Is a radiographer led immediate reporting service for emergency department referrals a cost effective initiative?

Maryann Hardya,*, John Huttonb, Beverly Snaithc

a School of Health Studies – Horton A, University of Bradford, Richmond Road, Bradford, West Yorkshire BD7 1DP, UK
b Yorkshire Health Economics Consortium, Market Square, University of York, Vanbrugh Way, Heslington, York YO10 5NH, UK
c Mid Yorkshire Hospitals NHS Trust, Aberford Road, Wakefield, West Yorkshire WF1 4DG, UK

ARTICLE INFO

Article history:
Received 16 September 2012
Received in revised form 8 November 2012
Accepted 11 November 2012
Available online 30 November 2012

Keywords:
Radiographer
Emergency care
Cost-effectiveness
X-ray
Reporting

ABSTRACT

Rationale, aims, objectives: Demand for both Emergency Department (ED) and radiology services continues to increase across the UK while simultaneously, healthcare organisations are being asked to evaluate the quality of care provided and constrain service costs. National guidance on radiograph reporting times recommends ED radiographs are reported on day of patient attendance but in practice, delays in reporting persist. This study considers whether a radiographer led immediate reporting service for ED referrals could provide a cost-effective service improvement solution.

Methods: A pragmatic multi-centre randomised controlled trial was undertaken. 1502 patients were recruited and randomly assigned to an immediate or delayed reporting arm and treated according to group assignment. Patient health gain was measured in terms of change in utilities derived from EQ-5D responses at baseline and 8 week follow-up. Resources used and the costs of an immediate reporting service were analysed at the patient level and compared to standard reporting practices.

Results: 1688 radiographic examinations were performed (1502 patients). 79 discordant radiographic interpretations were identified (n = 79/1688; 4.7%). Interpretive errors were significantly reduced within immediate reporting arm. No significant difference was noted in the relative improvement in patient perceived health status between the 2 arms of the study. The average cost saving per patient in the immediate reporting arm was £23.40.

Conclusions: Radiographer led immediate reporting of ED radiographs is a cost-effective service development and its universal introduction could make a significant contribution to the current drive to increase service productivity within current budget constraints.

© 2012 The College of Radiographers. Published by Elsevier Ltd. All rights reserved.

Introduction

Demand for radiographic imaging has steadily increased due to its role within clinical decision making pathways. Approximately 22 million X-ray examinations, and a further 16 million more complex imaging procedures, are undertaken in England each year.1 While advancements in imaging technology, service re-design and greater use of the independent sector have ensured that image acquisition capacity has increased, service delays in relation to examination reporting still persist.2–4

The reporting of radiographic images by radiographers (rather than radiologists) is an established practice in the United Kingdom (UK) and has attracted significant international interest from countries eager to consider similar systems of work.5,6 The quality of reports issued by radiographers has been demonstrated to be of a standard equivalent to a consultant radiologist,7–9 although the scope of an individual radiographer’s reporting practice is typically focussed to a single imaging modality (e.g. X-ray; ultrasound; mammography) and/or anatomical region. Previous research has demonstrated under-utilisation of the skills of these radiographers10 and as a result, the impact of radiographer reporting on service quality and capacity has to date been limited.

While radiographers are involved in reporting images acquired from a range of modalities and referral groups, one of their greatest contributions has been in terms of increasing capacity for the reporting of musculoskeletal (MSK) emergency department (ED) imaging referrals.2 Despite this increasing reporting capacity, and the introduction of national guidance on report turn-around times11 stating that reports for ED patients should be issued on the day of patient attendance, the timeliness of definitive ED image reports appears to be unchanged with delays in report availability of up to 10 days persisting.12 As a result, the responsibility for initial
radiographic interpretation lies with the ED clinician (medical or nursing) managing the patients care, although several authors have reported concerns in relation to ED radiographic interpretation errors\textsuperscript{13–17} and the significant clinical risk that undiagnosed and misdiagnosed injuries present\textsuperscript{15,17} and their potential predisposition to long term morbidity.

Failure to improve image report turnaround times in the UK has perhaps been a consequence of traditional Radiology workload organisation (typically 9 am – 5 pm Monday – Friday) which has previously precluded the implementation of immediate reporting. However, the introduction of 7 day working in imaging departments\textsuperscript{5} should overcome this barrier to reporting timeliness. It is also anticipated that this fundamental change in service availability will create additional benefits in relation to reducing inpatient stays thereby improving cost effectiveness, although no identified study has examined the impact of faster image reporting on service costs and resource utilisation. This paper presents an evaluation of the cost effectiveness of an immediate reporting service of ED MSK radiographs undertaken as part of a multi-centre randomised controlled trial funded by the National Institute of Health Research (Research for Patient Benefit Programme PB-PC-0407-13033).

Methods

Design & setting

This cost-effectiveness analysis was undertaken as part of a pragmatic multi-centre randomised controlled trial for which the complete protocol and results have been published elsewhere\textsuperscript{12,18} To control for local variation in ED practice and socio-demographic influences on patient attendance patterns, 5 hospitals from 3 National Health Service (NHS) Trusts across the north of England were used. At each hospital, a 24 h ED service operated and the delayed reporting of ED radiographs by a radiologist and/or reporting radiographer was standard practice. Ethical approval (NHS) for the study was obtained (08/H1003/168) alongside approval from the Research and Development Committee at each participating hospital Trust.

In order to determine the impact of immediate reporting, each hospital site committed to implementing an immediate ED radiograph reporting service (led by the reporting radiographer team at each site) for a period of 4 weeks. This service operated over 7 days (2 weeks during daytime hours (8 am – 6 pm) and 2 weeks during evening/twilight hours (6 pm – 2 am)) to take account of variations in patient groups, injury presentation and availability of senior staff cover in both the ED and radiology departments.

Participants

A convenience sampling approach to recruitment was adopted and all patients attending the ED with a MSK injury experienced in the preceding 48 h requiring radiographic examination to assist in diagnosis and able to provide informed consent were eligible to participate in the study. Patients were excluded from the study if the injury was sustained in excess of 48 h prior to ED attendance in order to control for potential alteration in the standard treatment pathway as a result of the delay in time to diagnosis. Patients were also excluded from the study if the radiographic referral included examination of visceral structures (chest/abdomen) as the scope of the majority of radiographers providing the immediate reporting service was restricted to MSK examinations. No exclusion was made based upon patient demographic variation (e.g. age, gender).

A sample size of 1242 (621 in each arm) was calculated (90% power) assuming a 5% difference in the proportion of discrepant interpretations across the immediate and delayed reporting arms.

Recruitment

Patients eligible for participation in the study were identified on arrival at the radiology department and invited to participate in the study while they waited for their imaging examination. An age appropriate information leaflet was used to explain the purpose of the study, implications for treatment, and follow-up data collection processes. The study information was available in languages other than English relevant to the clinical sites and also as a verbal recording to maximise inclusion. Those who agreed to participate were asked to provide written informed consent and complete an EQ-5D health related quality of life questionnaire\textsuperscript{19} Home address and telephone contact details were also collected to enable a further questionnaire to be distributed 8 weeks post attendance date for the evaluation of short term injury recovery status.

Intervention

The study adopted a parallel group approach and participants were randomly assigned to the immediate or delayed reporting arm and treated according to group assignment. Patients randomised to the immediate reporting arm were asked to wait in the radiology department following radiographic examination while the report was generated. The X-ray report was returned to the ED at the same time as the patient (electronically or hard copy as was appropriate locally) for the ED clinician to review alongside the images. Patients randomised to the delayed reporting arm were asked to return to the ED following radiographic examination to await review of the images by the referring ED clinician. For these patients the X-ray report was issued by the radiology department at a later time and returned to the ED as was standard practice at each site. In both arms, the ED clinician was able to discuss the case with the examining radiographer and any member of the radiology team normally available to the ED clinician for consultation. Where a radiographer abnormality detection scheme was in operation (e.g. red dot, commenting or similar), this continued as was normal practice.

Outcome measures

The primary study outcome measure, as reported elsewhere\textsuperscript{12} was concordance in the interpretation of radiographs by radiology and ED. For the cost-effectiveness analysis, patient health gain was measured in terms of change in utilities derived from the EQ-5D responses at baseline and 8 week follow-up. This was designed to capture the impact on health outcomes of a potentially faster and more accurate diagnosis in ED.

The resources used and the costs of an immediate reporting service were analysed at the patient level and compared to standard reporting practices. Measures that informed this assessment included patient journey time for initial ED attendance as recorded on the hospital data system and patient referral, admission and recall rates. Standard NHS reference costs\textsuperscript{20} were applied to each of these to calculate the financial costs.

Results

Recruitment took place between July 2009 and January 2010 and a total of 1502 patients, accounting for 1688 MSK X-ray examinations, were recruited and included in the final study analyses. 752 patients (839 examinations) were recruited to the immediate reporting arm and 750 patients (849 examinations) were recruited to the delayed reporting arm. The characteristics of the sample group within each arm were similar in terms of the distribution of patient age and gender\textsuperscript{12}.
Patient perceived health status

Completed baseline and follow-up EQ-5D questionnaires were obtained from 763 \( (n = 763/1502; \, 50.8\% \) recruited patients. Applying the matrix of valuations derived from the UK general population\(^2\) indicated that the utility scores\(^12\) of both arms had increased from baseline to 8 weeks, with a slightly higher mean change in the delayed reporting arm (Table 1). Given the extent of missing data from the follow-up EQ-5D questionnaire, a comparison of the hospital attended, clinical presentation (injury type) and social characteristics (age, gender, ranked deprivation of home postcode) of respondents to the follow-up questionnaire (763 records) and the complete sample (1502 records) was undertaken to determine representativeness and potential influence of non-response bias.

No statistically significant difference was noted in the clinical or social characteristics of patients completing initial and follow-up responses, with the exception of ranked deprivation of home postcode using National Indices of Deprivation 2007\(^12\) \( (z = -2.622, \, p = 0.008) \). A significant difference was also noted in the hospital attended \( (\chi^2 = 10.566, \, 4df, \, p = 0.032) \). These findings are likely to be linked as, for emergency care purposes, hospitals are typically situated in the geographical location of their attending patients. Consequently, it is likely that relative deprivation of home environment is the main differentiating factor between patients situated in the geographical location of their attending patients.

Consequently, it is likely that relative deprivation of home environment is the main differentiating factor between patients completing initial and follow-up questionnaires with fewer follow-up responses being received from patients residing in relatively deprived areas. While this may represent the possibility of non-response bias in the follow-up survey sample, it is not possible to identify the nature or direction of any such bias as no identified studies have considered the impact of deprivation on response to the EQ-5D questionnaire. Consequently, for the purpose of analysis, it was assumed that the follow-up data were representative of the whole sample and no significant difference was noted in the relative improvement in patient perceived health status between the 2 arms of the study \( (t = 0.208, \, p = 0.835) \).

Resource use and cost

A total of 79 discordant radiographic interpretations were noted between ED and Radiology \( (n = 79/1688; \, 4.7\% \) (Table 2). Independent review of patient notes, images, and results of other tests for patients with discordant interpretations identified that a significantly greater number of interpretive errors were made by ED clinicians \( (proportional \, difference = 57.0\%; \, 95\% \, CI [0.442, 0.698]; \, p < 0.001) \). Importantly, the interpretive errors made by radiographers did not impact on ED decision making and appropriate patient management and referral was noted for all patients. Despite a significant reduction in errors within the immediate reporting arm being noted for both radiology and ED, errors were not eliminated.\(^12\)

As a result, economic assessment of resource use and cost was restricted to variation in ED interpretive errors across the study arms and the subsequent impact on referral pathways, including admission, clinic referrals (ED or outpatient (OP)), or recall (Table 3).

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Patient health outcomes (EQ-5D scores).</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Study arm</strong></td>
<td><strong>n (%)(^a)</strong></td>
</tr>
<tr>
<td>Immediate reporting</td>
<td>383 (50.9)</td>
</tr>
<tr>
<td>Delayed reporting</td>
<td>380 (50.7)</td>
</tr>
<tr>
<td><strong>Difference</strong></td>
<td>0.005</td>
</tr>
</tbody>
</table>

\(^a\) % of total recruited sample in each arm.

Table 2

<table>
<thead>
<tr>
<th>Interpretive errors and referral pathways.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Discrepant interpretations</strong></td>
</tr>
<tr>
<td>ED false positive</td>
</tr>
<tr>
<td>Discharged</td>
</tr>
<tr>
<td>Admitted</td>
</tr>
<tr>
<td>Referred to hospital clinic</td>
</tr>
<tr>
<td>ED false negative</td>
</tr>
<tr>
<td>Discharged</td>
</tr>
<tr>
<td>Admitted</td>
</tr>
<tr>
<td>Referred to hospital clinic</td>
</tr>
<tr>
<td>Radiology false positive</td>
</tr>
<tr>
<td>Discharged</td>
</tr>
<tr>
<td>Admitted</td>
</tr>
<tr>
<td>Referred to hospital clinic</td>
</tr>
<tr>
<td>Radiology false negative</td>
</tr>
<tr>
<td>Discharged</td>
</tr>
<tr>
<td>Admitted</td>
</tr>
<tr>
<td>Referred to hospital clinic</td>
</tr>
</tbody>
</table>

While a significant reduction in interpretive discrepancies was noted within the immediate reporting arm, no difference was identified in the number of patients discharged or referred to hospital clinics across the arms. Patient journey time from ED arrival to discharge/referral was also similar across the study arms with no significant difference being noted on analysis of equality of distributions \( (z = 0.79; \, p = 0.432) \). While more patients were admitted to hospital in the delayed reporting arm (Table 4), this difference was again not statistically significant \( (proportional \, difference = 1.9\%; \, 95\% \, CI [−0.007, 0.044]; \, p = 0.147) \) although when number of hospital bed days were compared, (Table 4) the difference in number of short term bed stays \( (5 \, days \, or \, less) \) between the 2 arms was highly significant \( (z = −3.625, \, p < 0.001) \). No significant difference between the arms was noted for bed stays of 6 days or more.

Using the resource use and cost data as shown in Tables 3 and 4, the average NHS cost saving per patient in the immediate reporting arm \( (752 \, patients) \) was £23.40 (Table 5).

Cost-effectiveness

Combining the patient outcome and cost data generated by this study, the immediate reporting of MSK trauma radiographs by reporting radiographers appears to be cost-effective as no significant change in patient outcomes between the arms were apparent and resource use savings were generated. If this level of cost saving

<table>
<thead>
<tr>
<th>Table 3</th>
<th>ED interpretive errors and associated resource costs.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Discrepant interpretations</strong></td>
<td><strong>NHS unit cost (£)</strong></td>
</tr>
<tr>
<td>No. patients</td>
<td>Total cost (£)</td>
</tr>
<tr>
<td>ED false positive</td>
<td></td>
</tr>
<tr>
<td>Discharged</td>
<td>0</td>
</tr>
<tr>
<td>Referred to ED clinic</td>
<td>100</td>
</tr>
<tr>
<td>Referred OP(^a) clinic</td>
<td>100</td>
</tr>
<tr>
<td>Admitted – hospital days</td>
<td>255</td>
</tr>
<tr>
<td>ED false negative</td>
<td></td>
</tr>
<tr>
<td>Discharged</td>
<td>0</td>
</tr>
<tr>
<td>Discharged &amp; recalled</td>
<td>100</td>
</tr>
<tr>
<td>Referred to ED clinic</td>
<td>100</td>
</tr>
<tr>
<td>Referred OP clinic</td>
<td>100</td>
</tr>
<tr>
<td>Admitted – hospital days</td>
<td>255</td>
</tr>
<tr>
<td><strong>Total cost</strong></td>
<td>1200</td>
</tr>
</tbody>
</table>

\(^a\) Outpatient.
could be achieved nationally through the implementation of immediate reporting then, assuming approximately 5 million MSK trauma patients are referred for radiography each year in England, the total savings to the NHS in England would be £117 million. For a typical NHS hospital Trust with 20,000 ED MSK radiography referrals per annum, the annual savings from implementing immediate reporting would be £468,000.

While the costs of delivering the radiology reporting service were not monitored as part of this study, it is estimated that a minimum of 5–6 whole time equivalent (WTE) reporting radiographers would be needed to provide an 8 am–2 am service over a 7 day week, 365 days a year. Assuming advanced practitioner salary at midpoint Agenda for Change Band 7 (Point 30 £25,372), the annual cost of employing a radiographer led immediate reporting service as a new venture (assuming 6 reporting radiographers being required to operate an immediate reporting service) would be up to £253,326 (6 WTE band 7 radiographers).

**Discussion**

Demand for both ED and radiology services is continuing to increase across the UK while simultaneously, healthcare organisations are being asked to evaluate the quality of care provided and constrain service costs. Although the study was powered to test clinical hypotheses, it has produced a reasonably robust answer regarding the cost-effectiveness of a radiographer led ED MSK immediate reporting service. However, there remain some limitations and caveats to the economic analysis. The choice of an 8 week follow-up period was to some extent arbitrary, but was based on the belief that most patients presenting to the ED with traumatic MSK injuries will have recovered or be in rehabilitation and able to participate in most, if not all, normal daily living activities at 8 weeks post initial hospital attendance. The large and consistent rise in the EQ-5D scores between baseline and 8 weeks supports this belief. The missing data on the follow-up EQ-5D score is unfortunate, but detailed analysis of responders and non-responders to the follow-up questionnaire could find no reason to believe that the results are not representative of the whole sample.

The cost-effectiveness result is sensitive to two variables in particular: the equivalence of the health gain between the study arms; and the number of excess hospital bed days. If the observed average QALY gain in the delayed reporting arm of 0.005 (Table 1) were a reliable estimate, it implies that 1 QALY would be generated for every 200 patients whose radiographic images were diagnosed through the standard delayed reporting procedure. The savings lost by not implementing immediate reporting for this same 200 patients would be £4680. At the current threshold range (£28,000 – £30,000) below which the National Institute for Clinical Excellence (NICE) considers interventions to be cost-effective, the health gain of maintaining delayed reporting appears to be worth much more than the loss of savings. Given the nature and known healing patterns of the injuries being studied, it may be reasonably expected that convergence of the outcomes between the arms of the trial will occur over time as errors in initial management and referral pathways are corrected. Consequently, given this, and the expected variability in the EQ-5D data, a very small, and statistically insignificant, difference in the average patient outcome is to be expected.

Within this study, the number of hospital days avoided would have to fall from 60 to 37 (a 38% fall) before the costs of establishing a reporting radiographer service as a new venture (assuming 6 reporting radiographers employed as Band 7 advanced practitioners) exceeded the savings. However, it should be noted that this approach to costing a radiographer led immediate reporting service is very conservative. No account has been taken of the potential savings in the use of radiologist time by using radiographers to report MSK trauma radiographs. In addition, no account has been made of the other activities that may be undertaken by the reporting radiographer. These could include imaging patients as part of the radiography team or reporting images from other referral sources. The costings as presented have also assumed that the introduction of a radiographer led immediate reporting service is a new venture, although previous research has demonstrated that 63% of hospitals in England already employ reporting radiographers. Importantly, radiographer reporting activity within this study was limited to an average of 2 sessions (1/2 days) or less per week suggesting significant scope for expansion in reporting capacity within the existing reporting radiographer workforce. Finally, the costings have been based on 6 full time equivalent reporting radiographers being required to operate an immediate reporting service between 8 am and 2 am, 365 days per year. As local demand for ED and radiography services may vary from this pattern, the costs of a radiographer led immediate reporting service may be greater or less than those estimated here although it is anticipated that comparable savings will be achieved.

**Conclusion**

Based on the results of this study, consideration of its limitations and extension of the calculations to include further relevant factors, it can reasonably be concluded that the radiographer led
immediate reporting of ED MSK trauma radiographs is a cost-effective initiative for the NHS. Its universal introduction could make a significant contribution to the current drive to increase the productivity of the service within current budget constraints.

Funding

The research was funded by the National Institute for Health Research (NIHR) Research for Patient Benefit (RfPB) programme (PB-PG-0407-13033).

References