of a radiologist (2014-15) was calculated at £156 (Table 4).

The new Intervention

The RCR with the SCoR have jointly published guidance²⁵ to endorse the collaborative skills mix of radiographers and radiologists working in complimentary reporting roles (not substitution or replacement of roles) to sustain service delivery. The SCoR scope of practice^{26,27} legally entitles UK radiographers with accredited training and competence to report MRI examinations. The CfWI²⁸ have predicted an increase of 17% (to 19,830) of radiographers from 2012 to 2016, currently the Health and Care Professions Council (HCPC)²⁹ have 29,711 radiographers registered (3,100 are therapeutic radiographers³⁰) which is above the projected increase of workforce by the CfWI²⁸. Additionally Health Education England (HEE)³¹ have increased educational commissioning of places for 2014/15.

The 2014 UK radiographer unfilled vacancy rate was 5.1% at Band 7 reporting level³⁰; the SCoR³⁰ estimate 3,662 radiographers were in advance practice and 86 in consultant roles, with a further 1,288 in postgraduate training³⁰. The master's degree pathway in clinical reporting in our university currently offers a wide range of options of MRI reporting modules including head and neck, IAM, spine, breast, gastro-intestinal, knee, foot and ankle, with strong recruitment of students.

Unit costs and discounting

To estimate an hourly rate for a reporting radiographer, Netten et al's Ready Reckoner for staff costs in the NHS¹⁸ and PSSRU Unit Costs of Health and Social Care 2014¹⁹ were applied. The salary was based on a FTE mean of Band 7 (point 30) on the Agenda for Change³² wages for allied health professionals. A further 7.2% was added to reflect payments for additional requirements such as overtime, shift work and geographic allowances¹⁹, with NI contributions²⁰, and employer's contribution to superannuation²¹. The costs for education and training used PSSRU¹⁹ standard estimation approaches to calculate the components of pre-registration and post-graduate training, tuition fees, clinical placement costs, infrastructure, and lost production costs of staff training days. A 3.5% discounting rate was applied and the hourly unit cost of a reporting radiographer (2014-15) was determined as £53 (Table 5).

Comparison of costs per Intervention

By applying the unit cost per hour of both interventions, estimations of cost per examination for both interventions can be established. The RCR activity reporting guidelines³³ calculate time per test for reporting, which is the measure for appointing workload standards in radiology (applying a maximum of 50% of time spent reporting examinations). The RCR recognise that in attempting to identify one method to model the costings for reporting is difficult and each system had limitations, the RCR elected to calculate work output using the Gishen's Ready Reckoner³³. The RCR indicative modality-based method estimates against 1 hour of uninterrupted time a range of 3-6 (non-complex) MRI reports were possible³³, with three variable time calculations of slow, medium and fast (20, 13.33 and 10 minutes per exam per report respectively¹²). The CfWI and DoH¹² use weighted factors of 24, 16, 12 minutes per exam per report. The CfWI¹² calculated each FTE radiologist was allocated 10.3 programmed activities (PAs); 2 PAs for non-reporting administration of paperwork, teaching, and other duties, with 8 weeks deducted for annual leave / study. Likewise the RCR¹⁴ calculations use 10.3 PAs (8 PAs over 44 weeks).

A limitation of this review found the SCoR have no published costings of reporting radiographers' unit costs per non-complex MRI examinations to compare against, so the RCR^{12,33} and CfWI and DoH¹² systems have been adopted for comparisons. A literature search using resource databases of CINAHL, Cochrane Library, Medline, PubMed, Science Direct, and Google scholar; found no studies on the time taken for radiographers to report MRI scans. The study for arguments sake reverted to

the evidence of previous published studies from academic environments^{34,35,36} that applied timed reporting of MRI examinations (same caseloads) of radiographers and radiologists which produced near equivalent accuracy, agreement, sensitivity and specificity results.

Comparison of diagnostic thresholds per Intervention

The risk of discordance in reporting is an additional important measure to include in the evaluation of assessing interventions. This will influence if there is potentially an impact on patient outcomes (mortality, morbidity, functional status and quality of life) from the change of service delivery. The DGH audit data did not provide statistics from error/discrepancy meetings to assess the potential for detrimental risk to patient outcomes through reporting. The study completed a literature review using six electronic databases (Cochrane, Medline, Europe Pubmed Central, CINAHL, ScienceDirect and Google Scholar) on the diagnostic accuracy of radiologists and reporting radiographers interpreting MRI examinations to estimate the potential for errors in reporting that theoretically could affect the health of patients. The search results were limited due to the variation and quality of the literature methodologies and results, with details on sample size, and pathology range inconsistent. Additionally reference standards varied, with certain studies only providing agreement levels, mostly without confidence intervals, sensitivity or specificity.

Observer variation studies from a number of published sources comparing against set reference standards for MRI knee studies have identified radiologist agreement levels ranging from 48.1% to 96%^{34,37,38,39,40,41,42,43} from the published literature sources on radiologist diagnostic performance. Radiologist sensitivity levels ranged from 73.5% to 88%^{39,40,43,44}, with specificity between 90.8% to 97%^{37,40,43,44}. The introduction of reporting radiographers to interpreting MRI knee examinations has been reviewed previously by the university in an academic setting³⁶ which recorded a mean sensitivity 99.4% (95% CI 97.4,99.8)³⁶ and mean specificity 95.9% (95% CI 93.1,97.7)³⁶ for radiographers training in MRI reporting.

Radiologist lumbar spine MRI agreement ranged from 60.8% to 94.4%^{34,37,45,46,47}. Sensitivity and specificity were unrecorded. Reporting radiographer agreement ranged from 58.6 to 87.2%^{35,37}, sensitivity and specificity levels were 99%³⁵.

Scaphoid reporting by radiologists mean sensitivity rate ranged from 83.3% to 100%^{48,49,50}, specificity 90% to 100%^{48,49,50} and agreement of 86.65% to 100%^{48,49,50}. Radiographers demonstrated a mean sensitivity rate of 100% (95% CI 82.3,95.1)⁵¹, and specificity 96.3% (96% CI 90.1,100)⁵¹ and agreement of 92.2% (95% CI 89.3,95)⁵¹ for the reporting radiographers.

MRI lumbar examinations agreement for radiologists have documented agreement ranges from 60.8% to 94.4%^{34,37,45,47}, but no Sensitivity or specificity levels were identified from the literature. Reporting radiographers Lumbar spine agreement ranged from 58.6% to 87.2%^{35,37}, with sensitivity and specificity levels of 99%³⁵.

IAM diagnostic threshold studies have identified radiologist agreement levels of between 56% to 100%^{34,52}, with no found levels of separate sensitivity or specificity. Reporting radiographers agreement levels for IAMs were 98.4%³⁵, sensitivity 99%³⁵, and specificity 99%³⁵ respectively.

MRI Breast observer agreement levels by radiologists were 85%⁵³, with sensitivity and specificity at 88.6%⁵³ and 69.2%⁵³ retrospectively. Evaluated in comparison to Radiographers MRI breast agreement levels of 88.6%³⁶ and sensitivity and specificity at 95.2%³⁶ and 94%³⁶ the results were comparable. The findings indicated that radiographer's MRI results are approaching and similar to

the range of results identified for radiologists from the literature review (Table 6), taking into account the possible variations present in the study designs.

Outcome results of interventions to national tariffs and reference standards

The key findings estimated monetary value of the radiologist's hourly rate assessed against reporting radiographer's hourly rate using RCR33 unit costs per non-complex MRI report demonstrated a variance of £34.34-17.17 per patient/report. Applying the CfWI and DoH12 ranges to the radiologist and reporting radiographer's hourly reporting rate estimated a cost difference of £41.20-£20.60 per patient/MRI report (Table 7).

The committed price that NHS trusts and commissioners agree to cost at is set by the sector regulator Monitor⁵⁴, to reduce anti-competitive practice that is opposed to patient's interests. The Monitor 2014-15 direct access and outpatient diagnostic imaging services tariff (unbundled)⁵⁵ determines the cost paid by Clinical Commissioning groups for an MRI scan (one area, no contrast) as £13855 with reporting, and cost of reporting alone £2255. Although there are regional variations of cost and local modifications⁵⁶, this price is set in the current Healthcare Resource Groups (HRG4) costs currently in use by the NHS national tariff payment system (2014/15) and is enforced by the Health and Social Care Act 2012⁵⁷ for NHS trusts, NHS foundation trusts and private providers.

Comparison of the interventional cost of reporting radiographers to report a non-complex MRI scan against the national tariff of £2255 per report, demonstrates cost savings of between £2.83- £11.17 per scan calculated against all the proposed RCR33 and CfWI and DoH12 time ranges to report an MRI scan (Table 7). Extrapolation of the data allowed approximation over the observed range using the data (n=3,525) from the acute DGH 12 month audit of workload calculated potential savings of between £121,048 - £60,524 could be possible using reporting radiographers against the RCR33 workload model (fast, medium and slow reporting times). Calculating the reporting radiographer's unit costs against the CfWI and DoH12 reporting ranges gives an estimated annual cost saving of £145,230 - £72,615 (Table 8) compared to the current intervention of radiologists.

Discussion

The RCR15 have explored various responses to the capacity demands of reporting services and acknowledged reporting radiographers as one of several solutions (including out-sourcing, locums, overtime catch up sessions, and review of existing radiologist's performance). The use of locums and outsourcing to commercial private companies is not without a large additional financial burden and may not be a sustainable policy for the future on current NHS financial constraints.

The review has shown that both interventions have the diagnostic thresholds to achieve similar reporting standards. The societal cost/benefit to patients from integrating the new intervention could potentially improve reporting services and faster diagnosis. Evidence from studies in X-Ray^{58,59,60,61,62} CT^{63,64}, ultrasound⁶³ and magnetic resonance imaging⁶³ support achievable increases in reporting turnaround times. The influence of introducing system efficiencies in reporting enhances patient treatment and management^{58,65,66,67} which improves quality of care and patient satisfaction.

Healthcare economic evaluations normally review the trade-off in a comparison between two interventions of costs, benefits and harms, to review if one treatment is dominated (more expensive and worse than an alternative) or if a new treatment is better but more expensive, or dominant (cheaper and better). There has been precedence in the past from studies in X-Ray^{61,68,69,70,71} CT^{64,72} and fluoroscopy⁷² to establish the cost effectiveness of radiographers reporting. This

review predisposes any additional cost between the interventions could not be appropriately calculated to Quality Adjusted Life Years (QALYs) or Incremental Cost Effectiveness Ratios (ICER) as the sample audit data did not record the impact of the intervention on care pathways and treatment plans, as evidence from discrepancy audit meetings were unavailable.

An additional limitation of this study recognises that some NHS teaching hospitals employ registrars in training to report MRI exams and as such can be a cost effective approach to reporting. In justifying why registrars were not evaluated in the data modelling, the DGH where the audit was obtained did not commission registrars. Additionally the use of registrars could be problematic due to the various different levels of experience and exposure in reporting; moreover some will require a level of double reporting at an extra cost of time and money.

Conclusion

In summary the literature^{11,12,13,14} implies that current practice is not conducive to future service delivery, a consideration of future workforce planning to cope with capacity and demand should include a whole-team approach to developing an effective service delivery with involvement from professional bodies, commissioners and stakeholders. The current scope and boundaries of imaging professions will need to consider sufficient overlap of roles to enable an efficient service delivery.

The review of introducing an MRI skills mix reporting service model has shown one potential option in tackling the capacity and demand issues faced by NHS imaging department, with a possible £145,230 - £60,254 per annum cost saving using a generic acute NHS DGH workload model. Research into discrepancy audit data from MRI reporting by radiographers and radiologists for potential risk to patient outcomes identified a paucity of evidence on patient mortality/morbidity and quality of life, further research into this area is recommended.

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