The Implementation of a Radiographic Reporting Service, for trauma examinations of the skeletal system, in 4 National Health Service Trusts

Department of Radiography
Canterbury Christ Church University College

NHS Executive - South Thames
Funded Research Project

Executive Summary

The implementation of a Radiographic Reporting Service for trauma examinations of the skeletal system, in 4 National Health Service Trusts

Project Reference: SPGS 438

Project Dates: 1 September 1997 (project start) 30 November 1998 (project end)
31 March 1999: Date of report submission

Project Leader: Mr Keith Piper, Senior Lecturer and Programme Director, PgD Clinical Reporting, Canterbury Christ Church University College

Research Assistant: Ms Carol Ryan, Department of Radiography, Canterbury Christ Church University College

Project Supervisor: Mrs Audrey Paterson, Head of Department of Radiography and Dean of Faculty of Health and Sciences, Canterbury Christ Church University College

Main Research Objectives:

The purpose of the study was to evaluate the implementation of a Radiographic Reporting Service (RRS) in four NHS Trusts in the United Kingdom with specific reference to the reporting by radiographers of musculo-skeletal trauma examinations. The research investigated the accuracy of radiographers' written reports in terms of sensitivity and specificity; the impact on patient care and management as measured by the volume of reporting activity undertaken and the speed with which reports became available; costs related to the implementation of an RRR, and satisfaction of the users of the service.

Methodology and Sample Size

A longitudinal study design was used to measure the productivity and effectiveness of radiographic reporting in four NHS Trusts and five clinical sites in England. Data were collected by direct measure, report pro-forma, semi-structured questionnaires and interviews. A series of base line measurements were made at the commencement of the project. These were the volume of reporting activity prior to implementation of an RRS and the speed with which the reports became available. The satisfaction of the users of

the reporting service prior to the implementation of an RRS was also gauged. Three measures (volume, speed, satisfaction of users) were repeated after the RRS had been implemented. Longitudinal data on the accuracy of the radiographers' reports in terms of sensitivity and specificity were also collected at each site. Finally, some cost information related to the introduction and provision of an RRS was gathered.

Four NHS Trusts and 10 radiographers participated in the study. Radiographers completed 10275 reports and 7179 were used to assess accuracy, sensitivity and specificity. Volume and speed data were obtained from the normal workload in each Trust. Four radiology services managers provided the cost data, while 26 staff took part in the initial survey and 12 in the final survey.

Problems

The major problem with this study was the fact that it was investigating the implementation into practice of a new and controversial service. It was beset, therefore, with the difficulties of aligning a research project to practice and this was only possible imperfectly. Points of implementation of the new service varied considerably, workload of key staff made verification of reports difficult and information systems within Trusts proved problematic.

Findings

Radiographers' reports were accurate and consistently so over time. Significant improvements in the volume of reporting activity were found post-implementation at 2 of the 4 clinical sites in which this was measured. Additionally, the speed with which reports became available was shown to have improved significantly in all 4 NHS Trusts (but not at one clinical site). Cost data was not considered to be reliable and more evaluation of costs is required. Users of the radiographic reporting services were extremely or very satisfied with the quality of reports produced by the radiographers and also satisfied with the nature of the service implemented. Finally, a range of organisational issues were seen to affect the implementation of these services, at times quite inappropriately.

Conclusion

NHS Trusts that are unable to provide a full and/or timely musculo-skeletal trauma reporting service should implement a radiographic reporting service but must ensure that

this is properly planned, funded, implemented and managed. Monitoring of service effectiveness and auditing of reporting standards should take place periodically.

Acknowledgements

The four collaborating NHS Trusts and their staff; Expert panel members; Members of the Steering Group; Colleagues at Canterbury Christ Church University College, and the Research and Development Directorate at South Thames Regional Office (NHSE).

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1.1 Title

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1.2 Reference Number

SPGS 438

1.3 Start and End Dates

1 September 1997 (start date) 30 November 1998 (end date)

1.4 Date of Report

31 March 1999

2. Names and Place of Work of Project Leader and Others Involved

2.1 Canterbury Christ Church University College

Project Leader: Mr Keith Piper, Senior Lecturer and Programme Director, PgD Clinical Reporting

Project Supervisor: Mrs Audrey Paterson, Dean of the Faculty of Health and Sciences, Head of Department of Radiography

Research Assistant: Ms Carol Ryan, Department of Radiography

Administrative Assistant: Ms Sarah Dines, Department of Radiography

2.2 Names and Places of Work of Collaborators when Project was Approved

2.2.1 Ms S Page, Chief Executive
Dr D Lauckner, Consultant Radiologist
Mr Q Field-Boden, Radiology Services Manager

Cheviot and Wansbeck NHS Trust, Woodhorn Lane, Ashington, Northumberland NE63 9JJ (now Northumbria Healthcare NHS Trust)

2.2.2 Mr N Offen, Chief Executive
Dr J Gray, Consultant Radiologist
Mr D Blenkinsop, Radiology Services Manager

Essex Rivers Healthcare NHS Trust, Turner Road, Colchester, Essex CO4 5JL

2.2.3 Mr R Evans, Chief Executive
Dr P McMillan, Consultant Radiologist
Mr S Davies, Radiology Services Manager

Mid Kent Healthcare NHS Trust, Hermitage Lane, Maidstone, Kent ME16 9QQ

2.2.4 Mr M Lowe-Lauri, Chief Executive
Dr J Marshall, Consultant Radiologist
Mr R Milne, Radiology Services Manager

Peterborough NHS Trust, Bretton Gate, Peterborough, Cambridgeshire PE3 9GZ

3. Main Research Question /Objective (As Envisaged at Outset)

The purpose of the investigation was to evaluate the implementation of a Radiographic Reporting Service (RRS) in four NHS Trusts in the United Kingdom with specific reference to the reporting by radiographers of musculo-skeletal radiographic examinations undertaken on patients referred from the accident and emergency department.

In each of the four NHS Trusts, the RRS was evaluated in relation to the:

- accuracy of the radiographers' written reports in terms of sensitivity and specificity

- impact on patient care and management in terms of the volume of reporting activity undertaken and the speed with which reports became available

- costs related to the implementation of a Radiographic Reporting Service

- satisfaction of the users of the service. In this context users were considered to be radiologists, accident and emergency medical staff and radiology services managers

4. Background (why research necessary, literature search and preparation)

4.1 The Background

Reporting on radiographic examinations by radiographers is not a new phenomenon although the role of radiographers in reporting has been contested by the medical profession almost since the discovery of X-Rays in 1895 (BMJ, 1903:831 and Arthur and Muir, 1909, both cited by Larkin 1983). However, in more recent decades, the idea of using radiographers to alleviate radiological workloads by developing them to report on some categories of films has been raised. Notably, this suggestion was made by Swinburne in 1971 and, more recently, by Saxton (1992).

Little research has been carried out into whether radiographers can report radiographs to the same standards as radiologists and early work by Renwick and Butt (1991) was not promising. They examined how well radiographers without any preparatory training could triage radiographs from an accident and emergency department into one of four categories: normal, abnormal, insignificantly abnormal, further advice required. The radiographers' assessments were then compared to the reports of the radiologists. Renwick and Butt concluded that the radiographers' overall error rate was unacceptable to a busy accident and emergency department although they could offer useful advice to casualty officers.

Earlier work by Berman et al (1985), however, had demonstrated the potentially positive impact of radiographers' reporting on accident and emergency radiographs. In this study the radiographers' performances were compared to those of casualty officers and were found to be significantly better.

During the 1990s, perhaps due to the relentless growth of workload within departments of clinical radiology and, possibly, the influence of Saxton's (1992) comments, interest in the role of radiographers in reporting escalated and three, almost simultaneous, developments occurred. These were the introduction through a partnership between (then) Canterbury Christ Church College and Mid Kent Healthcare Trust of an accredited postgraduate education programme for radiographers to enable them to report musculo-skeletal radiographs; the evaluation of an in-service training programme at Macclesfield District General

Hospital to assess its impact on fracture reporting by radiographers with the subsequent use of those radiographers to report fracture radiographs; and the establishment of a collaborative research project between the University of Leeds and St James's University Hospital, Leeds to investigate the feasibility of plain film reporting by radiographers following a structured postgraduate training programme (Eyres, Henderson, Paterson et al, 1997).

All three developments and their consequences have received much attention from the radiological and radiographic communities, and have been presented at numerous conferences both within the United Kingdom and internationally during the past five years. In different ways, each has demonstrated that radiographers are capable of reporting radiographs of musculo-skeletal radiographic examinations at least to the standard of experienced radiologists. However, there is still a need for the reporting performance of radiographers when contributing to the routine clinical radiology reporting service to be investigated. Additionally, the issues associated with implementing a radiographic reporting service into practice merit exploration.

This study was designed to evaluate the implementation into practice of a radiographic reporting service and was based on four premises. Firstly, there were departments of clinical radiology about to implement a radiographic reporting service using properly trained radiographers; secondly, there was much need to explore whether the introduction of reporting radiographers was beneficial to departments; thirdly, it was important to assess whether radiographers maintained their reporting performance over time; and, finally, there were factors associated with the introduction of radiographic reporting services that were unknown.

4.2 Radiological Workload

The rationale for the introduction of any new service must be driven primarily by need and radiographic reporting services are no exception to this rule. Within departments of clinical radiology in the United Kingdom, there is much evidence to show that both the volume and the complexity of work undertaken is increasing at a much faster rate than can be accommodated with current and projected numbers of radiologists.

The Royal College of Radiologists (RCR) has estimated that workloads are 63% higher than recommended staffing levels and that workload has trebled since 1968 (RCR, 1993). It calculated that over 800 additional radiologists would be needed in England alone to address the mismatch between workload and staffing levels (RCR, 1993). This discrepancy between workload and radiological staffing levels has continued to diverge since 1990, as Brindle reported in 1996. However, it is highly unlikely that increases of the magnitude recommended by the RCR would, or could, ever be funded by the Department of Health (DoH). Hence, the problems of increasing service demand and insufficient numbers of new consultant radiology posts are likely to continue into the foreseeable future.

Part of the reason for the increase in workload is as a result of what has been referred to as "The Radiological Paradigm Shift" into three dimensional and interventional procedures (Isherwood, 1995).

A wide range of such imaging and interventional procedures are now possible and the development of the majority of these has taken place since 1970. The impact of these developments, amongst others, led Isherwood to forecast in 1995 that within ten years as much as 70% of surgery will be by minimally invasive therapy and that, increasingly, this work is likely to be carried out by radiologists.

Inevitably, the pressures outlined above have led to the prioritisation of work within radiology with resultant adverse effects on, for example, waiting lists and the reporting service. Studies have shown that the levels of reporting of accident and emergency films varies considerably. Beggs (1990) found that over 20% of UK teaching hospitals did not report on all accident and emergency films while another study showed that, of 190 large accident and emergency departments, 39% were not satisfied with the reporting services provided, with 49% stating that films were not reported within 48 hours of the examination (James, 1991). James found that the most common cause for dissatisfaction was the time taken to receive reports (mean 3.7 days; range 0-28 days) and only 5 (2.6%) of the hospitals surveyed were able to report the availability of a 'hot' reporting service (where the report is returned to the accident and emergency department with the films and the patient).

The situation reported by James in 1991 was echoed in a 1995 survey of 110 radiology departments carried out by Piper. In this study he followed-up Paterson's (1995) survey of radiographers' role developments and questioned radiology services managers about the reporting workload in their departments. He found that accident and emergency radiographic examinations were not reported in 13 (15%) of the 87 responding hospitals.

The fact that many films are unreported and that many receive a report too late to influence the clinical management of patients has been recognised within the radiological community. This recognition led, in part, to Saxton's (1992) proposals for radiological sector support by some, appropriately trained, radiographers, including some contribution to reporting services by radiographers.

4.3 Accident and Emergency Reading of Radiographs

Departments of clinical radiology are, clearly, service departments and the problems of increasing workloads and understaffing have a direct impact on users of clinical radiology. Accident and emergency departments are major users of clinical radiology services and, as was shown above, they are dissatisfied with aspects of radiological reporting, particularly the speed with which a report becomes available. The lack of a radiological report means that film reading must be undertaken by the doctor treating the patient and, often, this is a relatively junior and inexperienced member of staff.

A number of studies have investigated how well junior medical staff in accident and emergency departments are able to interpret radiographs. Vincent, et al. (1988) showed that senior house officer (SHO) error rates range between 4% and 7% when their interpretations of accident and emergency radiographs were compared to the radiologists' reports. This group also demonstrated that 39% of abnormalities missed by SHOs were of clinical significance.

Robson (1985) investigated the degree of agreement between SHOs and radiologists, reporting a 14% disagreement between their reports. More recently, Meek, et al. (1998) found that SHOs in 13 accident and emergency departments or

minor injury units achieved a mean correct score of 19.9/40 (inexperienced SHOs) and 25.1/40 (experienced SHOs) when asked to interpret a bank of appendicular trauma examinations.

Other studies have shown junior doctors to be relatively poor at abnormality detection when their findings have been compared to the radiological report. Typically, accuracy rates of between 80% and 90% have been found with de Lacey (1980) demonstrating 83.2%; Carew-McColl (1983) showing 85%, and Berman (1985) quoting 89% accuracy rates.

It is also important to remember that up to 70% of accident and emergency radiographs are taken during nights and at week-ends. One study examined abnormality detection rates out of normal hours and found that many abnormalities were missed. Over an eight month period, of the 505 demonstrated abnormalities, 178 were missed by the casualty officer giving an error rate of 35% (Vincent 1988).

Another study, completed over an eleven month period, identified those patients who had been allowed home with serious injuries that had been overlooked in the accident and emergency department. While the number of patients sent home with undiagnosed serious conditions was not great (a total of 19), the list of undetected abnormalities included skull fractures, spinal fractures, a case of free gas under the diaphragm and a pneumothorax (Carew-McColl, 1983).

4.4 Potential of Radiographers to Contribute to the Reporting Service

Evidently, the pressures on both departments of clinical radiology and accident and emergency in relation to the reporting of radiographs are significant. There is a need for staff in accident and emergency departments to receive accurate reports in time for those reports to influence patient management. Yet, the lack of sufficient radiologists coupled with the escalating workload in clinical radiology makes this a goal that is likely to prove increasingly unachievable unless alternative methods of providing radiology reporting services are considered.

Over a number of years radiographer reporting has been proposed as one solution and it is the case that radiographers already contribute in many hospitals to the interpretation of radiographs in the accident and emergency department through the 'red dot' signalling system (or a derivative). Such systems are in place in over 150 hospitals in the UK (Paterson, 1995) and earlier studies have demonstrated clearly their value in the improved management of patients referred from the accident and emergency department (Cheyne, et al. 1987; Bowman, 1991).

Recently, however, the concept of radiographer reporting as opposed to informal signalling has begun to be considered seriously and a number of authors have discussed radiographer reporting with particular reference to the accuracy with which radiographers are able to report. Piper and Paterson (1997), for example, examined the sensitivity and specificity rates achieved by a small group of trained radiographers who collectively reported 6592 musculo-skeletal examinations. The scores for both measures were greater than 97%. Robinson (1996) also assessed the accuracy of a group of suitably trained radiographers and found that they were not significantly different to a group of radiologists. In relation to fracture detection, Loughran (1994) found that radiographers who had received training improved over a six month period with error rates reducing from 8% to 5.3%; and sensitivity and specificity rates increasing to 95.9% and 96.8% respectively. These rates were compared to those of the radiologists who achieved rates of 96.8% (sensitivity) and 99.6% (specificity). At the end of Loughran's study there was no statistical difference in sensitivity for fracture detection between radiographer and radiologist, although a highly significant difference in specificity ($p<0.001$) remained. Nevertheless, these results may be considered to be encouraging, given the training and experience of the radiologists and, comparatively, the short period of training (six months) given to the radiographers in this study.

4.5 Potential Constraints to Reporting by Radiographers

Within the radiological and radiographic communities the potential for radiographers to undertake some reporting duties has been examined and accepted to a limited extent, including by the Royal College of Radiologists (RCR). Its advice document 'Statement on Reporting in Departments of Clinical Radiology' (1995) signalled that the recording of observations might be "properly delegated to suitably trained non-medical staff" (p 5). This would include radiographers.

The highly cautious, almost reluctant, acceptance that radiographers may have a role to play in reporting would suggest that there may be external impediments or constraints that need consideration. These might include legal barriers, adverse risk benefit assessments and negative impacts on the quality, efficiency and effectiveness of clinical radiology services.

The practice of radiographers in the United Kingdom is governed in law by the Professions Supplementary to Medicine Act of 1960. Protection of the public in relation to the practice of radiography is vested in the Radiographers Board at the Council for Professions Supplementary to Medicine and exercised through the Statement of Conduct which is amended and re-issued periodically. Historically, it has always been claimed that the Statement of Conduct prevented radiographers from issuing reports. However, in recent years, the Statement has been amended to clarify the obligations of radiographers in relation to reporting and it is now not considered to be a breach of the law if radiographers were to report, providing it was in accordance with an agreed scheme of work and agreed by medical staff including radiologists (Radiographers Board, 1995). It would also not be considered a breach if radiographers were to describe orally and/or in writing, the imaging appearances in order to assist a referring clinician.

The professional body for radiographers, the College of Radiographers, also controls the practice of the profession through its Code of Professional Conduct (1994) and other professional advice and guidance documents. This body, too, does not preclude radiographers from carrying out the reporting role. Rather, within its document 'Reporting by Radiographers: A Vision Paper' (1997) this is encouraged although it is stressed that radiographers must be properly trained and

must work within an agreed scheme of work, supported fully by the employing authority.

Legally, it is evident that there is no impediment to the practice of radiographers developing to include reporting. However, wider legal implications need consideration, particularly those related to the potential for medical lawsuits to be pursued. It has been claimed that negligence claims are costing the NHS as much as £125 million per year (Harris 1994). It is not surprising, therefore, that risk management is a developing industry in health care management; and within clinical radiology, as Yule (1998) points out, risk management policies are essential. In the context of reporting Yule identifies the fact that mistakes in reports of radiological examinations can be extremely costly and suggests, for example, that a misdiagnosis in the field of obstetric ultrasound can lead to a bill of between £1.5M and £2M pounds.

It is not only obstetric ultrasound reports that give rise to litigation. Within the field of accident and emergency medicine, it has been reported that two-thirds of all claims concern radiographs and over half of these relate to missed abnormalities or difficult interpretations (Capsticks Solicitors, 1994). Given the potentially high costs of erroneous reports, it is not surprising that the advent of reporting radiographers is viewed with caution. Nevertheless, the potential for significant litigation and associated costs is not, in itself, a bar to reporting by radiographers. It is, however, essential that a proper risk analysis is carried out and that strategies to minimise risks associated with radiographer reporting are put in place. The minimum requirements necessary to implement radiographic reporting are laid down by the College of Radiographers (1995) and include professionally and academically accredited, competence based training; proper agreement amongst all relevant parties; audit; continuing professional development and research. Similarly, the Royal College of Radiologists sets out its view on what is required in order to delegate reporting safely (1995).

4.6 The Quality of Clinical Radiology Services

While caution needs to be exercised in relation to the introduction of radiographic reporting, it is apparent that there are no absolute barriers to this role development. It is also clear that at least some of the reporting workload is not being carried out, or is carried out some time after the treatment of the patient. This view was confirmed in the Audit Commission Report of 1995 "Improving your Image - How to manage Radiology Services More Effectively".

As part of the audit on which this report was based, a postal questionnaire was sent to 950 clinicians to gain their views on the importance of aspects of the imaging service, together with how satisfied they were with these aspects. The response rate was approximately 50% with over 400 completed questionnaires returned. Analysis of the returned questionnaires showed that accident and emergency medical staff considered the reporting of all films and the speed with which the report was returned to them to be the most crucial aspects of service quality. In contrast, these aspects of the service were those with which they were most dissatisfied. In particular, the speed with which reports were returned was the aspect of radiology services with which all hospital clinicians were least satisfied.

A key recommendation within the Audit Commission's report was that all departments of radiology should aim to report all basic radiographic examinations in time for the report to leave the department with the patient and without causing the patient to wait unduly. The current difficulties facing departments of clinical radiology in relation to providing a 'hot' reporting service were recognised by the Audit Commission but, nevertheless, they emphasised the point that providing such a service has definite patient management, medico-legal and practical organisational benefits to departments.

The contribution that radiographers could make was also recognised and the possibility that radiographers could be trained to interpret certain images was found to be "of particular interest in view of the difficulties that some departments currently experience with the reporting service" (p.59). One of the final recommendations in the report was that clinical directors of radiology services

should consider delegating more of the work traditionally performed by radiologists to experienced radiographers "subject to careful authorisation and detailed audit" (p. 61).

Piper's work in 1995 found a similar picture to that revealed in the Audit Commission's report. Only 24 hospitals were able to state that they reported all films and 13 replied that accident and emergency examinations were not reported. In relation to how quickly reports became available, 29 hospitals stated that reports took longer than 48 hours to be returned to the accident and emergency department and 10 of these admitted that reports took 6 days or longer to be returned. Using the Audit Commission's definition of 'hot' reporting, 22 hospitals stated that such a scheme was in place although many qualified this response. Comments such as "limited"; "when staffing permits", and "lukewarm rather than hot" suggested considerable variability in the 'hot' reporting provision and, when asked about an out-of-hours reporting service, fewer than 5% of the 87 hospitals were able to provide such a service. Encouragingly, however, over 95% of those replying felt that the reporting service could be improved and, echoing statements within the Audit Commission's report, that radiographers currently engaged in 'red-dot' signalling schemes could be trained to provide written reports.

4.7 The Rationale for Reporting by Radiographers

There would appear to be cautious support from a number of sources for the concept of radiographer reporting. The College of Radiographers advocates this clearly in its document 'Reporting by Radiographers: A Vision Paper' (1997), and there is conditional acceptance by the Royal College of Radiologists (1995, 1998). Research evidence, too, supports the view that radiographers are capable of reporting at least musculo-skeletal radiographic examinations referred from the accident and emergency department (Loughran, 1994; Robinson, 1996; Piper & Paterson, 1997).

The need for improvements in the reporting services provided by departments of clinical radiology has been identified (Audit Commission, 1995) but it is unlikely that improvements can be achieved given the chronic shortage of radiologists and the continuing escalation of workload within clinical radiology departments unless

other staff groups take on the reporting role. It is necessary, therefore, to consider skill mix strategies, one of which is radiographer reporting.

Radiography has undergone much development in the past decade and is now an all-graduate profession, with strong postgraduate education and continuing professional development frameworks in place. This development is enabling radiographers to extend the boundaries of their practice and to adopt roles that are new to them, with plain film reporting one such new area of practice. Radiology, too, has undergone considerable development, particularly into interventional work, and radiologists have extended the boundaries of their practice into the surgical domain. Such role developments support the need for coherent skill mix strategies within the clinical radiology team and, in particular, offer an opportunity to improve the provision of reporting services. Properly planned, implemented and supported skill mix strategies enable the NHS to meet service users' expectations especially where there are staff shortages such as in radiology or where cost considerations are significant, for example the potential costs of litigation arising from unreported radiographic examinations.

These various factors together suggest that there is a clear rationale to introduce radiographic reporting services and, over the past five years, a number of NHS Trusts have come to that view and have taken steps to provide the necessary education to equip radiographers with the knowledge and skills required for reporting. Educational developments have been carried out in partnership with Higher Education Institutions and there are now eight postgraduate level programmes available in the UK. The first students to graduate from these programmes did so in 1996 and it is estimated that there are now in excess of 100 radiographers with formal qualifications in reporting. It is also known from a role development survey carried out in 1997 that radiographers are carrying out reporting duties in 38 hospitals (Maguranyanga, 1997).

4.8 This Study

Although an increasing number of radiographers are contributing to reporting services in a growing number of hospitals, there is still much reservation about this role development amongst radiologists (Cunningham, 1997). Fundamental to this

reservation is doubt about whether radiographers can report to the same high standards as radiologists. Whilst research evidence suggests that they can, it is the case that studies carried out to date have tended to be linked to training and development programmes (Loughran, 1994; Piper and Paterson, 1997) or have been set up as experimental studies (Robinson, 1996). It is intended, therefore, to investigate radiographic reporting in the 'real' situation within a small number of Trusts to examine whether the positive research findings to date can be supported as radiographic reporting is implemented in practice.

5. Methodology, including type of study and sample size

5.1 Introduction

The method utilised a longitudinal study design which measured the productivity and effectiveness of radiographic reporting in four NHS Trusts (1, 2, 3, 4) consisting of five clinical sites (A, B, C, D, E) within England. Data were collected by direct measure, report pro-forma, semi-structured questionnaires and interviews. A series of base line measurements were made at the commencement of the project. These were the volume of reporting activity prior to implementation of a radiographic reporting service (RRS) and the speed with which the reports became available. The satisfaction of the users of the reporting service prior to the implementation of an RRS was also gauged although three of the five clinical sites had already implemented an RRS by the time this study commenced. For each site, these three measures (volume, speed, satisfaction of users) were repeated some time after the RRS had been implemented and as this study concluded at each site. Longitudinal data on the accuracy of the reports written by radiographers in terms of sensitivity and specificity were also collected at each site although the period of time over which these data were collected was dictated by the local operational constraints related to the introduction and maintenance of an RRS and so varied across the five sites. Longitudinal data collection permitted assessment of how well the accuracy of the radiographers' reports was maintained over time. Finally, some cost information related to the introduction and provision of an RRS was gathered.

It should be noted that the four collaborating NHS Trusts had first agreed to participate in 1996. This meant that when the project commenced in September 1997 a radiographic reporting service had already been implemented in three of the five clinical sites and, as indicated above, this complicated data collection somewhat. Nevertheless, it was considered valid to retain these three clinical sites in the study as the study sought to investigate the 'real world' situation of implementation into practice.

5.2 Ethical considerations

Prior to commencement of the study application was made to the Local Research Ethics Committee in each of the four participating NHS Trusts and permission granted.

5.3 The Study Baseline (Pre-Implementation)

For the three sites (sites A, D and E) where radiographer reporting had been implemented prior to the commencement of the study, the pre-implementation periods were identified as the twelve weeks immediately prior to the points at which their radiographic reporting services had become operational. Accordingly, the data to provide two of the baseline measures (volume of reporting activity prior to implementation of a radiographic reporting service (RRS) and the speed with which the reports became available) at these three sites were taken from these twelve week periods. Clearly, however, it was not possible at these sites to obtain data relating to the satisfaction of the users of the reporting service prior to the implementation of the RRS. Hence, this was carried out during the first site visit by the study team following the commencement of this study.

For the two sites (sites B and C) that had not implemented an RRS prior to the commencement of the study, the 12 week period immediately preceding the initial site visit by the study team was selected as the pre-implementation phase. This period was used to collect data to enable the volume and speed measures to be performed and the initial site visit by the study team permitted the satisfaction of users' data to be generated well before the RRS at these two sites was implemented.

The commencement dates of the pre-implementation periods relative to the dates of implementation of an RRS are shown in table 1 for all sites.

Table 1: RRS Implementation Dates and Pre-implementation Periods

Site	Commencement of RRS	Pre-implementation period	Time period
A	13/01/97	21/10/96 - 12/01/97	12 weeks
B	15/06/98	28/07/97 - 19/10/97	12 weeks
C	13/04/98	04/08/97 - 26/10/97	12 weeks
D	27/01/97	04/11/96 - 26/01/97	12 weeks
E	20/01/97	21/10/96 - 12/01/97	12 weeks

5.4 Implementation of Radiographic Reporting Services at the Study Sites

The exact extent and nature of the implementation of an RRS varied considerably across the five sites included in the study. Details of implementation and the periods for collection of data post-implementation are outlined below by site.

Site A:

An RRS was implemented for seven non-contiguous weeks spanning a 13 week period commencing on 13/01/97. Data relative to the accuracy of the radiographic reports, the volume of reporting activity undertaken following the introduction of an RRS and the speed with which the reports became available were collected for each of these seven weeks. Operational constraints prevented the RRS at this site from continuing beyond the seven weeks although towards the end of this study it had been re-instituted. (This will be addressed in the discussion section of this report.) The post-implementation survey of the satisfaction of users of the reporting service and cost data were gathered towards the end of the study period and after the re-introduction of an RRS at this site.

Site B:

The RRS at this site was implemented in the week commencing 15/06/98 and the period selected for post-implementation volume and speed data collection was the first 12 weeks of operation of the RRS. This excluded those weeks where the full RRS was not operational, for example when the reporting radiographers were on annual leave. Data relating to the accuracy of the radiographic reports were taken from the point of commencement of the RRS to the point within this study at which it was necessary to cease data collection in order to carry out data analysis. The post-implementation survey of the satisfaction of users and cost information was obtained at the end of the study period.

Site C:

At this site, the RRS was implemented in the week commencing 13/04/98 and, as with site B, the period chosen for post-implementation speed and volume data collection was the first 12 week period following implementation. Again, any weeks where a full RRS was not implemented were excluded. Accuracy of the radiographic reports was calculated from data generated between the date of

implementation of the RRS at this site and the point at which it was necessary to conclude data collection in order to facilitate analysis. The post-implementation survey of the satisfaction of users and cost information was obtained at the end of this study period.

Site D:

An RRS was implemented on 27/01/97 at this site. Hence, the 12 weeks immediately prior to the initial site visit by the study team were selected for collection of post-implementation volume and speed data. As at other sites, those weeks where a full RRS was not operational, for example as a result of annual leave of reporting staff, were excluded. By the commencement of this study, the RRS at this site was well embedded and a large number of radiographic reports had already been generated. Accordingly, all of these were used to obtain the necessary data to determine the accuracy of the reports, together with those produced between the commencement of the study and the initial site visit by the study team. For this site, the post-implementation survey of users' satisfaction was carried out towards the end of the study period and cost information was also obtained at this time.

Site E:

Implementation of the RRS took place on 20/01/97, with the 12 weeks immediately prior to the initial site visit by the study team being selected for post-implementation speed data collection (volume data could not be obtained at this site, as is explained later). Once again, in common with other sites, those weeks where a full RRS was not operational were excluded. As with site D, a large number of radiographic reports had been produced prior to the beginning of this study. Hence, all of the reports up to the point of the initial site visit by the study team were used to derive the data required to examine the accuracy of the reports. Cost data and the post-implementation user satisfaction data were gathered near the end of this study.

5.5 Accuracy of the Radiographers' Written Reports

5.5.1 The Number and Nature of the Reports Considered

To enable the accuracy of the radiographers' written reports to be determined, it was necessary to calculate the number of reports that needed to be produced by each radiographer. The proposed sample size of 1050 reports from each radiographer was based, firstly, on a realistic estimate of the level of reporting activity per radiographer in a six month period and, secondly, on a sample size calculation which estimated that a minimum of 350 examinations would be necessary to detect 5% differences in accuracy. Accuracy for each radiographer was examined over the period during which each radiographer was reporting and measures were made at three intervals for all those radiographers who were able to complete the required minimum number of reports. Accordingly, the sample size was set at 350 reported examinations per post-implementation interval, a total of 1050 examinations per radiographer.

Collection of data to calculate the accuracy of radiographers' reports proved problematic. One radiographer was unable to complete 1050 reports within the study period, and the necessary verification for a further five of the radiographers' reports was not possible due to operational constraints within one of the Trusts. This meant that complete data relative to calculating the accuracy of radiographers' reports was available for 4 radiographers only. Nevertheless, statistical advice indicated that comparative analysis could be undertaken using all available verified reports. This meant that there was one radiographer with one batch of verified reports, four with two batches and five with three batches, although some batches did not contain a full 350 reports. For each radiographer, the time span over which the batches of reports were taken varied considerably and was dictated entirely by the operational constraints of the RRS at each site.

A report was taken to be the report of a single radiographic examination which, in turn, was considered to be the projections that would be performed for a standard radiographic examination of the particular body part. Each named joint with its adjacent long bone was counted as one examination and two named joints were

counted as two examinations. However, where two examinations were requested but where a single standard radiographic examination would include both anatomical areas identified in the request, the examination was counted as a single examination. This is illustrated below:

wrist and forearm	= 1 examination
wrist, forearm and elbow	= 2 examinations
wrist and scaphoid	= 1 examination
pelvis and hip	= 1 examination.

For those sites which had implemented an RRS prior to the commencement of the study (sites A, D and E), the post-implementation intervals for collection of accuracy data were determined by dividing the total number of reports undertaken by each radiographer at the time of data collection into three equal sized batches. The reports produced by the radiographer for the first 350 examinations from each batch were then used as the data from which to determine accuracy for each of the intervals. This enabled the maintenance of accuracy to be gauged over time.

For the two sites (B and C) that had not implemented an RRS prior to the commencement of the study, data was collected prospectively and consecutive reports were included in the study data but, again, divided into three batches.

Table 2 demonstrates the number of reports taken from each radiographer for the purposes of this study, the number of these that were verified and, hence, the number of batches per radiographer included in the accuracy analysis. (It should be noted that some radiographers have produced considerably more reports overall since the implementation of the RRS at their study site.)

Table 2: Numbers of Reports per Radiographer

Site	No. of radiographers	No. of reports per radiographer	Total no. of reports verified (no. of batches)
A	1	a) 1050	1050 (3)
B	5	a) 1050 b) 1050 c) 1050 d) 1050 e) 1050	494 (2) 442 (2) 350 (1) 417 (2) 451 (2)
C	2	a) 1050 b) 825	1050 (3) 825 (3)
D	1	a) 1050	1050 (3)
E	1	a) 1050	1050 (3)
Total	10	10275	7179

5.5.2 Calculation of Accuracy of the Radiographers' Written Reports

The accuracy of the radiographers' reports was determined initially by a three stage process.

Stage 1:

Each of the reports produced by a radiographer was verified initially by a consultant radiologist. The radiologist was required to agree or disagree with the radiographer report and, where there was disagreement, to include additional information so that the nature of the disagreement was apparent.

Stage 2:

Next, the reports were examined by the study team and assessed for agreement in three separate areas as follows:

1. recent bony injury or acute trauma
2. any skeletal pathology including old injuries or other incidental findings
3. any further comments made by the verifying radiologist.

Stage 3:

Finally, those examinations where the radiologist disagreed with the radiographer's report as identified in stage 1 were retrieved, coded and reported by a second radiologist who was blind to any previous report although aware of the fact that the examination to be reported was part of this study. However, they were unaware that there was disagreement between the radiographer's report and that of the verifying radiologist.

There were a few cases in which there was disagreement at stage 1, and where films were unavailable at stage 2 (for example due to films being unavailable in file). These were scored by the study team based on the initial radiological verification only. The number of films scored in this manner was small and is indicated where appropriate.

Following these three initial stages, a further stage of analysis was undertaken to evaluate the accuracy of the radiographers reports, as follows:

Stage 4:

This stage was the allocation and analysis of fractions. The radiographic reports were examined by the study team and fractions were allocated according to three different criteria, based on agreement between the radiographer and the verifying radiologist's findings:

Analysis 1: report of recent bony injury and/or acute trauma

Analysis 2: in addition to analysis 1, any other skeletal pathologies including old injuries and/or other incidental findings

Analysis 3: in addition to both of the above analyses, the concordance of the radiographer's report and the verifying radiologist's report were assessed for additional comments made by the radiologist but not noted by the radiographer.

Wherever there was disagreement between the radiographer and the verifying radiologist, the second radiologist's report was used to determine a consensus view of the findings. Where this third opinion was in disagreement with both the radiographer and the verifying radiologist, the cases were excluded from further quantitative analysis.

True positive (TP), true negative (TN), false positive (FP) and false negative (FN) scores were allocated as follows:

TP: The radiographic report and the radiological verification agreed on the presence of an abnormality, and on the description of the abnormality in terms of its site and nature. If a number of abnormalities were present, and one or more were missed by the radiographer according to the verifying radiologist's report, a TP score was not recorded. Similarly, credit was not given if the site and/or nature of the abnormality/ies were incorrectly described.

TN: The radiographic report and the radiological verification agreed on the absence of any abnormal appearances. If a normal variant was clearly identified as such by the reporting radiographer and verified by the radiologist's report, a TN was allocated.

FP: The radiographic report identified and commented on an appearance as abnormal but both the first and second radiologist's views disagreed and considered the examination to be normal.

FN: The radiographic report identified an examination as normal but both the first and second radiologist's reports agreed on the presence, site and nature of an abnormality. An FN score was also allocated in cases where the radiographer described appearances incorrectly and/or used inaccurate terminology.

Following the construction of a 2x2 table, accuracy, sensitivity and specificity were then determined by the accepted formulae, as follows:

Accuracy: (TP+TN) / (TP+TN+FP+FN)
Sensitivity TP/(TP+FN)
Specificity TN/(TN+FP) (Maisey and Hutton, 1991).

5.5.3 Categorisation and Analysis

The reported examinations were categorised into the following anatomical areas: upper extremity, lower extremity, pelvis, cervical vertebrae, thoracic vertebrae, lumbo-sacral vertebrae, cranium and facial bones for each radiographer.

Descriptive data analysis was completed and examined for significant differences amongst the radiographers; over time, and across different anatomical areas. Regression analysis and Chi squared tests were used for these analyses.

5.5.4 Independent Analysis (Stage 5)

A final stage of independent analysis, outside of the boundaries of this study, is in progress currently and is to be completed when all 1050 reports for each radiographer have been verified. For this stage, all examinations where the radiographer's report had been allocated an FP or FN score, together with those examinations which lacked any agreement between the three opinions, are to be reported by two additional consultant radiologists blind to any previous reports and blind to each others reports, such that these reports can be compared with the findings of the preceding independent radiological report as well as the

radiographer's report. Where possible, a consensus radiological report is to be derived and these reports will be used as the gold standard to re-judge each radiographer's original FP and FN cases. These additional independent radiological reports are to be carried out by two consultant radiologists who are completely independent of any of the clinical sites in the study.

Additionally, a random sample of examinations where the radiographer report had originally been allocated a TP or TN are also being selected for further independent review by the two consultant radiologists, according to the same protocol. This TP/TN sample is to be randomly selected but will include appropriate proportions of all anatomical areas from each radiographer as far as is possible.

A revised estimate of sensitivity and specificity is to be calculated accounting for the proportion of the original TN, TP, FN and FP cases that disagreed with the more absolute "gold standard" arrived at through this final independent assessment.

Sample size calculations indicate that, relative to the number of FP and FN examinations to be reviewed, a further 300 TN and 300 TP examinations are required for this scrutiny to be robust and should enable an accuracy of estimation of +/- 2.5% at the 95% confidence interval to be achieved.

As stated above, this final stage of analysis is not included in this study. However, the detail of the methodology is included here as some of the results from this stage are available and feature in the discussion section of this report.

5.5.5 Clinical Significance of Reporting Errors

The analysis outlined in Stage 5 above, should enable the FN and FP examinations to be identified with a high degree of confidence. At this point the clinical significance of the radiographers' reporting errors will be evaluated by consultant accident and emergency clinicians within the four NHS Trusts participating in the study. The results of this analysis will be reported subsequently.

5.6 The Impact on Patient Care and Management

5.6.1 Volume of Reporting Activity

The volume of accident and emergency skeletal reporting activity at each site was determined prior to implementation of the RRS at the site, and again post-implementation. All data were collected by using each NHS Trust's hospital information system (HIS) or radiological information system (RIS) and hard-copy print-outs were obtained for each site. Depending on the capabilities of the computer systems at each site, volume data were collected initially by either examinations performed or by patient attendance. All examinations/attendances were identified individually by patients' names, dates of birth and attendance/examination numbers.

For both pre-implementation and post-implementation calculations, the number of skeletal accident and emergency examinations reported were determined for each of the following anatomical regions of the body:

- Upper extremity
- Lower extremity
- Pelvis
- Cervical vertebrae
- Thoracic vertebrae
- Lumbo-sacral vertebrae
- Cranium
- Facial bones.

Any non-musculo-skeletal examinations requested by the accident and emergency departments were excluded, as were accident and emergency examinations produced by other imaging modalities (for example, computed tomography or ultrasound). The ribs (chest radiography) and sternum were also excluded from this study.

The data for each site were entered in weekly intervals on a specially designed spread-sheet pro-forma. Each radiographic examination undertaken which conformed to the study protocol was counted and included in the appropriate category on the spread sheet according to its report status at the time of data collection (i.e. whether or not it had been reported) and also according to its anatomical area.

Weekly counts were calculated individually and cross-referenced to both the weekly totals and the total number of examinations (totals were generated by RIS) as a quality assurance check.

The nature of the HIS and RIS systems in each NHS Trust meant that the collection of volume of reporting activity data varied at each site. The specific detail for each site is shown below.

Site A:
A list was generated by the Trust's RIS system of all accident and emergency attendances. However, these did not enable the number or type of examinations performed or the report status to be identified. It was necessary, therefore, to access each accident and emergency attendance individually to determine the number and type of examinations performed and its report status at the time of data collection. This work was undertaken using a modem link to access the Trust's RIS remotely.

Site B:
At this site, a list was generated by the Trust's RIS system of all accident and emergency examinations and it was possible, therefore, to identify the number and type of examinations performed and the report status for each examination at the time of data collection.

Site C:
The Trust's RIS system permitted separate lists to be generated for both reported and unreported examinations and it was possible to identify the number and type of examinations performed for each patient attendance from these lists.

Site D:

This Trust's RIS system enabled separate lists to be generated for both reported and unreported examinations. These lists were used to identify the number and type of examinations performed for each patient attendance.

Site E:

The nature of the RIS system in place in this Trust did not allow for the generation of any lists that would identify those accident and emergency examinations which were reported. Eventually and with much difficulty, specific computer print-outs from which manual comparisons would be possible were produced by the Trust late in the study. However, at the outset of the study it was not envisaged that it would be necessary to collect such data manually. Additionally, the late arrival of these print-outs, meant it was not possible to undertake the manual exercise necessary to enable the volume of reporting activity to be determined at this site.

5.6.2 The Speed of Report Availability

The speed of report availability was determined by the following method for both pre- and post-implementation calculations.

The initial data used to determine the speed with which the report became available were the weekly volumes of all accident and emergency activity which were collected for each week during the designated pre-implementation and post-implementation periods. From these weeks, a 'typical' week was selected according to the volume of reporting activity undertaken. This was identified as the week which was closest to the mean in terms of the volume of reporting activity. Any weeks which included a Bank Holiday were not considered for selection as the typical week.

Once the typical week was selected, all examinations/ attendances for each day of that week were numbered and randomised using computer based random number generation (Microsoft Excel Version 7). A minimum of 100 examinations were selected per week, with no more than 15 examinations chosen for any one day (Monday to Sunday). This minimum sample size enabled differences of 20% in the speed of report availability to be detected. The examinations were selected in the

sequential order in which they appeared on the randomly generated list. Certain categories of examinations were ignored when considering those to be included in the data. These included:

1. any non skeletal examination
2. any skeletal examination which was not part of the study protocol
3. any repeat attendances on the same day
4. any unreported examinations.

If for any of the reasons outlined above an examination was ignored, the next number on the random list was used.

The date on which the examination was performed and the date the report became available on the hospital RIS was recorded. Times were also recorded if these were available.

Where the volume of examinations reported for any one day was too small to allow the minimum sample size of 100 examinations to be collected, the randomly selected examinations were taken from more than one week.

The types of examination included, as well as whether data collected was based on the number of examinations or number of attendances used, was determined by the list generating capabilities of the RIS at each hospital. The exact method used and the type of data collected at each site is highlighted below.

Site A:
Data on the volume of accident and emergency activity for the purposes of calculating the typical week, were based on the number of accident and emergency attendances, including attendances for computed tomography and ultrasound. Pre-implementation data collection was as per the protocol outlined above, and post-implementation data was collected for the 7 weeks during which a radiographic reporting service was operational.

Site B:
Similar to site A, data on the volume of accident and emergency activity for the purposes of calculating the typical week, were based on the number of accident and emergency attendances and included computed tomography and ultrasound attendances.

During the pre-implementation data collection period a total of 10 accident and emergency examinations only as defined by the study protocol were reported. Although the minimum data required for the study protocol could not be met, the speeds of availability of these 10 examinations reported were recorded.

Post-implementation data collection was as per the study protocol outlined above.

Site C:
At this site, data on the volume of accident and emergency activity for the purposes of calculating the typical week were also based on the number of accident and emergency attendances but excluded computed tomography and ultrasound attendances.

Pre-implementation of the RRS, there were relatively few examinations meeting the study protocol which were performed during the weekends or were reported. It was impossible, therefore, to meet the minimum sample size by choosing a 'typical' week. In this case two weeks closest to the mean were chosen for data collection and both of these weeks had identical numbers of attendances.

The post-implementation data collection was as per the study protocol.

Site D:
Data on the volume of accident and emergency activity for the purposes of calculating the typical week were based on the number of accident and emergency attendances and, at this site, excluded computed tomography and ultrasound attendances.

Due to the nature of the site, few examinations meeting the study protocol were either performed or reported during weekends. It was impossible, therefore, to meet

the minimum sample size by choosing a typical week for either pre- or post-implementation data collection. Accordingly, all examinations for both the pre- and post-implementation data collection were randomised by day of the week to meet the minimum sample size required. Once randomised, examinations to be included in the two samples were selected as per the study protocol.

Site E:

Data on the volume of accident and emergency activity for the purposes of calculating the typical week were based on the number of accident and emergency examinations and included computed tomography and ultrasound examinations. It was possible to collect both pre- and post-implementation data in accordance with the study protocol outlined previously.

At all sites reports were placed into the following categories depending on the speed with which they became available on the Trust's RIS system:

1. hot (immediately after the examination)
2. on the same day of examination
3. 1 day after the examination
4. 2 days after the examination
5. 3 days after the examination
6. 4 days after the examination
7. 5 days after the examination
8. 6 days after the examination
9. 7 - 13 days after the examination
10. 14 - 27 days after the examination
11. 28 days or longer after the examination.

The percentage of reports available in fewer than five days was also calculated and Chi squared analysis was used to test for significant difference between the speed of availability of the report pre- and post- RRS implementation. The period of 'fewer than five days' was chosen in the light of statistical advice and was based on the need for an adequate sample size for the test.

5.7 Cost Information Related to Implementation of a Radiographic Reporting System

Estimations of the financial costs and departmental resources involved in implementing a radiographic reporting service were made. These were based on the number of radiographers reporting; the volume of reporting activity undertaken by the radiographers; the time they spent on this activity and the costs identified by each Trust as being associated with the implementation of radiographic reporting. Data were collected via a questionnaire issued to the radiology service managers within the four NHS Trusts (Appendix 1).

5.8 Satisfaction of Users

For the purposes of this study, users of the reporting services provided by the departments of clinical radiology within the four NHS Trusts were identified as radiologists, accident and emergency medical staff and radiology services managers. Accordingly, views on both the reporting services provided and on related issues were sought from these three groups of staff within each NHS Trust, using a combined questionnaire/semi-structured interview technique.

Technically, data were meant to be collected both prior to and post implementation of an RRS in five clinical sites. However, as has been explained, implementation of an RRS had already taken place in three of these five sites by the time this study commenced. It is more appropriate, therefore, to consider the two surveys in terms of an initial survey, conducted in the early weeks of this study and a final survey, carried out as the study neared completion.

The initial survey was carried out between September 1997 and November 1997 when the study team visited all four NHS Trusts (and the five clinical sites) in order to carry out base line data collection. As part of this, taped interviews were carried out with the key clinical radiology staff and both senior and junior accident and emergency medical staff and were transcribed for analysis by the Administrative Assistant of the study team.

The instrument used as the questionnaire/semi-structured interview schedule in the initial survey was in two parts. Part 1 was answered by 26 staff and was a questionnaire similar to the tool used by the Audit Commission in its survey of referring clinicians referred to in its report 'Improving Your Image: How to Manage Radiology Services More Effectively' (1995). Permission was given by the Audit Commission to use this tool. A number of aspects, eleven in total, of the radiology service were identified in the questionnaire (Appendix 2) and respondents were asked to rate each of these. Firstly, they were asked to judge the importance of each aspect on a five point scale ranging from crucial to irrelevant. Secondly, they were asked to rate the quality of each aspect from their own particular perspective on a three point scale ranging from good to poor.

The second part of the schedule was a semi-structured interview which had been designed by the study team to address the local background issues relating to the reporting services within each NHS Trust, as well as those surrounding radiographer reporting specifically (Appendix 2). Only the senior personnel participated in these interviews (n = 12).

During October and November 1998, the study team returned to all four NHS Trusts and conducted a second round of semi-structured interviews, again with senior personnel only; the clinical directors/lead clinicians of both the accident and emergency and the clinical radiology departments and the radiology service managers. On this occasion, the interviews aimed to gauge the satisfaction of these key personnel with the Radiographic Reporting Service that had been implemented at the five sites. In particular, it was anticipated that this would enable common themes surrounding implementation to be identified.

The schedule for these final survey interviews was, again, designed by the study team (Appendix 3) and, as with the initial survey, interviews were taped and transcribed subsequently.

The respondents to the questionnaire part of the initial survey were divided into two groups, accident and emergency staff and clinical radiology staff in order to explore the commonalities and differences between the two groups using rank order tables and Chi squared analyses.

The rating data obtained from the respondents were assigned weighted scores in order to construct rank order tables of firstly, the relative importance of the eleven statements and secondly, the relative quality of each aspect. Weighted scores were as follows:

Importance:	crucial	5
	very important	4
	quite important	3
	not very important	2
	irrelevant	1
Quality:	good	3
	adequate	2
	poor	1

Next, the interviews from the initial survey were analysed thematically with the aid of a computer software package designed to assist in the analysis of qualitative data (QSR NUD*IST 4). For this analysis respondents were considered as a single population and were not sub-divided.

The final survey, the second round of semi-structured interviews with senior accident and emergency staff and senior clinical radiology staff only, was analysed qualitatively and thematically supplemented, where appropriate, with descriptive statistics.

6. Project Plan and Timetable

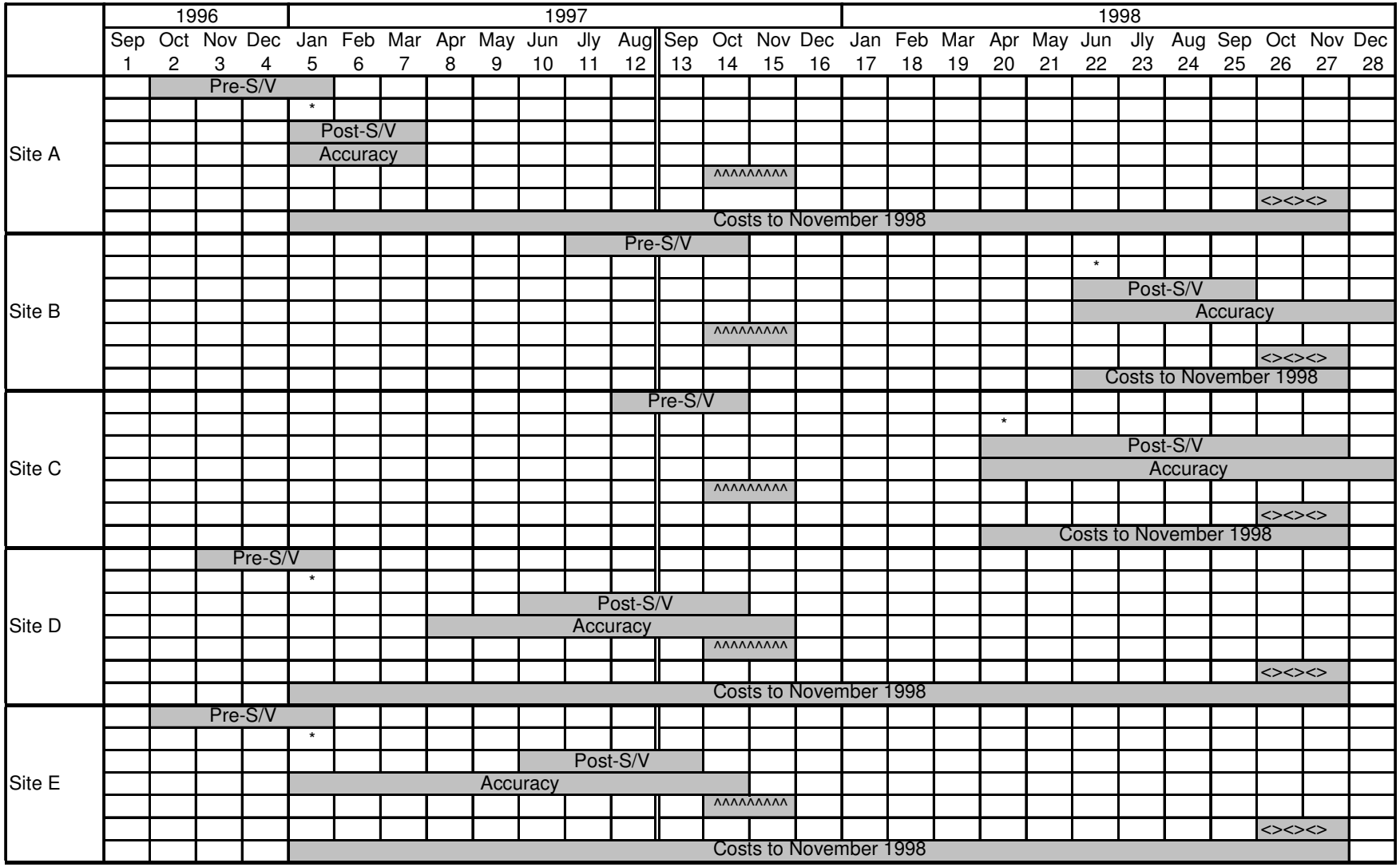
The project commenced on 1 September 1997 and was completed on 31 December 1998. The report of the project was completed in the period 1 January 1999 to 31 March 1999.

The detail of how the project was carried out has been described within the methodology section of this report and is not repeated here. However, it must be emphasised that this was a study that explored the implementation into practice of a new method of delivering, or assisting in the delivery of, reporting services provided by departments of clinical radiology, as well as new roles for radiographers. As such, it was bounded by the considerable operational constraints with the four NHS Trusts implementing a radiographic reporting service at various times in relation to the period agreed for this study. In particular, implementation had taken place on three sites prior to the date on which this study commenced and, at the other two sites, implementation did not take place until well into the study period. This meant that data collection was not co-incident at any of the five sites. The operational constraints also meant that the nature and volume of data collected at each site was not identical and it was necessary to take this into account within the methodology.

An initial site visit was made by the study team to each NHS Trust and all five clinical sites early in the study in order to collect base-line data. Similarly, a final visit was made close to the end of the study period to gather final data. In the interim regular visits were made to the sites according to need and progress towards, or with, implementation of an RRS.

Figure 1 demonstrates the actual project timetable for each site and shows when the various data required were collected.

Figure 1: Project Timetable



Pre-S/V = Pre-implementation Speed and Volume
Post-S/V = Post-implementation Speed and Volume
* = RRS Implemented
^^^^^^^ = Initial questionnaire/interview
<><> = Final questionnaire/interview
‖ = Commencement of the study

7.0 Results

Throughout these results, the identities of each participating NHS Trust, the five clinical sites and the 10 radiographers have been anonymised so that they remain confidential to the study team. The Trusts are referred to as Trusts 1-4, the clinical sites as sites A-E, and the radiographers are numbered randomly 1-10.

7.1 Accuracy of Written Reports for Skeletal Examinations

Nine of the 10 radiographers involved in the study each completed 1050 reports. One radiographer only completed 825 reports due to a period of sickness as the project was nearing its end. In 4 of the 5 clinical sites, every report was verified by a consultant radiologist practising at that site. At one site, however, radiological verification of 2153 reports only was possible. This equated to an average of 430 reports per radiographer involved at that site and, hence, only enabled 2 batches of accuracy data to be included for 4 of the radiographers and 1 batch for the fifth radiographer at that site.

7.1.1 First Analysis

Table 3 shows the total number of examinations reported and verified, together with figures for the number of reports where there was disagreement. It also demonstrates the number of reports which were unable to be resolved. The unresolved cases arose where the first radiologist disagreed with the radiographer's report and the second radiologist's blind report did not enable a consensus to be reached.

Table 3: Agreement between Radiographers and Verifying Radiologists

Total number of examinations reported	10275
Total number of examinations verified	7179
Total number of examinations where the initial radiologist agreed with the radiographer's report	7074
Total number of examinations where the initial radiologist disagreed with the radiographer's report	105
Total number of examinations where there was disagreement and this was confirmed as an FN or FP by second radiologist's blind report	* 74
Total number of examinations where the disagreement was unresolved by the second radiologist's report	31

[* A very small number of examinations (n=4) were unavailable to be reported by the second radiologist and the allocation of FP and FN scores has therefore been based on the first radiologist's findings only.]

It was also noted that in 45 examinations where there was disagreement between the radiographer and the verifying radiologist, the second radiologist's blind report agreed with the radiographer's report. Accordingly, these reports were scored as TP or TN as appropriate on the basis of a two from three consensus.

The prevalence of examinations in which abnormal appearances were reported varied considerably between the 5 clinical sites and is shown in Table 4.

Prevalence was estimated as the total number of TP examinations reported by each radiographer, added to the number of examinations judged to be FN by the two radiologists' reports as a percentage of the total number of examinations reported by that radiographer:

$$\text{Prevalence} = \frac{(TP + FN)}{(TP + TN + FN + FP)} \text{ x } 100\%$$

Table 4: Prevalence of Abnormal Skeletal Examinations (First Analysis)

Radiographer	Prevalence (%)
1	9.4
2	9.1
3	9.4
4	25.3
5	10.2
6	8.7
7	24.0
8	15.1
9	11.2
10	26.1

Descriptive statistical analyses for the prevalence rates are included below:

mean = 14.9

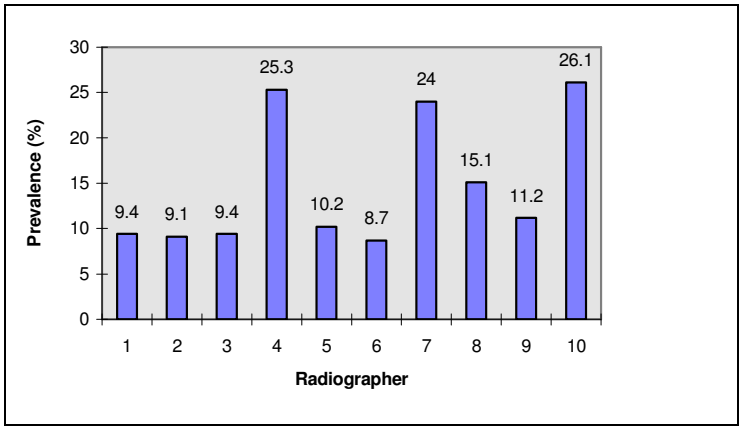
minimum = 8.7

maximum = 26.1

SD = 7.3

The range of prevalence rates are shown in Figure 2.

Figure 2: Prevalence Rates for Examinations Reported by Individual Radiographers



Accuracy, sensitivity and specificity percentages for individual radiographers, for all batches of reports are included in Table 5.

Table 5: Accuracy, Sensitivity and Specificity Percentages for Individual Radiographers (First Analysis)

Radiographer	Accuracy (%)	Sensitivity (%)	Specificity (%)
1	99.1	97.6	99.2
2	99.1	96.9	99.4
3	99.8	100	99.7
4	99.7	99.2	99.9
5	99.1	97.2	99.4
6	99.3	97.4	99.5
7	99.1	98.4	99.4
8	98.8	97.6	99
9	99.6	96.4	100
10	97.1	94.9	97.9

Descriptive statistics for the accuracy, sensitivity and specificity rates are shown below:

Accuracy

mean	=	99.07
minimum	=	97.1
maximum	=	99.8
SD	=	0.76
SE	=	0.24

95% confidence in total of mean = 98.5 to 99.6

Sensitivity

mean	=	97.6
minimum	=	94.9
maximum	=	100
SD	=	1.43
SE	=	0.45

95% confidence in total of mean = 96.5 to 98.6

Specificity

mean	=	99.3
minimum	=	97.9
maximum	=	100
SD	=	0.59
SE	=	0.19

95% confidence in total of mean = 98.9 to 99.8

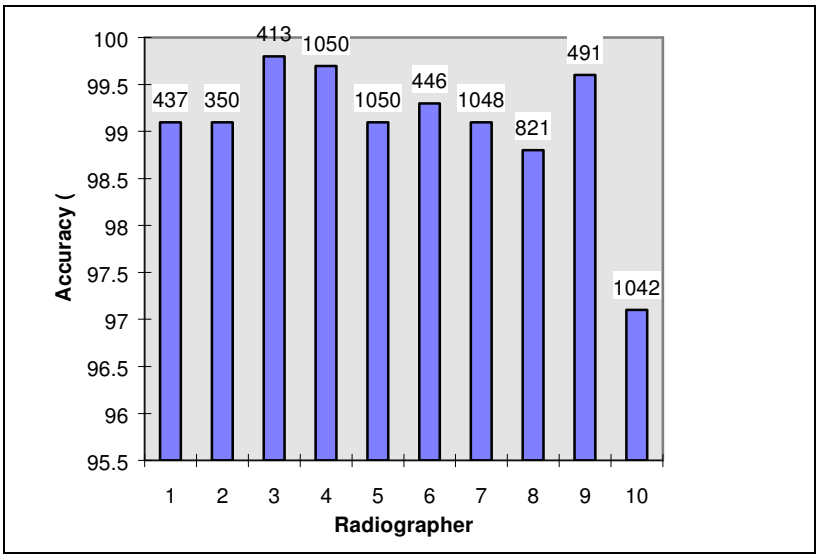
Regression of agreement rates on total reports was performed with each radiographer omitted in turn. Table 6 shows F values and nominal significance levels of the degree to which consistency was improved by each omission.

Table 6: Regression Analysis on Accuracy Rates

Radiographer	F Value	P
1	0	1.0
2	0.043	0.842
3	0.099	0.763
4	6.957	0.034
5	0.2	0.668
6	0	1.0
7	0.186	0.68
8	0.014	0.91
9	0.099	0.763
10	56	0.001

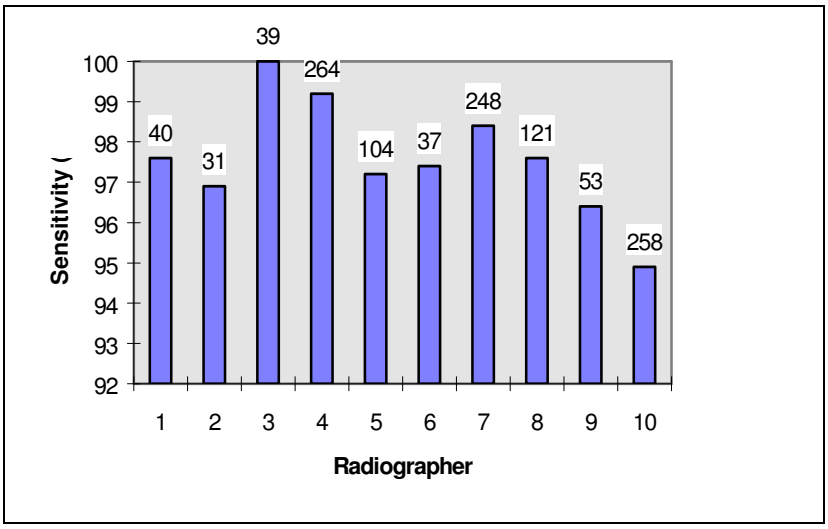
A significant difference was demonstrated for radiographer 10. However, the 95% Confidence Interval is extremely close to 100% and the data does not exactly fit that of a normal distribution. It would be advisable therefore to submit these agreement rates to further regression analysis using Poisson modelling. Figures 3, 4 and 5 show the range of accuracy, sensitivity and specificity percentages respectively.

Figure 3: Accuracy Percentages for Individual Radiographers



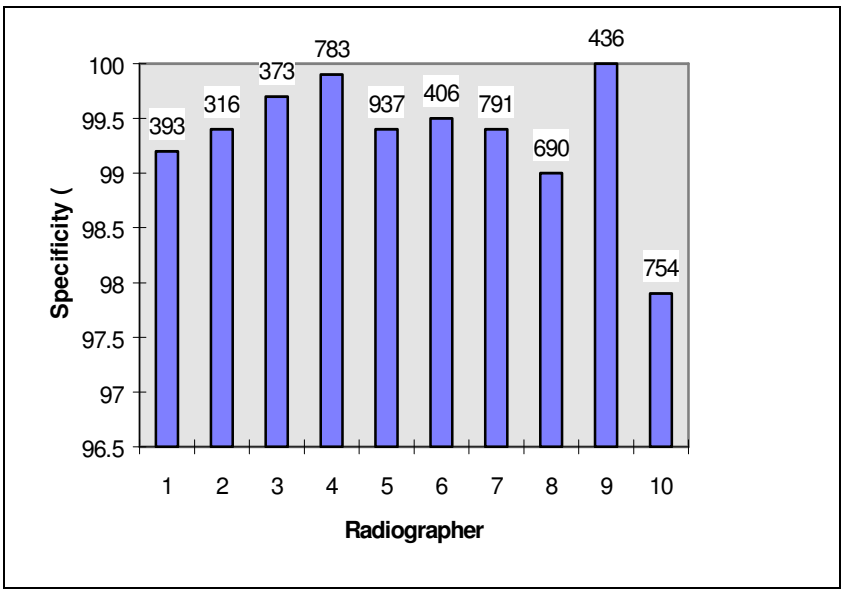
[The number at the head of each column refers to the number of examinations included in the analysis.]

Figure 4: Sensitivity Percentages for Individual Radiographers



[The number at the head of each column refers to the number of examinations included in the analysis.]

Figure 5: Specificity Percentages for Individual Radiographers



[The number at the head of each column refers to the number of examinations included in the analysis.]

The aggregated totals of true positive, true negative, false positive and false negative rates for each anatomical area are shown in Table 7 and the corresponding accuracy, sensitivity and specificity percentages are shown in Table 8.

Table 7: Aggregated Totals of Agreement and Disagreement Fractions by Anatomical Area

Anatomical Area	TP	TN	FP	FN
Upper extremity	785	2529	24	24
Lower extremity	353	2340	15	4
Pelvis	26	173	2	1
Cervical vertebrae	0	164	0	0
Thoracic vertebrae	0	28	0	0
Lumbo-sacral vertebrae	12	76	0	0
Skull & facial bones	19	569	2	2
Total	1195	5879	43	31

Table 8: Accuracy, Sensitivity and Specificity Percentages by Anatomical Area

Anatomical Area	Accuracy (%)	Sensitivity (%)	Specificity (%)
Upper extremity	98.6	97.0	99.1
Lower extremity	99.3	98.9	99.4
Pelvis	98.5	96.3	98.9
Cervical vertebrae	100.0	-	100.0
Thoracic vertebrae	100.0	-	100.0
Lumbo-sacral vertebrae	100.0	100.0	100.0
Skull & facial bones	99.3	90.5 *	99.6

(* based on a very small sample of TP examinations, n=19)

Accuracy, sensitivity and specificity values are shown in Figures 6, 7 and 8. [In each of the graphs, the number at the head of each column refers to the number of examinations included in the analysis.]

Figure 6: Aggregated Accuracy Percentages for Different Anatomical Areas

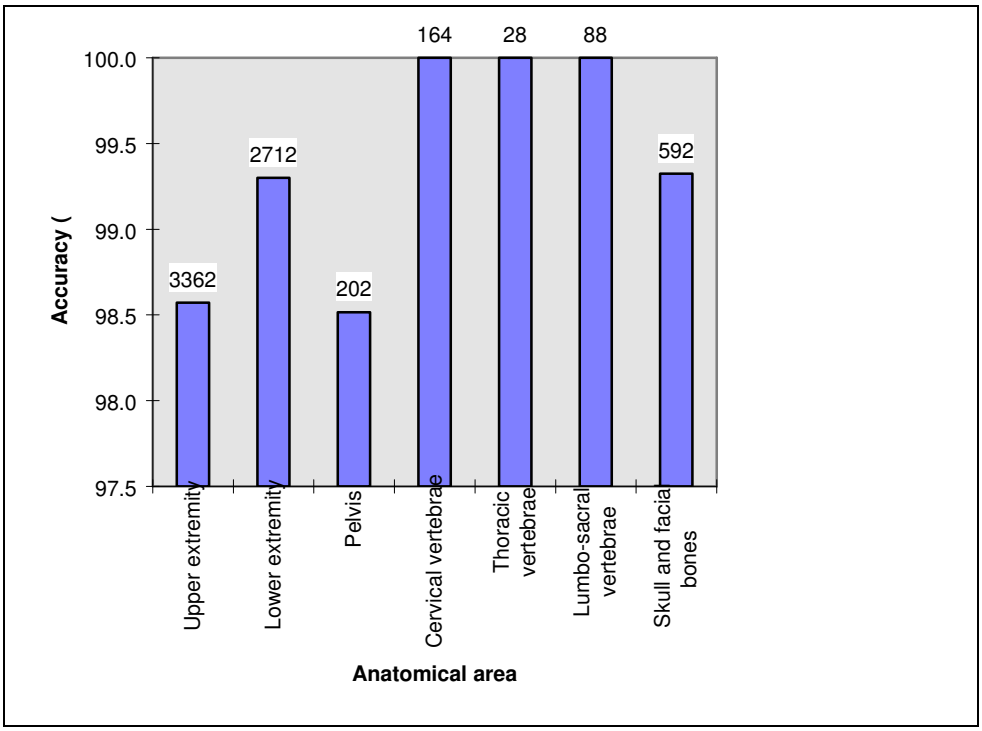


Figure 7: Aggregated Sensitivity Percentages for Different Anatomical Areas

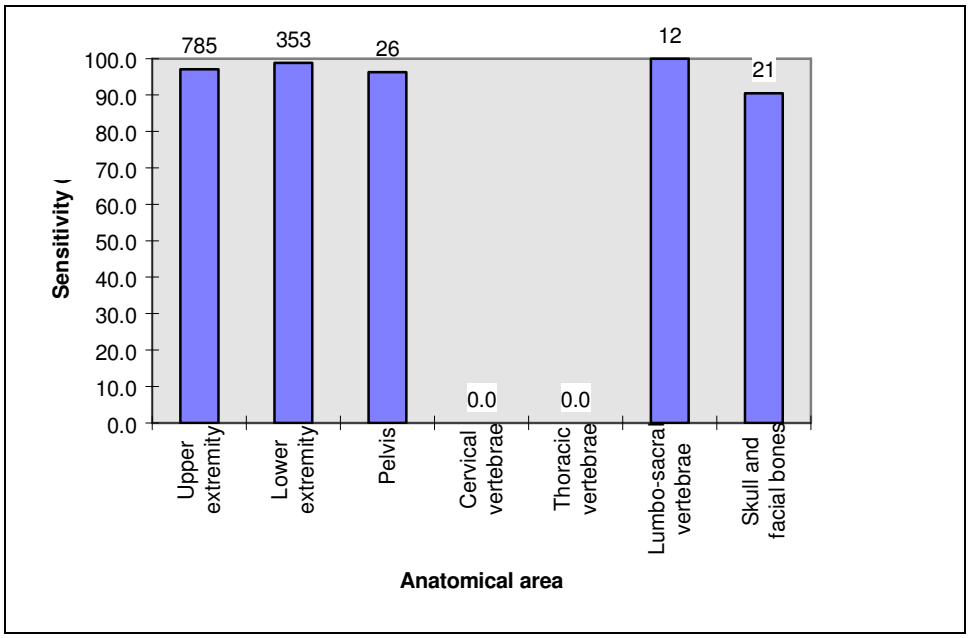
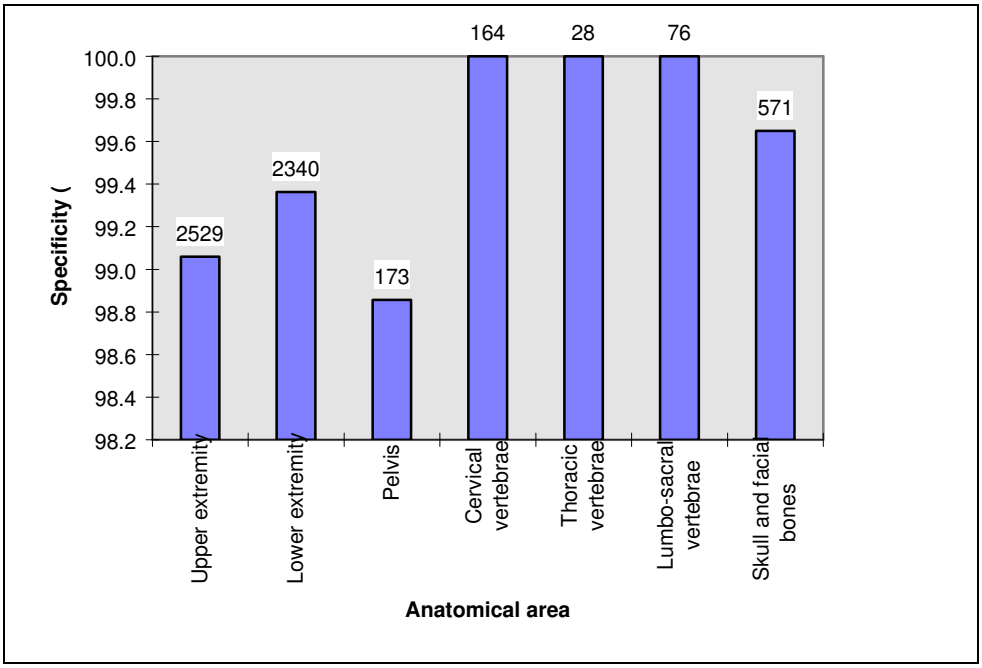


Figure 8: Aggregated Specificity Percentages for Different Anatomical Areas



Chi^2 tests for significance revealed no statistical difference between the accuracy, sensitivity and/or specificity rates for the different anatomical areas. Results are shown in Table 9.

Table 9: Tests for Significant Differences Between Anatomical Areas

Rate	Chi^2 value	DOF	P
Accuracy	0.07	7	0.99
Sensitivity *	0.10	4	0.99
Specificity	0.02	7	1

* Cervical and thoracic vertebrae not included as no positive examinations were reported.
Skull and facial bones were aggregated for values to exceed 5.

Accuracy, sensitivity and specificity percentages were calculated for each radiographer and were analysed for any significant differences between batches of reports. The results of these Chi^2 analyses are summarised in Table 10.

Table 10: Chi squared Tests for Differences in Accuracy, Sensitivity and Specificity for Different Batches of Reports

Radiographer	Accuracy			Sensitivity			Specificity		
	Chi squared	DOF	P	Chi squared	DOF	P	Chi squared	DOF	P
1	.005	1	.94	.009	1	.92	.003	1	.96
2	-	-	-	-	-	-	-	-	-
3	.0002	1	.99	*	*	*	.0002	1	.99
4	.002	2	.99	.003	2	.99	.001	2	.99
5	.009	2	.99	0	2	.99	.009	2	.99
6	.005	1	.94	.015	1	.90	.002	1	.96
7	.011	2	.99	.018	2	.99	.005	2	.99
8	.02	2	.98	.05	2	.97	.007	2	.99
9	.0008	1	.98	.037	1	.85	+	+	+
10	.015	2	.99	.04	2	.98	.006	2	.99

- \- Only one batch (n=350) was available for this radiographer
- * Sensitivity 100% in the two batches of reports for this radiographer
- \+ Specificity 100% in the two batches of reports for this radiographer

No significant differences in accuracy, sensitivity and/or specificity were demonstrated for any radiographer over time.

Individual Trusts

In Trusts where more than one radiographer had contributed to the RRS the TP, TN, FP and FN scores for individual radiographers were aggregated to estimate the total fractions as shown in Table 11. The resultant accuracy, sensitivity and specificity for each Trust is shown in Table 12 and Figures 9, 10 and 11.

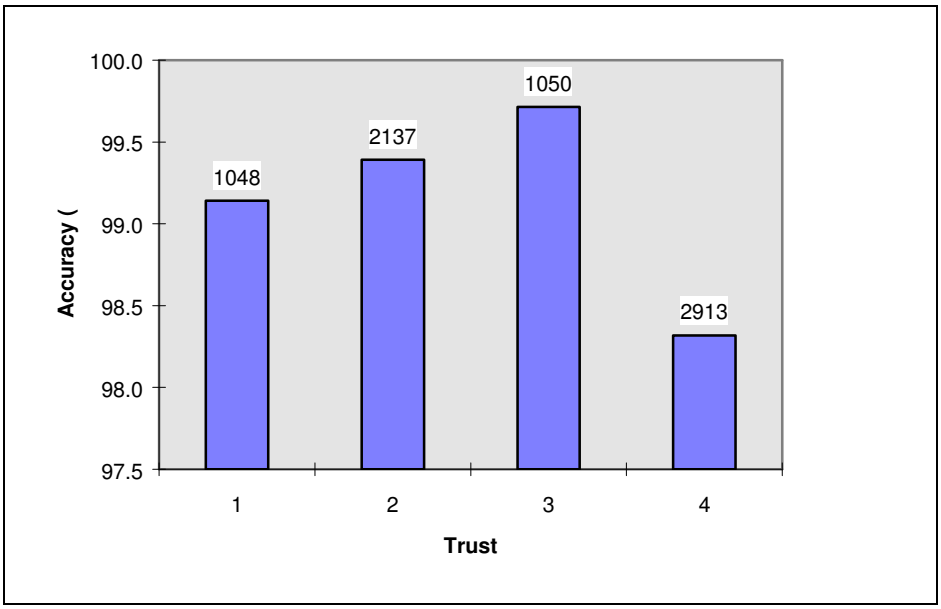
Table 11: Aggregated Totals of Agreement and Disagreement Fractions by Trust

Trust	TP	TN	FP	FN	Total
1	248	791	5	4	1048
2	200	1924	8	5	2137
3	264	783	1	2	1050
4	483	2381	29	20	2913
Total	**1195**	**5879**	**43**	**31**	**7148**

Table 12: Aggregated Accuracy, Sensitivity and Specificity Percentages for each Trust

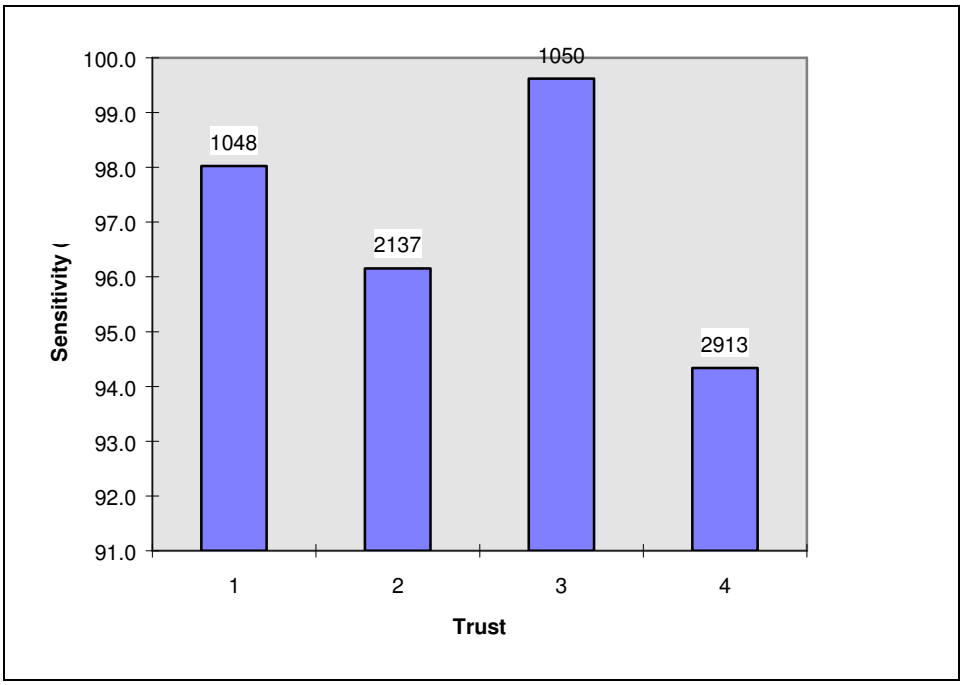
Trust	Accuracy (%)	Sensitivity (%)	Specificity (%)
1	99.1 %	98.4 %	99.4 %
2	99.4 %	97.6 %	99.6 %
3	99.7 %	99.2 %	99.9 %
4	98.3 %	96.0 %	98.8 %

Figure 9: Aggregated Accuracy Percentages for all Trusts



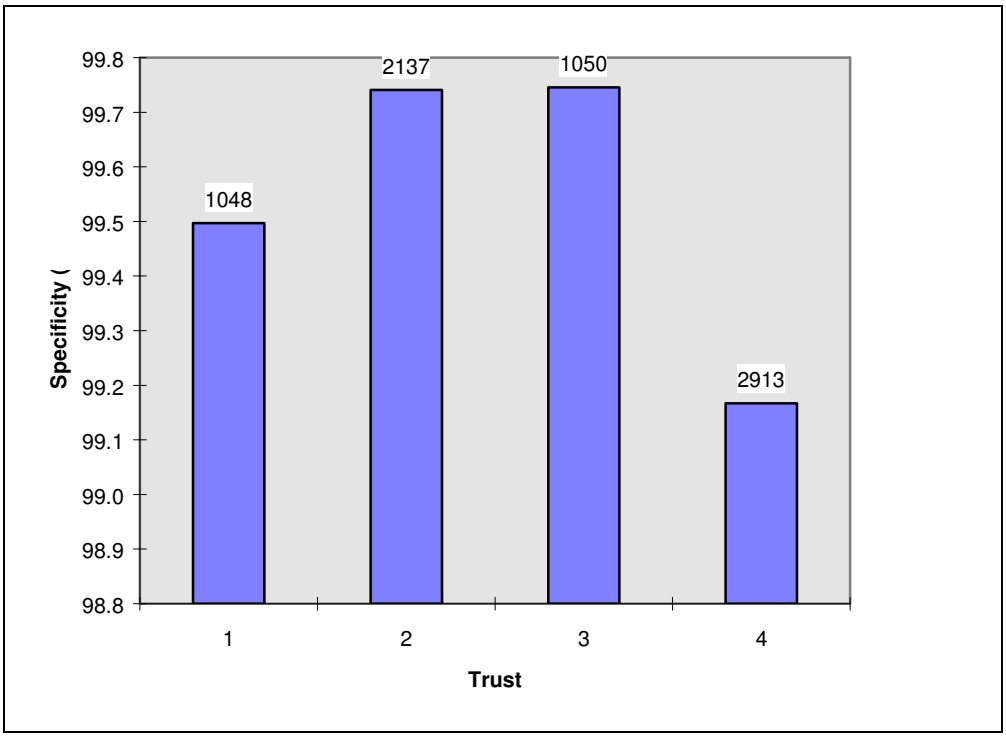
[Numbers at the head of each column refer to the number of reports included in the analysis.]

Figure 10: Aggregated Sensitivity Percentages for all Trusts



[Numbers at the head of each column refer to the number of reports included in the analysis.]

Figure 11: Aggregated Specificity Percentages for all Trusts



[Numbers at the head of each column refer to the number of reports included in the analysis.]

7.1.2 Second Analysis

The prevalence of abnormal examinations was estimated as for the first analysis. The resulting prevalence values for this second analysis are shown in Table 13.

Table 13: Prevalence of Abnormal Skeletal Examinations (Second Analysis)

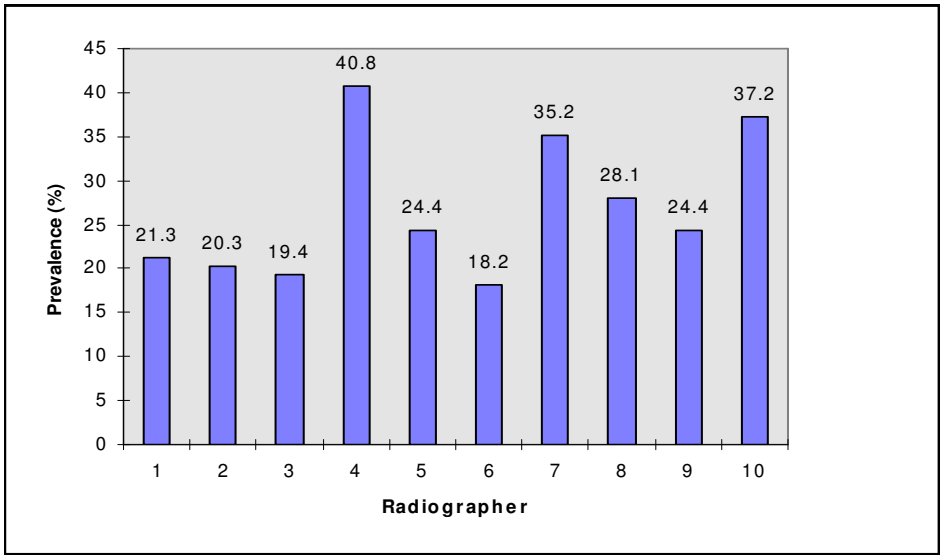
Radiographer	Prevalence (%)
1	21.3
2	20.3
3	19.4
4	40.8
5	24.4
6	18.2
7	35.2
8	28.1
9	24.4
10	37.2

Descriptive statistics for the prevalence of abnormal examinations for the second analysis were calculated as follows:

Mean	=	26.9
Minimum	=	18.2
Maximum	=	40.8

Prevalence percentages for the second analysis are also shown in Figure 12.

Figure 12: Prevalence Percentages (Second Analysis)



[Numbers at the head of each column refer to the individual prevalence rates for each radiographer.]

Accuracy, sensitivity and specificity percentages (second analysis) for individual radiographers are included in Table 14 and Figures 13, 14 and 15.

Table 14: Accuracy, Sensitivity and Specificity Percentages for Individual Radiographers (Second Analysis)

Radiographer	Accuracy (%)	Sensitivity (%)	Specificity (%)
1	99.1	98.9	99.1
2	98.9	97.2	99.3
3	99.5	100	99.4
4	99.7	99.5	99.8
5	98.5	96.5	99.1
6	99.3	98.8	99.5
7	99	98.6	99.1
8	98.3	97	98.8
9	99.4	97.5	100
10	95.8	95.3	96

Descriptive statistics for the second analysis are shown below:

Accuracy

mean	=	98.75
minimum	=	95.8
maximum	=	99.7
SD	=	1.12
SE	=	0.36
95% confidence in total of mean	=	97.9 to 99.6

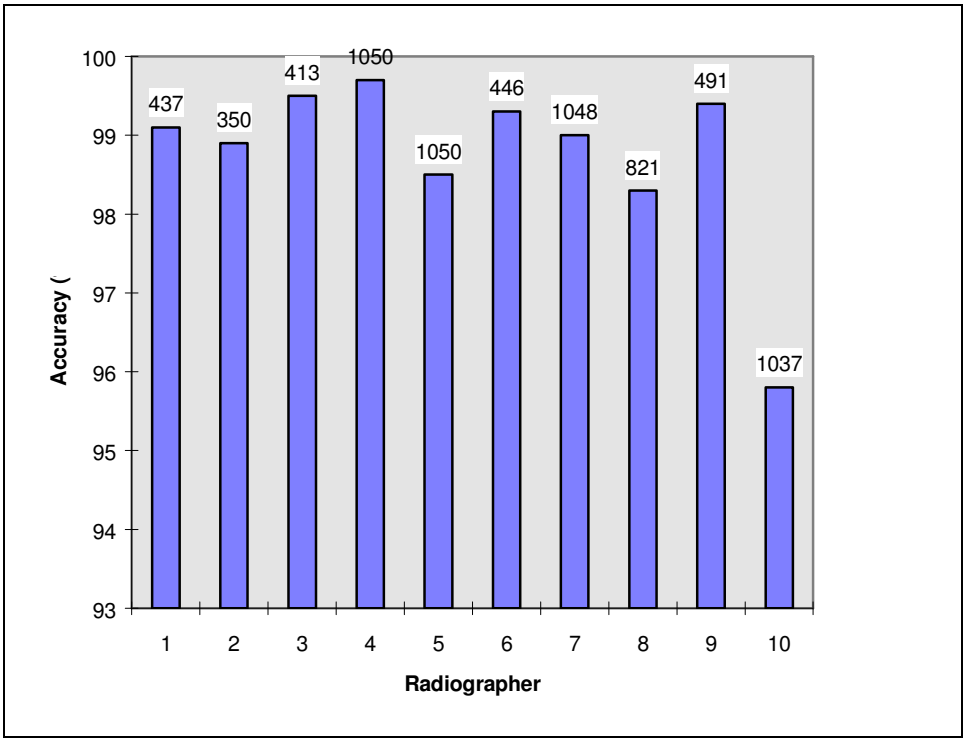
Sensitivity

mean	=	97.9
minimum	=	95.3
maximum	=	100
SD	=	1.47
SE	=	0.46
95% confidence in total of mean	=	96.9 to 99.0

Specificity

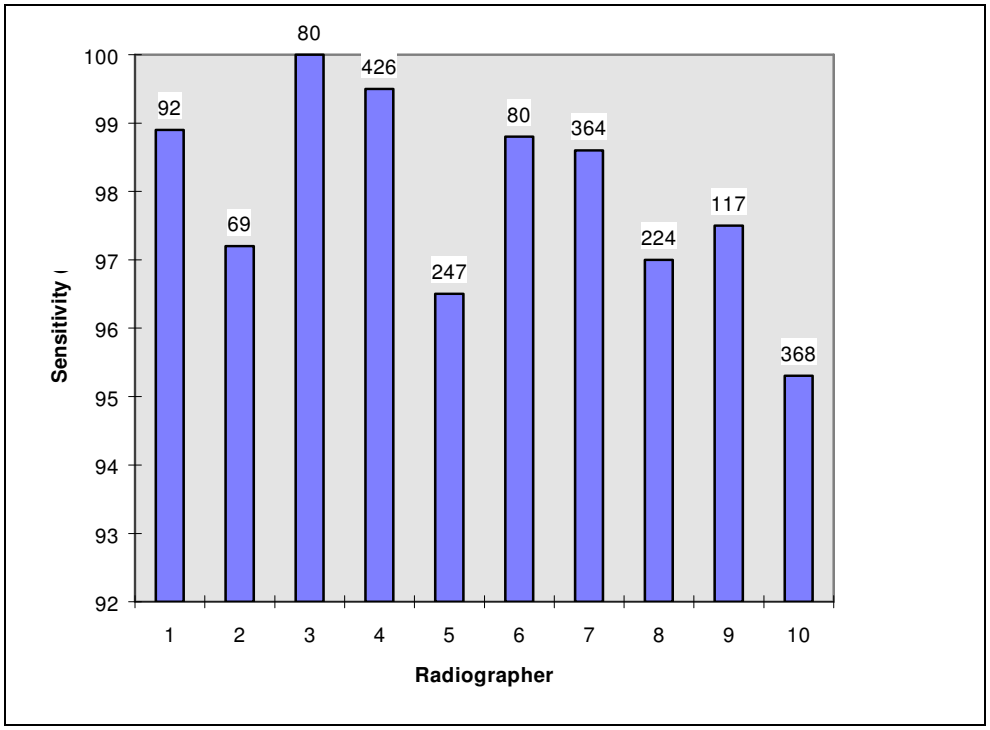
mean	=	99.0
minimum	=	96.0
maximum	=	100
SD	=	1.12
SE	=	0.35
95% confidence in total of mean	=	98.2 to 99.8

Figure 13: Accuracy Percentages for Individual Radiographers (Second Analysis)



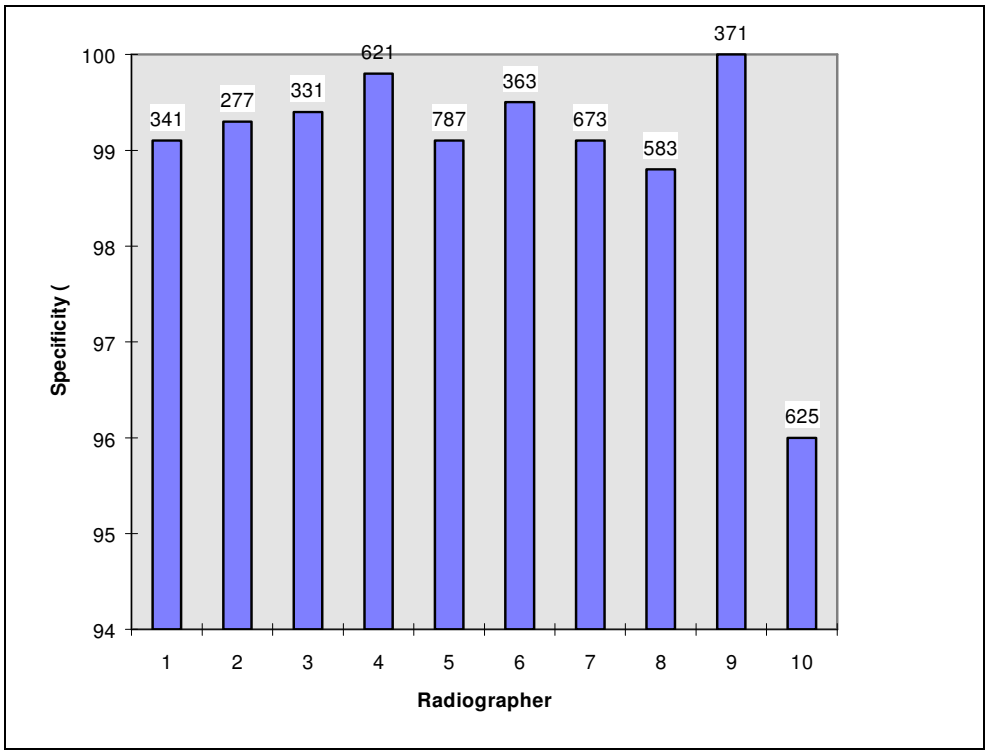
[Numbers at the head of each column refer to the number of reports included in the analysis.]

Figure 14: Sensitivity Percentages for Individual Radiographers (Second Analysis)



[Numbers at the head of each column refer to the number of reports included in the analysis.]

Figure 15: Specificity Percentages for Individual Radiographers (Second Analysis)



[Numbers at the head of each column refer to the number of reports included in the analysis.]

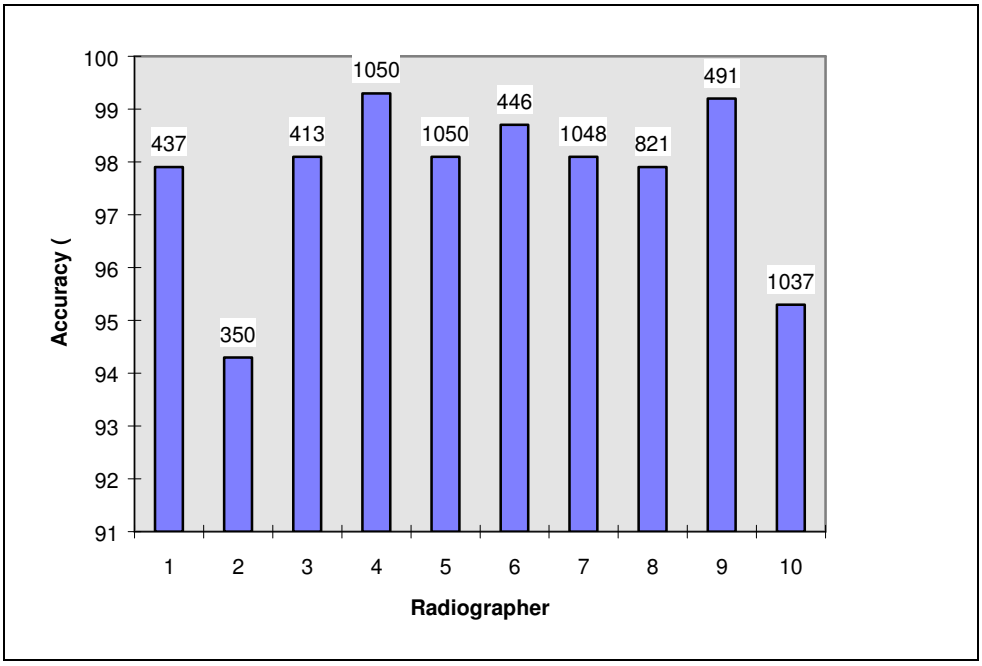
7.1.3 Third Analysis

Accuracy, sensitivity and specificity percentages for the third analysis are shown in Table 15 and Figures 16, 17 and 18.

Table 15: Accuracy, Sensitivity and Specificity Percentages for Individual Radiographers (Third Analysis)

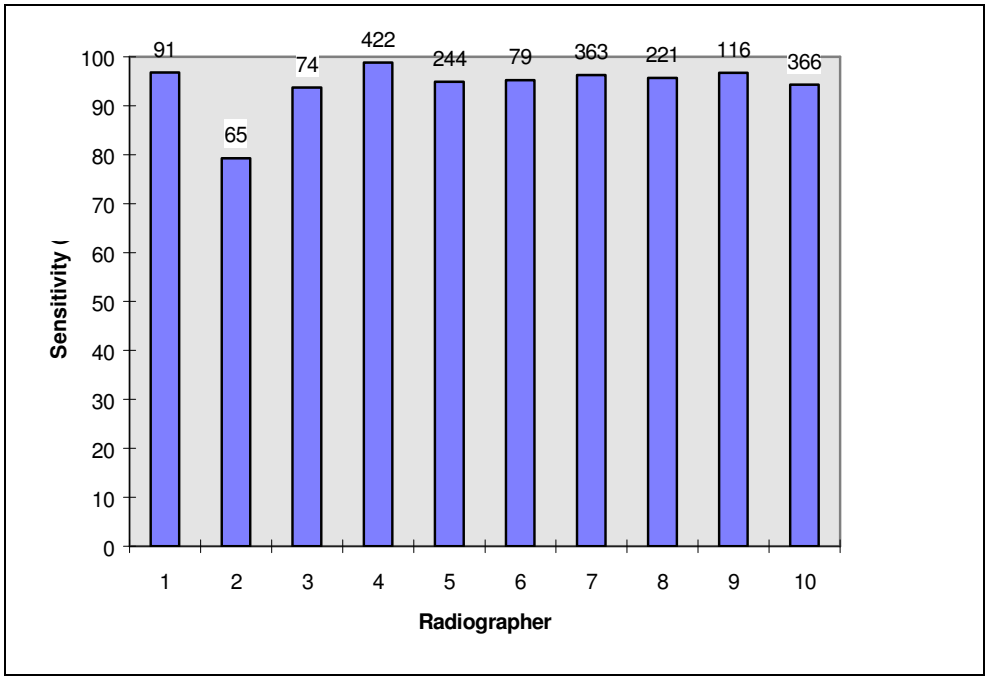
Radiographer	Accuracy (%)	Sensitivity (%)	Specificity (%)
1	97.9	96.8	98.3
2	94.3	79.3	98.9
3	98.1	93.7	99.1
4	99.3	98.8	99.7
5	98.1	94.9	99.1
6	98.7	95.2	99.4
7	98.1	96.3	99.1
8	97.9	95.7	98.8
9	99.2	96.7	100
10	95.3	94.3	95.8

Figure 16: Accuracy Percentages for Individual Radiographers (Third Analysis)



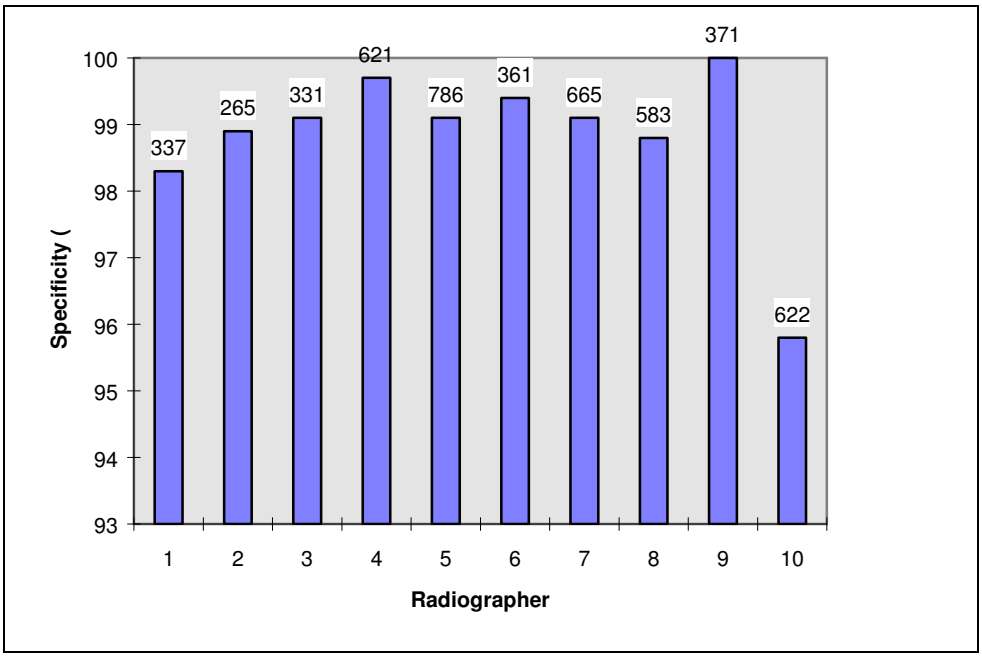
[Numbers at the head of each column refer to the number of reports included in the analysis.]

Figure 17: Sensitivity Percentages for Individual Radiographers (Third Analysis)



[Numbers at the head of each column refer to the number of reports included in the analysis.]

Figure 18: Specificity Percentages for Individual Radiographers (Third Analysis)



[Numbers at the head of each column refer to the number of reports included in the analysis.]

Table 16: Reported and Unreported Accident and Emergency Skeletal Examinations (Pre and Post-Implementation RRS)

Site	Pre- implementation of RRS			Post-implementation of RRS			Difference	
	Total examinations	Total reported	% reported	Total examinations	Total reported	% reported	Chi squared	p
A *	2889	2871	99.4 %	1770	1758	99.3%	0	NSD
B	4488	12	0.27 %	4534	2611	57.6 %	2080	0
C	3360	1943	57.8 %	2993	1713	57.2 %	0.05	NSD
D	665	467	70.2 %	1013	921	90.9 %	11.4	.0007
E	5909 +	N/A	N/A	6076 +	N/A	N/A		

N/A Data not available

NSD No significant difference

* The post-implementation data relates to the 7 weeks where the RRS was in operation.

+ includes ALL accident and emergency referrals

Of the 4 sites where comparison was possible a significant improvement was demonstrated at 2 of the sites. At the remaining 2 sites no difference was evident in relation to the volume of accident and emergency radiographs reported, with the total percentage of examinations reported remaining largely unchanged.

The total number of reported and unreported accident and emergency skeletal examinations were also aggregated for each Trust and are shown in Table 17.

Table 17: Aggregated Total of Reported and Unreported Accident and Emergency Skeletal Radiographs for each Trust

Trust	Pre-implementation of RRS			Post-implementation of RRS		
	Total examinations	Total reported	% reported	Total examinations	Total reported	% reported
1	5909	N/A	N/A	6076	N/A	N/A
2	4488	12	0.3 %	4534	2611	57.6 %
3	2889	2871	99.4 %	1783	1770	99.3 %
4	4025	2410	59.9 %	4006	2634	65.8 %

N/A Data not available

The aggregated totals for Trust 2 and Trust 4 reveal significant increases in the volume of examinations reported,

(Chi squared = 2080, p=0, Chi squared = 6.7, p=0.009, respectively).
The number and percentage of accident and emergency skeletal examinations reported for each anatomical area and for 4 of the 5 sites is shown in Tables 18, 19, 20 and 21. Site E is not shown as data are unavailable.

Table 18: Percentage of Accident and Emergency Skeletal Examinations Reported at Site A for each Anatomical Area (Pre and Post-Implementation RRS)

Anatomical area	Pre-implementation		Post-implementation	
	Total number of examinations	% reported	Total number of examinations	% reported
Upper extremity	1238	99.4 %	774	99.4 %
Lower extremity	769	99.3 %	475	99.2 %
Pelvis	176	98.3 %	129	99.2 %
Cervical vertebrae	181	99.4 %	97	100 %
Thoracic vertebrae	13	100 %	21	100 %
Lumbo-sacral vertebrae	69	100 %	43	100 %
Cranium	294	100 %	161	99.4 %
Facial bones	149	98.7 %	83	97.6 %
Total	2889	99.4 %	1783	99.3 %

Table 19: Percentage of Accident and Emergency Skeletal Examinations Reported at Site B for each Anatomical Area (Pre and Post-Implementation RRS)

Anatomical area	Pre-implementation		Post-implementation	
	Total number of examinations	% reported	Total number of examinations	% reported
Upper extremity	1918	0.05 %	2084	53.4 %
Lower extremity	1464	0.27 %	1384	68.4 %
Pelvis	310	0.65 %	303	33.3 %
Cervical vertebrae	193	0	168	56.0 %
Thoracic vertebrae	35	0	36	41.7 %
Lumbo-sacral vertebrae	89	1.12 %	102	39.2 %
Cranium	387	0.52 %	343	66.2 %
Facial bones	92	2.1 %	114	65.0 %
Total	4488	0.27%	4534	57.6 %

Table 20: Percentage of accident and emergency skeletal examinations reported at site C for each anatomical area (pre and post-implementation RRS)

Anatomical area	Pre-implementation		Post-implementation	
	Total number of examinations	% reported	Total number of examinations	% reported
Upper extremity	1479	47.1 %	1460	47.4%
Lower extremity	986	70.4 %	1032	66.5%
Pelvis	361	42.7 %	79	52.0%
Cervical vertebrae	173	79.2 %	154	69.0 %
Thoracic vertebrae	32	71.9 %	23	74.0 %
Lumbo-sacral vertebrae	92	80.4 %	76	73.9 %
Cranium	196	71.0 %	126	71.4 %
Facial bones	41	61.0 %	43	58.2 %
Total	3360	57.8 %	2993	57.2 %

Table 21: Percentage of Accident and Emergency Skeletal Examinations Reported at Site D for each Anatomical Area (Pre and Post-Implementation RRS)

Anatomical area	Pre-implementation		Post-implementation	
	Total number of examinations	% reported	Total number of examinations	% reported
Upper extremity	374	62.3 %	534	90.1 %
Lower extremity	204	80.0 %	341	93.6%
Pelvis	32	75.0 %	64	84.4 %
Cervical vertebrae	20	100 %	19	89.5 %
Thoracic vertebrae	5	80.0 %	2	100 %
Lumbo-sacral vertebrae	12	91.0 %	14	92.9 %
Cranium	12	75.0 %	23	95.7 %
Facial bones	6	50.0 %	16	81.3%
Total	**665**	**70.2 %**	**1013**	**90.9 %**

7.3 Speed of report availability

The number and percentage of reports for accident and emergency skeletal examinations which became available within 5 days of the examination are shown in Table 22. Figures for both the pre and post-implementation periods are shown.

Table 22: Number and Percentage of Reports Available within 5 Days

Site	Pre- RRS implementation		Post- RRS implementation		Difference	
	Number of reports	%	Number of reports	%	Chi squared	p
A	30/103	29.1%	69/105	65.7 %	9.32	0.002
B	2/10 +	20 %	100/105	95.2 %	51.55	0
C	102/105	97.1%	80/103	77.7%	0.99	0.3
D	71/105	67.6%	102/105	97.1%	2.72	0.09
E	50/105	47.6 %	83/105	79.0 %	4.58	0.03

* In the pre-implementation period fewer than 1 % of accident and emergency skeletal examinations had been reported and during the typical week selected for speed of report analysis only 10 examinations had been reported.

\+ Value is less than 5.

Sites A and E demonstrated a significant improvement in the speed with which the reports became available.

The number of reports which were available within 5 days were also aggregated for each Trust and are shown in Table 23.

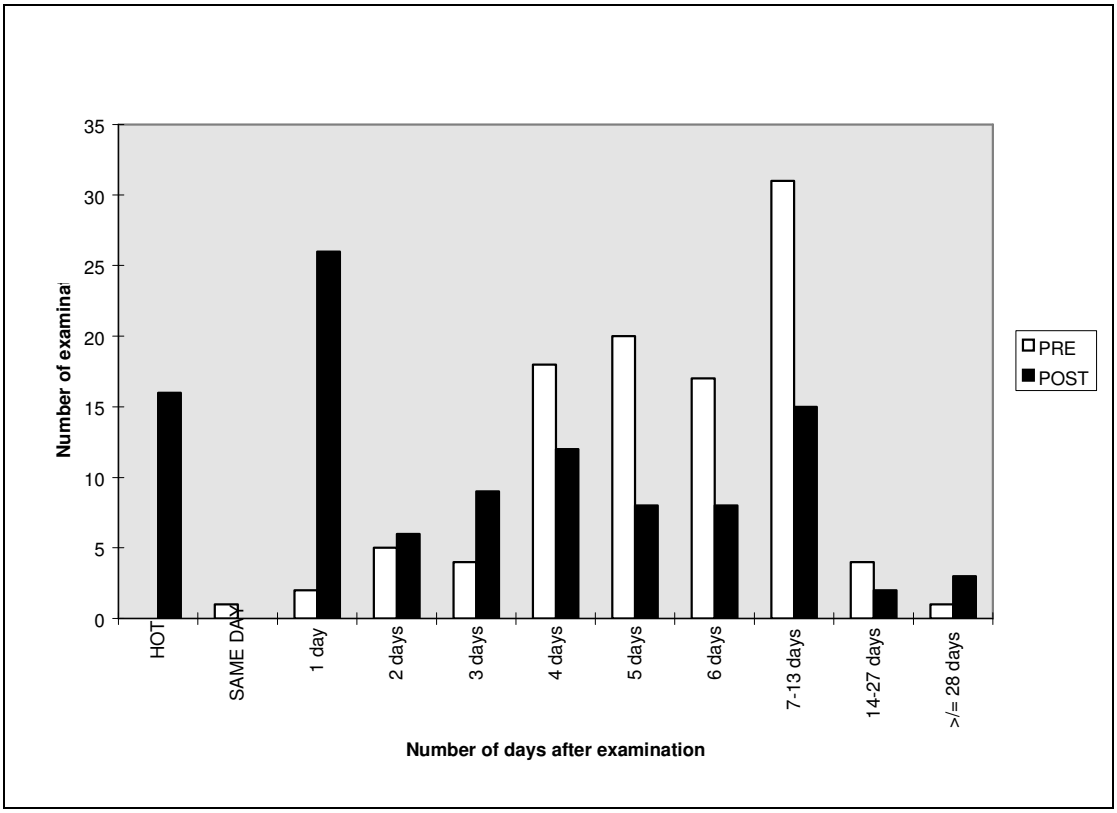
Table 23: Aggregated Number of Reports Available within 5 Days for each Trust

	Pre- RRS implementation		Post- RRS implementation	
Trust	Number of reports	%	Number of reports	%
1	50/105	47.6 %	83/105	79.0 %
2	2/10	*	100/105	95.2 %
3	30/103	29.1 %	69/105	65.7 %
4	173/210	82.4 %	182/208	87.5%

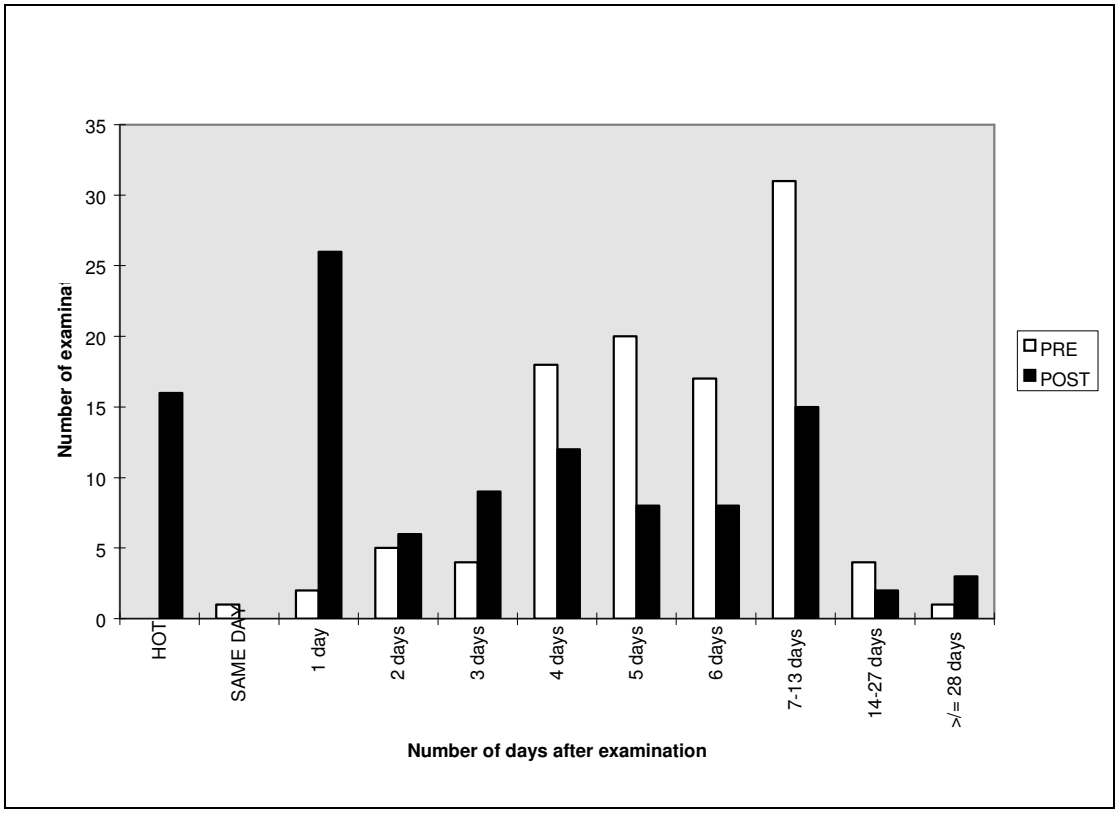
Trusts 1 and 3 demonstrated a significant increase in the speed with which reports became available (Chi squared = 4.58, p=0.03; and Chi squared =9.32, p=0.002 respectively). Trust 4 shows some increase between the pre- and post-implementation periods although the difference does not reach statistical significance (Chi squared =0.1, p=0.7).

The speed of report availability is illustrated graphically in Figures 19, 20, 21, 22 and 23 respectively.

Figure 19: Speed of Report Availability at Site A (Pre and Post-Implementation)

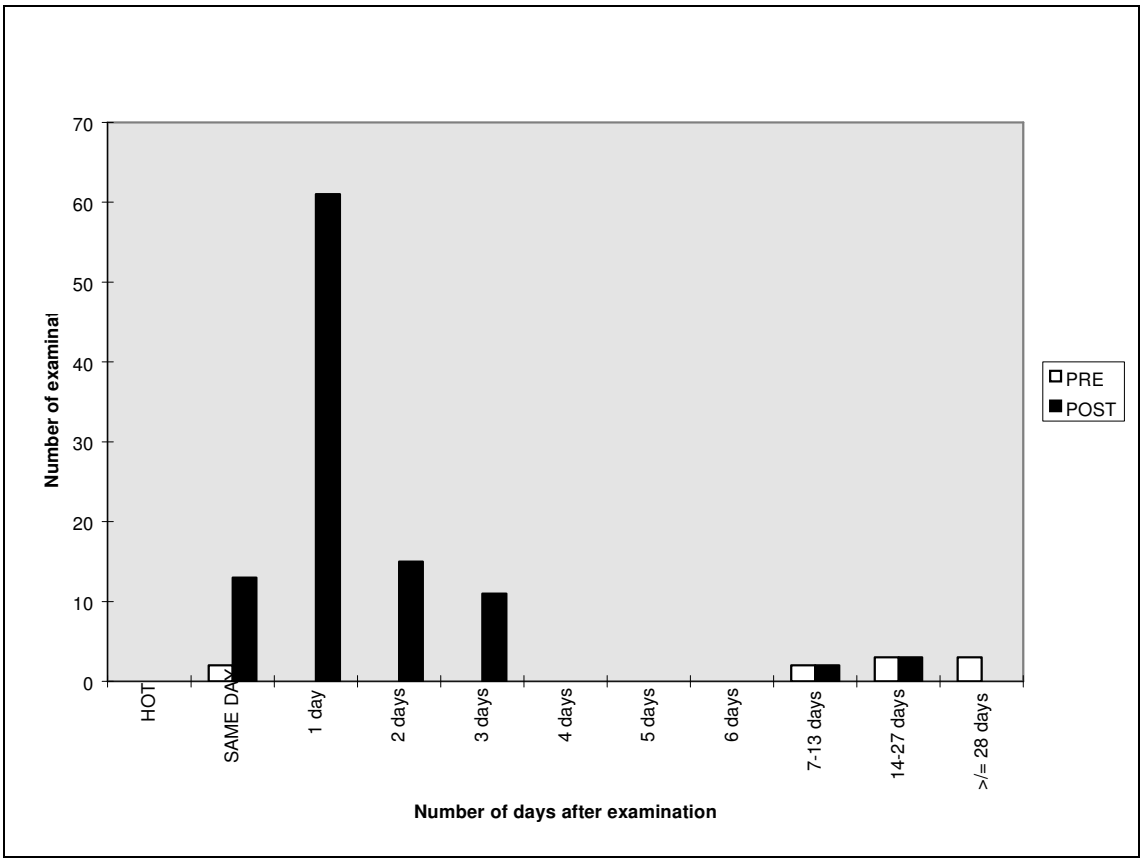


At this site there was a significant increase (29 % to 66 %) in the number of reports which became available within 5 days in the post-implementation period (P=0.002) as shown in Table 22.



At this site there was a significant increase (29 % to 66 %) in the number of reports which became available within 5 days in the post-implementation period (P=0.002) as shown in Table 22.

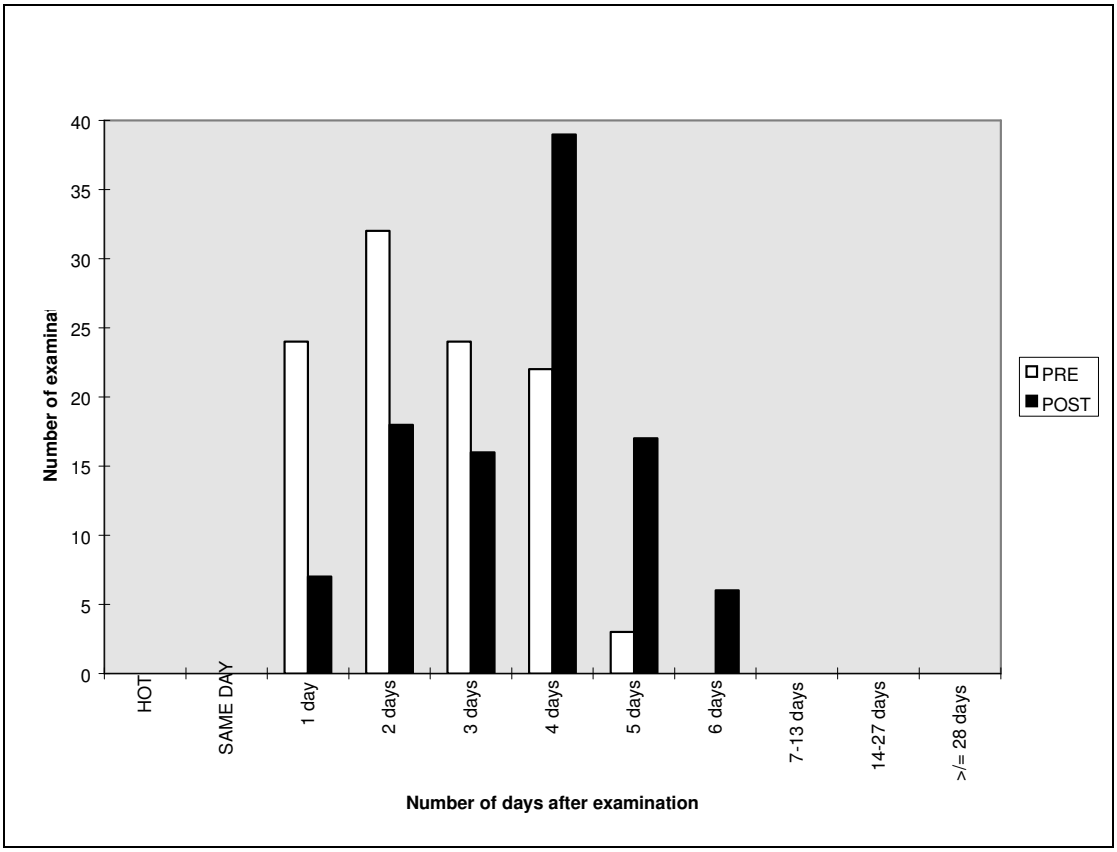
Figure 20: Speed of Report Availability at Site B (Pre and Post-Implementation)



At Site B, due to the very low level of reporting in the pre-implementation period, it was not possible to collect sufficient data in this period to enable a statistical comparison of the pre- and post- implementation periods to be made.

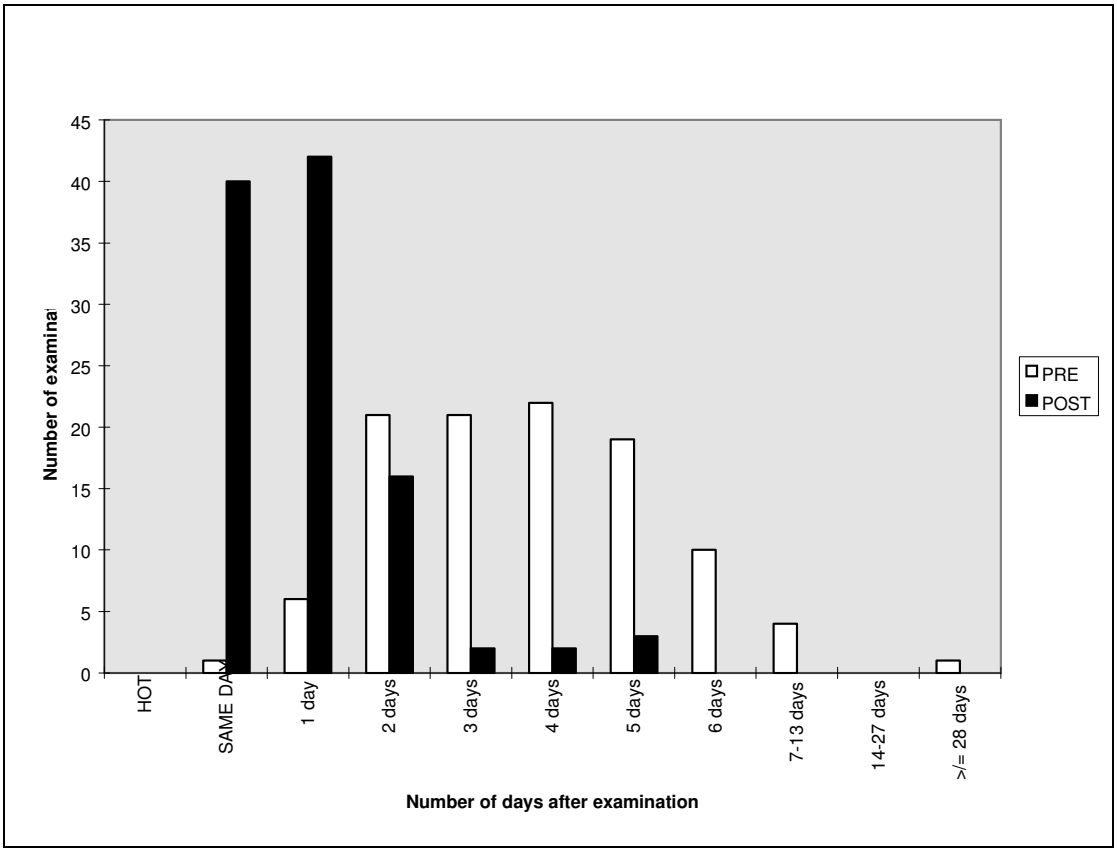
In the post-implementation period, however, 95 % of reports on accident and emergency skeletal examinations became available in fewer than 5 days from the date of the radiographic examination. This is demonstrated in Table 22.

Figure 21: Speed of Report Availability at Site C (Pre and Post-Implementation)



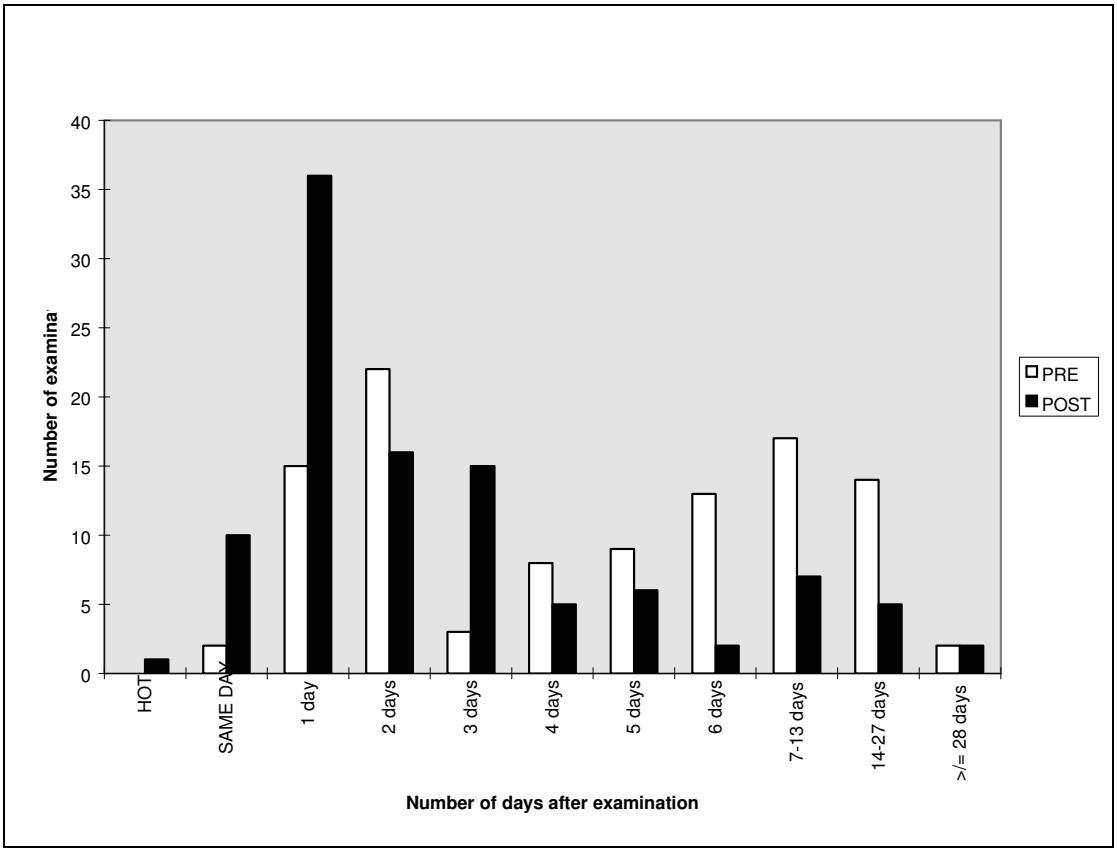
There was a decrease (97% to 78%) in the number of reports which became available within 5 days at Site C although the difference did not reach statistical significance (p=0.3). See Table 22.

Figure 22: Speed of Report Availability at Site D (Pre and Post-Implementation)



There was an increase (68% to 97%) in the number of reports which became available within 5 days at Site D. The difference did not reach statistical significance (p=0.09), as is shown in Table 22.

Figure 23: Speed of Report Availability at Site E (Pre and Post-Implementation)



There was a significant increase (48% to 79%) in the number of reports which became available in the post-implementation period ($p=0.03$), as shown in Table 22.

7.4 Summary of Key Results for Radiographer Accuracy, Volume of Reporting Activity and Speed of Availability of Reports

The results from the first analysis of the accuracy of the radiographers reports are summarised in Table 24. Additionally, this table summarises the results of the analyses carried out to examine changes in the volume of reporting activity and the availability of reports within 5 days of examination.

Table 24: Summary of Key Accuracy, Volume and Speed Results

	First analysis of accuracy of radiographers' reports			Volume of reporting activity		No. of reports available within 5 days	
Trust	Accuracy	Sensitivity	Specificity	Pre RRS	Post RRS	Pre RRS	Post RRS
1	99.1 %	98.4 %	99.4 %	N/A	N/A	47.6 %	79.0 %
2	99.4 %	97.6 %	99.6 %	0.3 %	57.6 %	2/10	95.2 %
3	99.7 %	99.2 %	99.9 %	99.4 %	99.3 %	29.1 %	65.7 %
4	98.3 %	96.0 %	98.8 %	59.9 %	65.8 %	82.4 %	87.5 %

As Table 24 demonstrates, the accuracy of the radiographers' reports is high in all 4 NHS Trusts in this study with no measure (accuracy, sensitivity, specificity) falling below 96.0% on the first analysis of accuracy.

For 2 of the 3 Trusts (Trusts 2 and 4) in which it was possible to collect volume of reporting activity, an increase in the volume of reporting activity in the post-implementation period is also evident. Statistical analysis showed these increases to be significant (see Table 17).

Changes in the availability of reports within 5 days of the radiographic examination were seen in all 4 NHS Trusts, with the number of reports available at this point increasing in each case. The change was shown to be significant statistically in Trusts 1 and 3 but not significant in Trust 4. It was not possible to determine significance in Trust 2 as so few reports were available in the pre-implementation period.

7.5 Costs Associated with Implementing a Radiographic Reporting Service

Cost data were gathered from the radiology services managers in each NHS Trust in the study using a short questionnaire (Appendix 3). Information on the number of reporting radiographers and their grading were sought. An estimation of the average amount of time spent by the radiographer(s) each week on reporting activities was also sought. Finally, estimates were required of additional costs per week incurred by the Trust in relation to the implementation and maintenance of a radiographic reporting service. The responses are shown in Table 25.

Table 25: Costs of the Radiographic Reporting Service in each NHS Trust in the Study

Trust	Number of reporting radiographers	Grade/s of reporting radiographers	Weekly average of radiographer time spent reporting	Weekly average of all additional staff costs	Weekly average of other additional costs
Trust 1*	2	Senior I: x 1 Senior II: x 1	0.7 WTE	10 hours of clerical officer time (£54/week)	5 hours weekend clerical officer (£27/week)
Trust 2	5	Supt IV: x 2 Senior I: x 1 Senior II: x 1 Basic: x 1	0.4 WTE	£15,000 per year (no details given)	nil
Trust 3	1	Supt I: x 1	0.5 WTE	nil	nil
Trust 4	3	Supt IV: x 2 Senior II: x 1	0.7 WTE	25 hours of consultant radiologist time; 19 hours clerical officer time	nil

[* During the period of this study, Trust 1 increased the number of its reporting radiographers by 1.]

No consistent pattern related to costs of a radiographic reporting service is evident. The number and grades of radiographers reporting in each Trust varies considerably although each Trust appears to staff the service to the equivalent of a 0.5 whole time equivalent radiographer (approximately) per week. Three of the four Trusts admit additional costs but these vary widely and data from Trust 4 must be viewed with caution as costs identified include 25 hours of consultant radiology time.

7.6 Satisfaction of Users of Reporting Services Offered by Departments of Clinical Radiology

The initial satisfaction of users survey was carried out at the beginning of the study period and used a questionnaire/interview schedule that was in two parts as described in section 5.8 of this report. (Appendix 2)

7.6.1 The Importance and Satisfaction Questionnaire

The first part of the initial survey was quantitative in nature and was concerned with assessing respondents views on the importance of eleven aspects of the clinical radiology services provided within their own NHS Trust, together with the degree of satisfaction they felt in relation to the provision of these services. In relation to importance, respondents were asked to rate each aspect on a five point scale (crucial, very important, quite important, not very important, irrelevant) whilst, for the degree of satisfaction felt, they were asked to use a three point scale (good, adequate, poor). These ratings were then scored numerically as described in section 5.8 of this report, so enabling the rank order tables 26 and 27 to be generated.

Table 26 demonstrates the rank order of statements in terms of the importance of these to respondents. Ranking is given, firstly, by using the summed 'crucial' and 'very important' scores only and, secondly, by summing 'all scores', as shown in parentheses in the table.

Table 26: The Ranked Importance of Aspects of Reporting Services

Statement	**A & E staff (n=16)**		**Radiology staff (n=10)**	
	Rank of summed scores		**Rank of summed scores**	
	Crucial / Very important	**(All scores)**	**Crucial / Very important**	**(All scores)**
Availability of old films	4=	(5=)	8	(7)
Quality of images	2	(1=)	1	(1)
Speed with which urgent examinations are performed	1	(1=)	6	(6)
Radiologist reporting of all films	9	(8=)	11	(11)
Speed with which reports are returned	7=	(8=)	7	(8)
Quality of reporting	3	(3)	2	(2)
Shorter waiting times for patients in radiology	11	(10)	10	(10)
Radiologists' availability for consultation	10	(11)	3=	(3=)
Constructive, helpful advice	4=	(5=)	3=	(3=)
Joint clinical meetings	6	(4)	9	(9)
Action to reduce the burden of inappropriate examinations	7=	(5=)	5	(5)

[Crucial /Very important indicates ranking using the 'crucial' and 'very important' scores only. (All) indicates ranking using all five rating scores.]

Table 26 demonstrates some commonalities and some differences between the two groups of staff in relation to the rank order attributed to the importance of these aspects of clinical radiology services.

Accident and emergency medical staff identified the three most important aspects from their perspective as:

- speed with which urgent examinations are performed (1)
- quality of images (2)
- quality of reporting (3).

This compares with clinical radiology staff who identified the following as the most important aspects:

- quality of images (1)
- quality of reporting (2)
- radiologists' availability for consultation (3=)
- constructive, helpful advice (3=).

Both groups, however, have rated 'quality of images' and 'quality of reporting' highly.

Similarly, those aspects judged to be the least important also showed commonalities and differences according to staff group. For accident and emergency medical staff the three least important aspects were:

- shorter waiting times for patients in radiology (11)
- radiologists' availability for consultation (10)
- radiologist reporting of all films.

For clinical radiology staff, the least important aspects were:

- radiologist reporting of all films (11)
- shorter waiting times for patients in radiology (10)
- joint clinical meetings (9).

Again, there appears to be agreement between the two staff groups in that 'shorter waiting times for patients in radiology' and 'radiologist reporting of all films' are the least important aspects of clinical radiology services.

In relation to the purposes of this study, it was noted that the quality of reporting was ranked highly by both groups of staff (accident and emergency medical staff = 3; clinical radiology staff = 2) but the speed with which reports are returned and radiologist reporting of all films were ranked towards or at the bottom end of the scale.

Overall there was no significant differences in the preferences of the two staff groups as shown in this small sample (Chi squared = 4.284, P = 0.93).

Table 27 demonstrates the rank order of the same statements but in relation to how satisfied respondents were with the services provided. Two rank orders are provided, firstly, by using the 'good' scores only and, secondly, by using the summed 'good', 'adequate' and 'poor' scores.

Table 27: The Ranked Satisfaction with Aspects of Reporting Services Provided

Statement	**A & E staff (n=16)**		**Radiology staff (n=10)**	
	Rank of summed scores		**Rank of summed scores**	
	Good	**All**	**Good**	**All**
Availability of old films	3	3=	1=	1=
Quality of images	4=	3=	3=	1=
Speed with which urgent examinations are performed	2	2	5=	6
Radiologist reporting of all films	6=	7=	8=	9
Speed with which reports are returned	8=	7=	8=	8
Quality of reporting	1	1	3=	1=
Shorter waiting times for patients in radiology	6=	6	5=	5
Radiologists' availability for consultation	8=	9	7	7
Constructive, helpful advice	4=	5	1=	1=
Joint clinical meetings	11	11	10	11
Action to reduce the burden of inappropriate examinations	10	10	11	10

[Good indicates ranking according to the 'good' scores; All indicates ranking according to the combined 'good', 'adequate' and 'poor' scores]

Table 27 demonstrates some agreement between the two staff groups for those aspects of the clinical radiology services considered to be good. The three aspects ranked most highly by accident and emergency medical staff were:

- quality of reporting (1)
- speed with which urgent examinations are performed (2)
- availability of old films (3).

Clinical radiology staff ranked most highly the following aspects:

- availability of old films (1=)
- constructive, helpful advice (1=)
- quality of images (3=)
- quality of reporting (3=)

The two staff groups were agreed that the most satisfactory aspects of the clinical radiology services are 'quality of reporting' and 'availability of old films'.

In relation to those aspects of the service judged to give the least satisfaction, accident and emergency medical staff considered the following to be the least satisfactory:

- joint clinical meetings (11)
- action to reduce the burden of inappropriate examinations (10)
- speed with which reports are returned (8=)
- radiologists' availability for consultation (8=).

Those aspects considered to be the least satisfactory by clinical radiology staff were: action to reduce the burden of inappropriate examinations (11)

- joint clinical meetings (10)
- radiologist reporting of all films (8=)
- speed with which reports are returned (8=).

As can be seen, staff from both the accident and emergency departments and the clinical radiology departments agreed to a large extent on the least satisfactory aspects of the services provided by clinical radiology.

Three further comparisons were made as follows:

- aspects considered most important by accident and emergency medical staff with those aspects considered to be least important by clinical radiology staf
- the least satisfactory aspects as judged by accident and emergency medical staff compared to those considered least important by clinical radiology staff
- again, the least satisfactory aspects from the perspective of accident and emergency staff against those aspects felt to be the most satisfactory by clinical radiology staff.

Only one aspect emerged as contentious. Accident and emergency medical staff considered joint clinical meetings to be one of the least satisfactory aspects of the clinical radiology services provided whilst clinical radiology staff considered this to be an aspect of least importance. It was also interesting to note that an aspect considered to be most important by clinical radiology staff (radiologists' availability for consultation) was judged to be unsatisfactory by accident and emergency medical staff.

7.6.2 The Initial Interview

Twelve of the 26 respondents who took part in the first part of the initial survey were considered to be key, senior personnel and, accordingly, these twelve participated in the initial qualitative interviews. No attempt was made to make comparisons between accident and emergency medical staff and clinical radiology staff although the designation of each participant was recorded.

Respondents were asked first about the 'red dot' signalling system which was in place in each NHS Trust at the time of the initial interviews. Although each of the systems in place varied in nature, the large majority of respondents (n = 9) identified benefits provided by the system, particularly its value in alerting inexperienced casualty staff to abnormalities which may otherwise go undetected. Additionally, the beneficial effect that a red dot system has for radiographers in relation to an extended role as image interpreters and their self-perception in this role was also noted.

Two main issues emerged when respondents were asked about the possible pitfalls or drawbacks of a red dot system. These were the potential inconsistencies in how the system could be applied and the effect that the ambiguous nature of the system may have on accident and emergency clinical staff's interpretation of the image. A small number of respondents (n=3) also felt that junior accident and emergency staff might become too reliant on the red dot signal and so not examine the image properly themselves.

The part radiographers play in providing verbal advice to accident and emergency staff was also explored and, when asked how often staff sought verbal comments from radiographers, all respondents believed that comments were sought. However, the degree to which it was felt advice was sought varied. Over half of the respondents (n=7) felt that this was done often or on a regular basis and five made special note of the fact that comments were sought more frequently out of normal hours, when junior staff tended to be working on their own much more.

In view of the Audit Commission's recommendation regarding 'hot' reporting, it was felt appropriate to explore this with correspondents. All respondents welcomed broadly the Audit Commission's recommendation but all felt there were obstacles to its implementation. These related to resources and workload, including the availability of staff, office space and departmental budgets. Personnel issues, however should not be ignored and were also seen as obstacles to changing practice. Such issues were cited by half the respondents and some strident views were forthcoming, for example, as a radiology services manager expressed it: "I think the primary obstacle…is the refusal of radiologists to change working practices". Or a view from an accident and emergency consultant: "…it's an interpersonal problem between different radiologists….".

A general consensus was apparent (n=11) in that, although welcomed, the Audit Commission's recommendation was unrealistic for the NHS Trust to implement given current departmental organisation, practice and attitudes.

The consequences of a lack of a report from the clinical radiology department was also subject to examination during the interviews. The large majority of respondents (n=10) agreed that the lack of a report can have an effect on patient management although the extent to which they felt it was likely to affect patient management varied and a not insignificant minority (n=4) felt that cases where management was affected were infrequent. Accident and emergency consultants held this view most widely (three out of the four interviewed).

The possibility of using radiographers to report accident and emergency musculo-skeletal examinations was considered and respondents were asked to what extent they felt the introduction of reporting by radiographers could contribute to reporting services. Half of the respondents (n=6) felt that a key contribution radiographers could make to reporting services was to relieve the burden of reporting trauma films from radiologists. There was, however, no real consensus as to the primary extent to which they felt radiographers could contribute. A third of the respondents (n = 4) felt that radiographers could report all trauma examinations or carry out reporting duties full-time while three respondents felt that radiographer reporting could be extended to other types of examinations, for example, chest radiographs or general practitioner (GP) examinations. A contrary view was also expressed and one respondent stated specifically that radiographers should not report on chest or GP examinations. Another also expressed some caution and felt that extending the contribution of reporting radiographers to non-trauma examinations should be taken slowly. Interestingly, one respondent was also of the view that it was realistic to expect all reporting activity be carried out by radiologists.

Respondents were asked to identify potential benefits that might arise from the introduction of a radiographic reporting service. Two main points emerged. Firstly, it was felt that there would be an impact on patient management in that reports would become available more quickly. Specifically mentioned were benefits of reducing the need to re-call patients due to initial misdiagnosis and a reduction in the number of further inappropriate examinations. The second issue to emerge was a wider one. It was felt that an RRS would free radiologists to perform other examinations, so providing benefit beyond the patient group attending the accident and emergency department. A further benefit cited by a number of respondents

(n=4) was the professional development of radiographers who would be using their skills more effectively.

On questioning about potential constraints to radiographer reporting, no clear consensus was forthcoming and the issues that were considered constraints ranged widely. These included matters related to training, to resources and to organisational problems, including the failure to agree protocols for reporting. Resistance by various staff groups was also noted as a constraint by a number of respondents (n=4).

In summary, it was recognised that radiographers contributed beneficially to accident and emergency services through the use of red dot signalling systems and by giving advice. Relative to the Audit Commission's recommendation that all departments of clinical radiology should implement 'hot' reporting systems, there was complete consensus that, although desirable, this was unrealistic and not possible for a range of organisational, logistical and attitudinal reasons. There was agreement, too, that the lack of a report can affect the management of patients adversely but the degree to which serious adverse effects occurred was considered debatable. Finally, there was cautious encouragement for radiographers to develop their roles and to use their skills more effectively by undertaking, at least, musculo-skeletal trauma reporting. Some potentially important benefits of reporting by radiographers were identified, together with an array of constraints.

7.6.3 The Final Survey

The final survey to gauge the satisfaction of users took place towards the end of the study period and after all sites had experienced the implementation and operation of a radiographic reporting service (RRS), although to varying extents.

Site A had, initially, operated an RRS for seven weeks only and prior to commencement of this study. However, at the time of the final survey, the service had been re-instituted and had been operational for some time. Sites B and C had each implemented an RRS approximately 5 months prior to the final survey, while sites D and E had operated an RRS continuously since well before this study commenced. The experience of users was, therefore, varied.

As with the qualitative part of the initial survey, 'users' were considered to be accident and emergency medical staff, consultant radiologists and radiology service managers. Again, too, this final survey was limited to key, senior staff in these groups only, with twelve individuals participating.

Respondents were asked, first, about the benefits of the RRS that had been implemented within their own NHS Trusts. All 12 respondents stated that the service had brought benefits although one individual expressed reservations regarding its actual impact. A wide range of benefits were cited but two main ones emerged. These were the speed with which the report became available to the accident and emergency department (n=6) and the freeing up of consultant radiology time (n=5). Time benefits were also noted by an accident and emergency consultant:

"…every morning I used to come in and review all the x-rays from the previous night which took me on average about 45 minutes every morning. So now I have free time."

Accident and Emergency Consultant

Other benefits cited included a reduction in the number of unidentified fractures and an improved reporting service overall because other (non-trauma) reports were available more quickly than previously.

Questions were also asked about the pitfalls or drawbacks of providing a radiographic reporting service and ten respondents recognised that the introduction of the service had not been problem free. No particular problem predominated but a range were identified. These included training, resource allocation, maintaining service continuity, the loss of the radiologists' expertise in reporting, the potential for a high false positive rate within the radiographers' reports, and the failure of radiologists and non-reporting radiographers to accept the role of the reporting radiographers.

Respondents were also asked to indicate their satisfaction with two aspects of the RRS that had been implemented within their own NHS Trust. These were:

the quality of the reports issued by the radiographers
the nature of the RRS implemented (for example, hours of service, availability, number of reporting radiographers)

In each case, respondents were asked to use a five point scale ranging from extremely satisfied to unsatisfied. Tables 28 and 29 summarise the responses.

Table 28: Satisfaction with the Quality of the Radiographers' Reports

Response	Consultant Radiologists (n=4)	Radiology Services Managers (n=4)	Accident and Emergency Consultants (n=4)	Totals (n=12)
Extremely satisfied	2	3	2	7
Very satisfied	1	1	2	4
Quite satisfied	1	0	0	1
Not very satisfied	0	0	0	0
Unsatisfied	0	0	0	0

Table 29: Satisfaction with the Nature of RRS Implemented

Response	Consultant Radiologists (n=4)	Radiology Services Managers (n=4)	Accident and Emergency Consultants (n=4)	Totals (n=12)
Extremely satisfied	0	1	0	1
Very satisfied	3	2	1	6
Quite satisfied	1	0	3	4
Not very satisfied	0	1	0	1
Unsatisfied	0	0	0	0

As can be seen, respondents were extremely (n=7) or very (n=4) satisfied with the quality of reports provided by the radiographers. However, the degree of satisfaction with the nature of the service implemented is more muted with six respondents very satisfied and 4 quite satisfied. Overall, dissatisfaction appeared minimal and no-one claimed to be unsatisfied on either measure.

When asked about changes or improvements they might like to make to the service which had been implemented, six of the respondents felt there were changes that would be useful. These centred on extending the service provided and included increasing the number of reporting radiographers, offering the service to cover the 24 hour day/7 day week, or to a provide 'hot' reporting. However, almost half the respondents (n = 5) felt that, for the moment, there were no changes they would like to make in the service provided currently.

Respondents were also asked about the potential for developing radiographic reporting services further. Ten participants indicated that further development could, or could potentially, take place. Suggestions for possible developments tended to mirror the views expressed about the changes they would like to implement in relation to their own RRS. However, a small group (n=4) suggested that the type of examinations reported by radiographers should be increased beyond musculo-skeletal trauma examinations, for example to include examinations requested by GPs, and chest radiographs.

The question from the initial survey regarding the Audit Commission's recommendation (1995) on 'hot' reporting was repeated during the final survey. It was evident from the responses that the implementation of an RRS had not altered respondents views and these were almost identical to the opinions expressed during the early interviews. Again, there was consensus that it was an excellent ideal to aspire to but was impractical. As in the first round of interviews, obstacles to implementing the recommendation included workload, resources, staffing levels and attitudes of staff.

Little of surprise arose from this final survey. The introduction of an RRS was considered to be beneficial, with both operational and patient management advantages. Respondents expressed themselves to be very satisfied with the quality of reports provided by the radiographers and reasonably satisfied with the nature of the RRS implemented. Nevertheless, a range of pitfalls and drawbacks were also evident, suggesting that implementation had not been easy. Suggestions for changes and developments of the RRS were given and, largely, these related to extending the operation of service provided. Some views were expressed, too, about broadening the nature of the service to include a wider range of reporting activities.

However, almost half of the respondents were of the view that no changes should be made at present. Finally, it was clear that the implementation of an RRS had not altered views on the feasibility of introducing a 'hot' reporting system as recommended by the Audit Commission (1995) and this was still considered to be impossible by almost all staff interviewed.

8.0 Discussion

8.1 Introduction

The study was designed to explore the implementation into practice of radiographic reporting services in four NHS Trusts and five clinical sites in England. Measures were made of the accuracy of the reports produced by radiographers providing these services. Additionally, the volume of reporting activity and the speed with which reports became available were measured before and after the implementation of the service. Some information was also obtained regarding the additional costs to each Trust of implementing its radiographic reporting service and, finally, the satisfaction of users of the reporting service were gauged at the beginning and at the end of this study. (Users were defined as accident and emergency medical staff, consultant radiologists and radiology services managers.)

8.2 The Study NHS Trusts/Clinical Sites

It is, perhaps, inevitable that examining the implementation into practice of a new and innovative service is difficult and this study was no exception. The four NHS Trusts differed widely and were not connected to, or related to, each other in any way. All had determined to implement a radiographic reporting service some time in advance of the commencement of this study but, as has been explained, the point at which implementation occurred was unique to each Trust and depended largely on factors peculiar to each. It is appropriate to outline the particular issues related to each Trust that bear on this study.

Trust 1:

At this Trust a measured approach to the implementation of an RRS was evident. Planning for the service had commenced when this study was at a conceptual stage, and implementation occurred during January 1997 once the reporting radiographer had completed an accredited education programme successfully. The reporting service progressed smoothly, without interruption and was still in operation as this study concluded. By this time, too, a second radiographer had completed an accredited education programme and was also contributing to the reporting service.

Trust 2:

Planning for a radiographic reporting service in this Trust commenced a long time in advance of this study but was beset with almost insurmountable obstacles such that implementation did not occur until June 1998, fewer than five months from the date of completion of this study. A number of factors played a part in the delay in implementation but, probably, the single most important issue was related to finance. Five radiographers of differing grades were to provide the radiographic reporting service and, in the light of this, a mechanism to reward them equitably needed to be agreed and funded. Unfortunately, the agreement and the additional funding required was not sanctioned until the first quarter of 1998. By this stage, the Trust felt it important that the five radiographers should undergo a refresher or start-up period as two years had elapsed since they had completed their accredited education programmes successfully. Further complications resulted from turnover of lead radiology clinicians with three different individuals holding this position during this study.

Trust 3:

Like NHS Trust 1, planning for a radiographic reporting service in Trust 3 commenced during the conceptual phase of this study. Again, this meant that implementation took place in January 1997, prior to the start of this study. However, once implemented, the service did not progress smoothly and was provided for seven non-consecutive weeks only during the early part of 1997. The major reason for the failure of the service at this Trust was the conflict of responsibilities carried by the reporting radiographer. These spanned significant departmental management responsibilities as well as the responsibility of providing the RRS single-handedly (no provision or planning for additional radiographers to take on a reporting role had been made). The conflict was not resolved until towards the end of this study when a new manager was appointed and the reporting radiographer was able to resume providing the RRS. However, while the RRS was resumed, no maintenance planning to ensure its continuity was evident as this study drew to its close.

Trust 4:

This single Trust was complex and spanned two distinct clinical sites. Both sites implemented an RRS but the experience of implementation at each site was markedly different with one site implementing in January 1997 and the other in April 1998.

The site which was able to implement in January 1997 was a community hospital that had no radiological or accident and emergency consultant medical staff based on the site and there was a pressing need to improve the reporting service offered. These two factors, the lack of on-site consultant medical staff and the need to improve the reporting service offered, together with the availability of a properly trained reporting radiographer facilitated the smooth introduction of the service which was still operational as this study concluded. However, despite almost trouble free implementation, there are two issues that the Trust must address in relation to the on-going operation of the service. Firstly, the service rests on one individual and is only provided when that person is working. Hence, the service falters during periods of annual leave or sickness. Secondly, the reporting radiographer is somewhat isolated and this may prove difficult in terms of ensuring proper support and appropriate continuing professional development related to the reporting function.

The larger site to implement an RRS within this Trust suffered considerably from personnel difficulties and these confounded the early implementation of an RRS despite the fact that it had been first proposed during 1996. There were key personnel changes early in the study. Firstly, the long-standing Radiology Services Manager resigned with the post being filled in an acting capacity for a long period. Inevitably, this affected the initiative and some matters were not resolved until the substantive appointment was made. Secondly, there was a change in the lead radiology clinician. The individual who had supported the implementation of an RRS was replaced by a consultant who was not committed to the initiative and who attempted to modify the nature of the RRS. For example, support for the reporting radiographers to report on axial skeletal examinations was withdrawn for a time and, when re-instated, there was still some feeling that the radiographers should not be permitted to report cervical vertebral examinations.

8.3 The Methodology

The methodology has been described in some detail in section 7 of this report and, as can be seen, was not straightforward. This was due largely to the lack of control that the study team could exercise over the implementation into practice of radiographic reporting services in the 4 NHS Trusts. In particular, the considerable variation in terms of date of implementation across the five clinical sites was a major confounding factor. On three sites, the mismatch between the date of commencement of this study and the date of implementation meant that some data needed to be collected retrospectively. At the remaining two sites, implementation was so protracted that it was necessary to continue data collection beyond the conclusion date of this study.

Another factor over which the study team could exercise no control was the variability of key information systems within each NHS Trust and, at one site, the nature of the information system was such that certain data could not be collected.

Despite the above shortcomings, the methodology was generally robust and, wherever necessary, steps were taken to ensure this. For example, in one Trust it was necessary to access all reports individually to assess each report's status in order to determine the volume of reporting activity and speed of report availability prior to and following implementation of the RRS. Similar steps were also necessary in another Trust where codes used to indicate the status of reports proved ambiguous.

Perhaps the two areas that might be considered problematic methodologically were the initial survey and the tool used to collect information on costs. In practice, the tool used for the initial survey was satisfactory and was based in part on a tool that had been used previously by the Audit Commission(1995) but, strictly, all of the initial interviews should have been carried out prior to the implementation of an RRS. However, as has been explained, this was not possible as three of the sites implemented an RRS prior to the commencement of this study.

The problem related to the tool used to collect cost data was one of deliberate, or over, simplification. As the study progressed it became apparent that information on costs would not be easy to identify coherently across all four NHS Trusts. Each Trust had taken very different approaches to implementing its RRS, ranging from costing it explicitly as an extra service and seeking the necessary additional funds to expecting the reporting radiographers to fit their reporting duties into their normal working day without the allocation of any time or support services. Accordingly, the study team took the view that it should attempt to collect basic cost information only and, hence, a very short questionnaire was developed and circulated to radiology services managers once the study period had been completed. As is evident in the relevant results section of this report (section 7.5), some misinterpretation of the basic questions asked was still possible.

In retrospect, it was, perhaps, ambitious to investigate the implementation into practice of an RRS in four, quite separate and geographically spread sites within a 15 month period. Some basic assumptions were also made about the nature of information systems within each Trust and the relative ease with which data could be accessed. These, unfortunately, proved to be unfounded and generating the necessary data from the information system in place in each Trust was, at least, problematic and, in one Trust for one measure, impossible. Nevertheless, the importance of investigating new practices as they are implemented cannot be overstated, particularly in controversial and contested fields of practice and, overall, the need to develop an evidence base related to radiographic reporting systems justified the original proposal to examine four such systems simultaneously.

8.4 The Accuracy of the Radiographers' Reports

A fundamental basis to the introduction of radiographic reporting services must be that the reports produced by radiographers are accurate to a very high degree, although it is recognised that there is no absolute accuracy standard. Accordingly, meticulous attention was paid to the calculation of the accuracy of the reports produced by the radiographers in this study and, as reported earlier (section 5.4.4), a further round of analysis is to take place outside of the confines of this study. Overall, the results of this study provide considerable evidence that the

radiographers are producing accurate reports and that accuracy is maintained over time. There are, however, some points worthy of discussion.

Within the study, a wide range of abnormality prevalence rates was demonstrated (8.7% to 26.1%). As a consequence, radiographer 10 in the study reported on almost 3 times the number of abnormal examinations as, for example, radiographer 6. The reason for this wide variation in prevalence is not known. Those radiographers with the higher prevalence rates could be working in situations where there is effective use of guidelines to reduce the number of inappropriate examinations (RCR, 1998). Alternatively, for those radiographers with lower prevalence rates, it might be that abnormal examinations were not returned for reporting but were diverted directly to, for example, fracture clinic. In one Trust this would have introduced a delay in excess of four days in returning the films to the clinical radiology department and, as a consequence, they would have been filed in an unreported state.

Sensitivity and specificity values should not be affected by the prevalence of abnormalities yet, in this study, the mean sensitivity rate (97.6%) was slightly lower than the mean specificity rate (99.3%). However, in this study, FP fractions were attributed for a number of different errors, as well as for identifying the presence of an abnormality incorrectly. These other errors were related to the radiographer's use of terminology in the descriptive and interpretative aspects of the report with which the verifying radiologist disagreed. For example, the use of the term 'Colles fracture' to describe an undisplaced fracture of the distal end of the radius and ulna was not an acceptable term for one verifying radiologist. Given the rigour with which the radiographers' reports were judged against the verifying radiologists' reports, it is not at all surprising, therefore, to find the difference identified between the mean sensitivity and specificity rates.

In the context of sensitivity and specificity, it is also interesting to note that one radiographer achieved 100% sensitivity and another achieved 100% specificity.

The aggregated agreement rates for all radiographers on first analysis were very high (mean accuracy: 99.1%; mean sensitivity: 97.6%; mean specificity: 99.3%) and these compare well to rates quoted by Loughran (1994). He identified the sensitivity and

specificity rates achieved by the radiologists in his study as 96.8% and 99.6% respectively. The radiographers in his study achieved sensitivity and specificity rates of 95.9% and 96.8% and this is lower than the values achieved by the radiographers in this study. It may be that the training received by the two groups of radiographers played a role in producing this difference. All radiographers in this study had undergone an accredited education programme (Postgraduate Certificate Radiography: Clinical Reporting) while those in Loughran's study had undergone an in-house training scheme.

The radiographers in this study made very few errors (1.05%) and there were only 74 instances amongst the 7179 verified reports where the disagreement between the reporting radiographer and the verifying radiologist was confirmed as an FN or FP by the second radiologist's independent, blind report. It should also be noted that there were 45 other cases where the second radiologist's report confirmed the radiographer's report to be a TP or TN and disagreed with the verifying radiologist's report.

The narrow 95% confidence intervals and the low standard deviations, for all three measures, suggest that there is little dispersion of the rates and that the radiographers involved in this study are performing very similarly in their reporting activities. The possible exception to this is radiographer 10 who demonstrated rates that would appear to be significantly lower ($F=56$ $P=0.0001$) than the other radiographers in the study. It is recognised, however, that Poisson modelling of the accuracy data is necessary when further regression analysis is undertaken in subsequent work on these data.

A number of cases could not be resolved by the second radiologist's blind report as a 2 out of 3 consensus could not be reached. Reasons for the lack of consensus were varied but can be characterised broadly as those examinations where the independent radiologist reported on different and/or additional appearances that had not been commented on previously by either the radiographer or the first, verifying radiologist. Typical examples are shown in Figure 24.

Figure 24: Examples of Failure to Achieve Consensus

Right Scaphoid Radiographer	The scaphoid appears intact. There is, however, a radiolucent line through the lateral side of the distal end of the right radius. This could possibly represent the site of a fracture.
1st Radiologist	Probably no bony injury.
2nd Radiologist	There is a lucent line in the distal end of the scaphoid. This is highly suspicious of a hairline fracture.
Right Foot Radiographer	There are fractures of the bases of the first and second metatarsal shafts.
1st Radiologist	Agreed but commented that there was also a fracture of the lateral cuneiform.
2nd Radiologist	There has probably been a small triangular avulsion of the anterior aspect of the base of the first proximal phalanx.
Lumbar Spine Radiographer	There is some anterior wedging of D11, D12, L1 and L2.
1st Radiologist	Agreed with the radiographer but noted a narrowed L5/S1 disc space.
2nd Radiologist	Minimal anterior wedging of L1 and D12 is noted, possibly due to previous trauma.

The range of agreement rates relative to anatomical areas was examined and was found to be small across the different anatomical areas. Additionally, no statistical significance was demonstrated when the accuracy, sensitivity and specificity rates were analysed for differences amongst the anatomical areas. It should be noted, however, that there were no positive examinations in the 164 cervical and 28 thoracic vertebral examinations carried out.

The performance of individual radiographers merits further comment. Overall, individual accuracy, sensitivity and specificity rates are very high as can be seen in Table 5, with 9 of the 10 radiographers in the study achieving accuracy rates in excess of 98%.

The errors (n=30) made by radiographer number 10 were subjected to further examination and the 16 FP and 14 FN examinations have been reported by two additional radiologists in accordance with the independent analysis described as stage 5 in the methodology section of this report. In 11 of these cases at least one of the independent radiologists agreed with the report issued by the radiographer. A further 10 cases were judged to be FNs due to the use of incorrect terminology, the majority of which related to descriptions of undisplaced fractures of the distal radius as Colles fractures or to volar plate fractures of the phalanges. The classification of

Colles fractures is not without contention and the Melone Type I classification of distal radius fractures has been described as a Colles fracture equivalent that is undisplaced and minimally comminuted (Melone, 1993). Interestingly, in the reports of this individual (radiographer 10) where a fracture was identified, the presence of the fracture was confirmed by the verifying radiologist in all cases, even when there was disagreement on the nature of the description and terminology used.

A small number of errors made by some of the radiographers related to the age of the fracture, and/or to the possibility that an appearance was the result of a recent injury as opposed to an old avulsion injury. There were also two cases of normal epiphyseal appearances at the base of the fifth metatarsal which had been reported as fractures.

To date, it has not been possible to explore the clinical significance of the errors made by the radiographers as the final independent analysis of accuracy is outside the bounds of this study and has yet to be completed. Once available, all FN and FP examinations will be reviewed to determine their clinical significance. Nevertheless, preliminary review of the nature of the errors made suggests that few should be significant clinically.

Accuracy measures were aggregated for each Trust and these showed a small variation in agreement rates (Table 12). In particular, the accuracy for Trust 4 was 98.3% compared to a mean for all Trusts of 99.1%. In this Trust, the errors of one radiographer contributed significantly. However, the variation is small and, overall, aggregated accuracy, sensitivity and specificity values may be considered high in all Trusts.

All but one of the 10 radiographers in the study completed 1050 reports and more than one of the three batches of reports were verified for 9 of the radiographers, with three verified batches available for 5 radiographers. No significant differences ($p=0.05$) in accuracy, sensitivity and/or specificity were demonstrated amongst any of the batches. It is encouraging to note, therefore, that the agreement rates have not reduced over time although some caution must be attached to this statement as the total period from which the radiographers' reports were obtained ranged from

three to nine months. Further evaluation of the maintenance of accuracy over a longer period of time would be useful.

In a previous study, Loughran (1996) reported that trained radiographers improved their competencies in accident and emergency fracture reporting over time. He noted that in the 8 month period following the 6 month training programme, the nonconcurrence rate reduced from 4.6% to 3.2%, when compared to the report of the radiologist. Agreement rates in this present study exceeded 99% at its commencement and were maintained over the duration of the project.

A primary function of accident and emergency reporting is to respond to requests to confirm or exclude the presence (or absence) of any recent bony injury. It is also important to confirm or exclude soft tissue and/or foreign body injuries. Certain soft-tissue signs, for example, fat pad elevation in the elbow; lipohaemarthrosis in the knee; a fluid level in a paranasal sinus, are strong indicators of the presence of a fracture and should be reported when seen. For the first analysis, all of these were regarded as TP or FN findings. Other reporting practices, however, are not standardised and the need to report on appearances such as soft-tissue swelling in the ankle or the presence of degenerative disease is less clear. Practices varied widely amongst the radiologists, radiographers, clinical sites and Trusts in this study but were accounted for in the second analysis. This classified other positive findings which had been reported by the radiographer and confirmed subsequently as a TP examination.

A wide range of appearances that caused difficulties in terms of TP or FN classification because of the considerable variation in reporting practices across the four NHS Trusts was identified. These included degenerative disease (in the hip, knee, shoulder, cervical/thoracic/lumbo-sacral vertebrae, wrist, foot and ankle); exostoses; enchondromas, and osteochondritis dissecans. There is little, if any, consensus, regarding the need to report such incidental findings. In attempting to clarify this, it became apparent that, for example, the classification of degenerative disease (whether it is described as mild, moderate, marked or severe) differs amongst individuals. In addition, there appeared to be differing expectations from radiologists regarding when it would be appropriate to report such appearances at all. It should be recognised, therefore, that the allocation of TN fractions for the

second analysis may not reflect fully the prevalence of other disease processes. The allocation of a TN fraction to a radiographer's report indicated only that the radiographer had not reported any abnormal appearances at all and that this judgement had been confirmed.

False negative (FN) scores were allocated where the first radiologist disagreed with the radiographer's report and considered that an appearance should have been reported and where this appearance was confirmed subsequently by the second radiologist's report.

For the second analysis, FP fractions were allocated where the radiographer reported on abnormal appearances (other than the presence of fracture and/or relevant associated soft-tissue signs) but where both the first and second radiologist's reports disagreed.

Following the allocation of fractions for this second analysis of accuracy, the prevalence rates increased for all radiographers in the study, with the mean increasing from 14.9% for the first analysis to 26.9% for the second. However, accuracy, sensitivity and specificity rates remained high with the mean percentages 98.8%; 97.9% and 99.0% respectively. The accuracy rate for nine of the 10 radiographers exceeded 98% while the minimum rate (96%) related to radiographer number 10. The errors reported by this individual have been discussed previously and, since the FN and FP fractions included in the first analysis are included in the second analysis, there was little change in the agreement rates.

For the third analysis, TP and TN fractions were allocated as for the second analysis. However, there were a number of cases where the verifying radiologist agreed with the radiographer's report but provided additional comments. These examinations were not reported by a second radiologist but FN or FP fractions were allocated to the radiographers' reports on the basis of the verifying radiologist's report only. The rationale for this was that the verifying radiologist had identified an appearance that the radiographer had missed and, hence, in comparison to the radiologist's report the radiographer's report was incomplete.

The overall agreement rates still remained high following the third analysis and the mean accuracy, sensitivity and specificity rates were 97.7%, 94.2% and 98.8% respectively. The accuracy value for radiographer number 10 remained at the lower end of the range as a result of errors classified in the first analysis. However, the accuracy value for radiographer 2 reduced from 98.9% in the second analysis to 94.3% following the third analysis. This was a direct result of failure to report soft tissue swelling in a sizeable number (>10) of ankle examinations. As was outlined earlier, the need to report soft tissue appearances on ankle examinations is not standard practice and further clarification on when and/or if such reporting is appropriate would be useful and would assist in setting reporting standards.

8.5 Volume of Reporting Activity

It was unfortunate that, despite much effort by the study team and clinical radiology staff at the site, the information systems at one of the clinical sites (site E) precluded the collection of data related to determining the volume of reported accident and emergency musculo-skeletal examinations. Hence it is only possible to report the findings for four of the five clinical sites. At these four sites, pre-implementation figures for volume varied considerably from 0.27% at site B to 99.4% at site A, with sites C and D showing pre-implementation figures for volume of reported examinations as 57.8% and 70.2% respectively.

At two of the sites, the volume of accident and emergency skeletal examination reported following the implementation of a radiographic reporting service increased significantly (site B: $p=0$, Site D: $p=0.0007$) while, at the remaining 2 sites, change in the volume of reported examinations was insignificant (site A: 99.4% to 99.3% and site C: 57.8% to 57.2%). As can be seen, following the introduction of the radiographic reporting services, none of the four clinical sites in which volume measures were possible experienced any significant reduction in the volume of accident and emergency examinations reported and two sites experienced considerable increases in the volume reported.

It is interesting to consider each site in turn. The volume of reporting of musculo-skeletal trauma examinations was already high prior to the implementation of an RRS at site A and it was not surprising, therefore, that it remained high

subsequently. Site B, on the other hand, undertook very little reporting of trauma examinations prior to the introduction of its RRS so, again, it was not difficult to improve upon the situation and to demonstrate a significant difference in the volume of reported examinations. However, it should be noted that the volume reported is still well short of 100% (57.6%) despite the fact that this site has 5 reporting radiographers contributing to its RRS. Site C showed little change in the volume of reported examinations post- implementation of its RRS and the volume of reported examinations remained below 60%. Two radiographers provided the RRS at this site and it is difficult to identify why no change occurred although it should be noted that this site was unable to implement its RRS until April 1998. It may be that late implementation has produced a spurious and unrecognised effect and that, over time, the RRS will bed down and the volume of reported examinations will increase. On the other hand, it may be that the lack of commitment to the initiative by the lead clinician in radiology is a key factor. Site D, where the RRS is provided by a single radiographer, showed significant change in the volume of reported examinations such that fewer than 10% of examinations were unreported post-implementation.

Of the four sites investigated, only sites A and D have any room for complacency in relation to the volume of accident and emergency musculo-skeletal examinations they report while sites B and C give considerable cause for concern, although site B has shown remarkable improvement. Even with the introduction of an RRS, these two are failing to report in excess of 40% of trauma examinations and this contrasts adversely with guidance issued by the Royal College of Radiologists (1995).

8.6 Speed of Report Availability

Data related to determining the speed with which reports became available following examination were collected and grouped into 11 categories. These spanned 'hot' (immediately following the examination), same day, next day, . . . to 28 days or more (see section 5.5.2 of this report). The data is displayed graphically by clinical site in figures 19, 20, 21, 22 and 23. Examination of these graphs demonstrates a trend to producing reports more quickly after the patient has been examined following the implementation of an RRS for 4 of the 5 sites but a reverse trend in site C. It is interesting to note that Trust 2, despite its late and difficult

start, was able to make the majority of reports (>70%) available within 48 hours during the post-implementation period. Possibly this is due to the fact that 5 radiographers participated in the RRS at this site.

The reports available within five days of examination were aggregated for each clinical site and, again, for each NHS Trust in order to carry out statistical analysis. This revealed that the speed with which reports became available following examination increased significantly at 4 of the 5 sites and for all 4 Trusts (see table 22). Overall, across all sites/Trusts, 83% of reports were available within 5 days following implementation of an RRS compared to 60% pre-implementation.

These results are very encouraging and suggest that the radiographic reporting services are enabling reports to be produced much more quickly, so assisting the Trusts to meet the Royal College of Radiologists guidelines (1995), albeit by using radiographers rather than radiologists to provide the reports.

Some concern must be expressed in relation to site C, particularly when it is remembered that this site also failed to improve the volume of reports produced (see section 8.5). It would appear that the introduction of a radiographic reporting service at this site has not proved beneficial despite the very high report accuracy rates discovered. The fact that there was no improvement in terms of volume and a decline, although not significant statistically, in terms of speed of availability of reports suggests the need to review the nature of the RRS implemented and/or reconsider its desirability.

8.7 Costs

There is little of note that can be drawn from the data gathered related to costs. Each NHS Trust approached the implementation of a radiographic reporting service in its own way and the additional costs identified for providing the service varied from nil to £15000 per annum. If the data from Trust 4 really is related to additional costs, then this maximum figure rises to considerably more than £15000 per annum as this Trust claimed that its average additional staff costs were those of 25 consultant radiology hours and 19 clerical hours per week.

Perhaps the two most realistic claims for additional costs arose from Trusts 1 and 2. As will be recalled Trust 2 implemented very late in the project, in June 1998, because of its need to agree and obtain funding for the service. It is likely, therefore, that data from this Trust is very accurate as it is likely to be derived from internal negotiating and bidding documentation. Trust 1, on the other hand, was able to implement an RRS very early (in January 1997) and it was still running as this study concluded. The trouble-free implementation and maintenance of this RRS would suggest that its costs were able to be identified with confidence. Although couched differently, when the cost information from these two Trusts is broken down to a figure per week, per reporting radiographer, costs do not differ vastly with a cost/week/reporting radiographer of £41 in Trust 1 and £57 in Trust 2.

These figures are, of course, not reliable but they may offer some guidance to those NHS Trusts who might be considering the implementation of an RRS. In the context of costs, it is, perhaps, cautionary to point out that Trust 3 identified zero costs but, at least initially, was unable to sustain its RRS.

8.8 Satisfaction of Users

It was heartening to note from the quantitative part of the initial survey that the aspects of a clinical radiology service judged to be the most important by accident and emergency medical staff were, in the main, considered to be provided satisfactorily, particularly the speed with which urgent examinations were performed and the quality of reporting. There were also aspects which accident and emergency staff considered to be unsatisfactory and one of these related directly to this study. The speed with which reports were returned was judged to be a source of dissatisfaction by both accident and emergency and clinical radiology staff. From the initial survey, it was clear that there were two important concerns to be considered in relation to the implementation of radiographic reporting services. These were the quality of the reports and the speed with which reports were returned to the accident and emergency department.

Of particular concern was the quality of reports. These were considered to be both important and satisfactory and any radiographic reporting service would need to

demonstrate that the quality evident within the Trusts prior to implementation of an RRS was maintained. As can be seen from the detailed scrutiny of the accuracy of the radiographers' reports carried out during this study and the discussion earlier in this section of the report, the view that accuracy, and so quality, of reports has been maintained can be expressed with confidence. Additionally, when specifically asked in the final survey about the degree of satisfaction with the quality of the radiographers' reports, 11 respondents expressed themselves to be extremely (n=7) or very (n=4) satisfied with the final respondent claiming to be 'quite satisfied'.

The second matter of note from the initial survey was the dissatisfaction felt with the speed with which reports were returned to the accident and emergency department. This, too, was subjected to scrutiny during this study and was found to have improved in all four NHS Trusts and at four of the five clinical sites. While it is not known whether this aspect of the clinical radiology services within these Trusts has improved its satisfaction score, it is likely and this view is supported by statements made in the final survey. Six (of 12) respondents made specific mention of the fact that reports were available more quickly following the introduction of the RRS.

The qualitative part of the initial survey identified general but cautious support for the implementation of radiographic reporting services, believing that they could have a beneficial effect on patient management. Difficulties, although not insurmountable, in implementing such services were also recognised. Analysis of the final survey suggested that the early views of respondents were well founded. Both patient and organisational benefits following the implementation of an RRS were identified, as illustrated by the following quotations:

"... the benefit actually is to the rest of the organisation where consultants are freed up to do more relevant work. Radiologists now are far more interventional. So the benefit is elsewhere to the organisation as well as to us."

Accident and Emergency Consultant

"There are two benefits. Firstly, the casualty films themselves are reported in a more timely way. And there's also a knock-on effect on the whole reporting situation in that it's taken that segment of films out of the reporting pile and so there's a knock-on effect on the timeliness of reports of all other examinations."

Consultant Radiologist

"Well, we used to miss quite a few fractures which is not the case now. And we have fewer litigations because of missed fractures...."

Accident and Emergency Consultant

Equally, however, the reality of difficulties related to implementation was apparent. This is, perhaps, best illustrated by the degree of satisfaction of respondents to the nature of the service implemented. Generally, the level of satisfaction was lower than the satisfaction with the quality of the reports and one respondent was 'not very satisfied'. Only one respondent was 'extremely satisfied' with 6 claiming to be 'very satisfied' and 4 'quite satisfied'. Some quotations from the final survey serve to underline this:

"... we never really funded this ... so really you need to make sure you've got adequate staffing and if you haven't the staffing you need to put in to get staff ..."

Radiology Services Manager

"I think there are initial difficulties. I wouldn't call them pitfalls and most of the ones we encountered have been with clinicians ... who have been disturbed by having a radiographer reporting. But I think it's fair to say that, now they have got used to it, they're pretty happy."

Consultant Radiologist

"... but really the consultant radiologists need to be on board and need to be convinced about the benefits ... I'm not saying they're not on board, but if its not happening, why isn't it happening?"

Radiology Services Manager

"It must be defined as to what x-rays [they] are allowed to report on. I think it would be wrong for them to be reporting on areas where a large amount of medical knowledge is required."

Accident and Emergency Consultant

"Yes, there are pitfalls because reporting is not seen as part of the radiographer's role. And when they do go to do reporting, the other radiographers perceive it as [pause] you know they take offence at it."

Radiology Services Manager

Generally, it can be concluded that users of the radiographic reporting services within the four NHS Trusts are very satisfied with the quality of the service offered by the radiographers and have expressed themselves to be extremely or very satisfied with the quality of the reports. Similarly, positive comments were made about improvements in the speed with which reports were received. These factors, too, are borne out by the detailed examination of the accuracy of the radiographers' reports and the investigation into the effect of an RRS on the speed with which reports became available. However, each Trust expressed difficulties in relation to implementation, although these varied according to Trust and/or clinical site. These difficulties were very apparent to the study team and formed real barriers to smooth implementation and/or maintenance of radiographic reporting services and, undoubtedly, contributed to the only moderate enthusiasm demonstrated by users in relation to their satisfaction with the nature of the services implemented.

8.9 Summary

The findings of this study demonstrate that radiographers report on musculo-skeletal trauma examinations with a high degree of accuracy and that accuracy is maintained over time, although this should be subject to further testing over a longer time period than was possible in this study. Implementation of radiographic reporting services has also brought benefits to most but not all clinical sites in the study. These benefits were, however, hard won and a number of problems were associated with implementation. Despite the problems, users declared themselves to be satisfied with the services implemented and very satisfied with the quality of the radiographers' reports.

Overall, these findings would suggest that implementation of radiographic reporting services is a strategic organisational and managerial matter to ensure a well planned and properly supported service is provided. The high quality of the work of the radiographers has been demonstrated in terms of the accuracy of the reports they produced and these were subjected to three levels of analysis. Additionally, the reporting work carried out by the radiographers enabled some improvement in the quality of clinical radiology services provided. In particular, the volume of reporting activity increased in 2 of the 4 Trusts following implementation of an RRS and the speed with which reports became available improved in all 4 Trusts.

On the basis of these findings it is, at least, possible to suggest that the debate about the implementation of radiographic reporting services should be re-focused. Perhaps the proper question to be addressed is not whether radiographers should be reporting but how should such services be implemented?

9. Conclusions

The aim of this study was to evaluate the implementation into practice of radiographic reporting services in four NHS Trusts within England. These services were confined to the provision of reports on musculo-skeletal trauma cases with a view to improving this aspect of clinical radiology reporting services and better supporting accident and emergency departments. Five measures were used in the evaluation, namely accuracy of the reports, the volume of reporting activity, the speed with which reports became available to accident and emergency staff, costs of these services, and the satisfaction of users of the services.

9.1 The Study Questions

The study has demonstrated that the radiographers were able to report musculo-skeletal trauma examinations with a high degree of accuracy, and to maintain this over time (see section 7.1 of this report). Users of the service, too, remarked on the quality of the reports produced and expressed themselves to be 'extremely' or 'very' satisfied with this aspect of the service. This was an important finding. Users had indicated in the initial survey that the quality of reports was a very important part of the services provided by clinical radiology and had also expressed themselves to be satisfied with this aspect of the service. Hence, it was crucial that this quality be maintained as radiographers took on the reporting role.

Some impact on patient care, as measured by volume of reporting activity and the speed with which reports became available, was also demonstrated although this varied from Trust to Trust and clinical site to clinical site. There were significant improvements in the volume of reporting activity post-implementation at 2 of the 4 clinical sites in which this was measured. (It was not possible to measure this at site E.) Additionally, the speed with which reports became available was shown to have improved significantly in all 4 NHS Trusts (but not at one clinical site) and was also perceived to have improved by users of the service. Of interest was the fact that the greatest improvement in speed of availability was at Trust 2 with 5 radiographers operating the RRS. This may have implications for the implementation of an RRS.

It must be concluded that cost data obtained during this study was not robust and, accordingly, conclusions are tentative. Nevertheless, it was evident that radiographic reporting services are not cost-free and, using data provided by two of the Trusts (1 and 2), it is possible to propose that additional costs (but not full costs) lie somewhere between £40 and £60 per reporting radiographer, per week. These Trusts operated the service for an average of 15 hours and 25 hours per week respectively. It is stressed, however, that these figures are offered as timid, early guidance and that they cannot be generalised.

Finally, an important part of this study was the exploration of the degree to which users of the radiographic reporting services implemented were satisfied with the services provided. Clear evidence emerged that users were very satisfied with the quality of the reports produced by the reporting radiographers. They were slightly less satisfied with the nature of the services provided although this was attributable to the considerable organisational issues that affected implementation at each site. These differed widely but an important conclusion to this study is that such services must be planned properly and implemented carefully, taking into account the concerns of both service providers and users. It may also be concluded that commitment from key senior personnel in both accident and emergency and clinical radiology departments is essential. Where this was in doubt (clinical site C) no significant benefits in terms of volume of reporting activity or the speed with which reports became available was apparent although the standard of reports produced was high and users were satisfied with the service.

9.2 Emerging Matters

In addition to the main research questions asked in this study, the study team also aimed to identify factors associated with the introduction of radiographic reporting services that were unknown or unrecognised. Perhaps the major point that emerged, particularly from the taped interviews, was the way that organisational and institutional 'politics', poor inter-departmental relationships, and inappropriate behaviours and attitudes of senior staff hampered the implementation of radiographic reporting services and no Trust or clinical site was free of such influences. It is recognised that this view is impressionistic and based on unreported

oral evidence. Nevertheless, it lends credence to the view that effort should begin to be directed towards exploring how radiographic reporting services should be provided, rather than continuing to focus exclusively on the abilities of radiographers in terms of reporting. Certainly, in this study, there can be little doubt about the abilities of the radiographers but some alarm might be expressed about the considerable difficulties that surrounded the implementation of most of the services scrutinised.

9.3 Recommendations

The study team concluded that the radiographic reporting services investigated were of a very high quality in terms of the accuracy of the reports produced by the radiographers, and were beneficial in improving services offered to patients. It is recommended, therefore, that those NHS Trusts that are unable to provide a full and/or timely musculo-skeletal trauma reporting service should implement a radiographic reporting service. However, steps must be taken to ensure that this is properly planned, funded, implemented and managed. This is considered to be a shared responsibility between the accident and emergency and the clinical radiology departments. Steps should also be taken to monitor the effectiveness of the service and to audit the reporting standards periodically.

It is further recommended that the disciplines involved in reporting should seek to standardise reporting practices to a greater extent than was evident in this study. In particular, the question of what should and what should not be reported for trauma examinations needs further exploration. Similarly, differences in the use of terminology were evident and would benefit from improved standardisation.

Finally, as far as is known, this study was the first to examine in detail the implementation of radiographic reporting services into practice in four different NHS Trusts, each with its own approach to and view on how such a service should be provided. There is a need, therefore, to develop this work further and to investigate additional and/or alternative ways of implementing full, cost effective, and timely trauma reporting services. Such investigation might pave the way to 'hot' reporting as recommended by the Audit Commission in its 1995 report.

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11. Acknowledgements

There are a large number of people who have contributed to the completion of this project in some way and it is impossible to acknowledge individually everyone. Nevertheless, the study team would like to take this opportunity to thank all of those people who contributed and who are not listed here, as well as to acknowledge formally the considerable help and support received from the following.

Our collaborating NHS Trusts who endured considerable intrusions into the day to day running of busy accident and emergency and clinical radiology departments. Particular thanks are extended to those consultant radiologists who were required to verify large numbers of radiographic reports, as well as to those staff who facilitated this work by pulling, preparing and re-filing films. Literally, without their help, this study would not have been possible. In the context of staff within the Trusts, special mention is made of the reporting radiographers. They were prepared to subject their work to minute scrutiny and they were also the ones that had to cope with the vagaries of implementation as these occurred. Again, without their work this study could not have been undertaken.

The expert panel members have also assisted greatly and, indeed, continue to do so now that this work is concluded. Much of their work has revolved around the scrutinising the report accuracy data and is extending to review the clinical significance of the small number of errors found in this study.

We are also indebted to the Steering Group for this project who guided this work and gave invaluable advice, support and constructive criticism throughout. Again, their work is extending beyond the confines of this project.

A number of staff at Canterbury Christ Church University College have supported this work directly and indirectly. Financial, secretarial and moral support has been forthcoming whenever it was required and we are very grateful that we have such good friends and colleagues within the University College.

Finally, of course, we are indebted to the Research and Development Directorate at the (then) South Thames Regional Office, not only for supporting this project financially but also for the friendly, constructive and helpful advice given throughout its duration.

Appendix 1: Radiographic Reporting Services: Costs Questionnaire

7 January 1999

Dear

Re: Implementation of Radiographer Reporting Service (RRS) Project

You will be pleased to hear that the above project is in its final phase and the report will be completed by 31 January 1999. There is, however, a small amount of costs data needed in order to round it off fully. I would be very grateful if you could return this letter (or a copy) with the following questions answered by 18 January 1999.

Number of radiographers that have been reporting? .....

Grade/s of radiographers involved? .....
.....
.....
.....
.....

Average time spent (per week) on reporting activities up to 30 November 1998 .....

Average additional staff costs (radiologists, radiographers, clerical, administrative and support staff) including on-costs. .....

Any other additional costs e.g. routine audit/training which have followed on from the implementation of the RRS (per week). .....

Thank you very much indeed for giving up your time to this (and, indeed) to the project as a whole. I really am most grateful.

Yours sincerely

Appendix 2: Initial Survey Questionnaire and Interview Schedule

Department of Radiography

Canterbury Christ Church College

NHS Executive - South Thames
Funded Research Project

Hospital Questionnaire

Name: ..... Hospital: .....

Position: ..... Date: .....

Please rank the importance of each aspect of NHS radiology services in conjunction with the quality of the service you currently receive. Please rank, using the following scale:

++	Crucial
+	Very important
0	Quite important
-	Not very important
--	Irrelevant

		How important is each aspect of the service to you?					What quality service do you receive?		
		++	+	0	-	--	Good	Adequate	Poor
1.	Availability of old films	r	r	r	r	r		r	r	r
2.	Quality of images	r	r	r	r	r		r	r	r
3.	Speed with which urgent exams are performed	r	r	r	r	r		r	r	r
4.	Radiologist reporting of all films	r	r	r	r	r		r	r	r
5.	Speed with which reports are returned	r	r	r	r	r		r	r	r
6.	Quality of reporting	r	r	r	r	r		r	r	r
7.	Shorter waiting times for patients in the radiology department	r	r	r	r	r		r	r	r
8.	Radiologists' availability for consultation	r	r	r	r	r		r	r	r
9.	Constructive, helpful advice	r	r	r	r	r		r	r	r
10.	Joint clinical meetings	r	r	r	r	r		r	r	r
11.	Action to reduce the burden of inappropriate examinations	r	r	r	r	r		r	r	r

Source: The Audit Commission (1995) Improving your image - how to manage radiology services more effectively London: HMSO

1. Does the x-ray department currently provide a "red dot" system, and if so:

   a) What do you see as its benefits?

   b) Does it have any draw backs or pitfalls?

2. How often do you think or believe A&E staff seek comments from radiographers on skeletal radiographs?

3. What are your feelings regarding the Audit Commission's recommendation that all departments "institute a 'hot reporting' system allowing reports of basic exams to be available before the patient leaves the department"?

4. What do you see as the obstacles to x-ray departments carrying out of the recommendation of the Audit Commission?

5. Considering current practice, do you feel the Commission's benchmark of 'hot reporting' is realistic?

   a) If realistic, why do you believe it is?

   b) If unrealistic, why do you believe it is not?

6. To what extent do you feel patient management is affected by the lack of a report from the imaging departments?

7. How realistic is it to expect that all reporting activity be carried out by radiologists?

8. To what extent could the introduction of reporting by radiographers contribute to the services offered to patients by imaging departments?

9. Considering the introduction of reporting by radiographers;

   a) What do you see as the benefits to such a development taking place?

   b) Are there any constraints?

10. Are there any further comments you wish to make in respect to:

   a) reporting in general?

   b) radiographic reporting, specifically?

Appendix 3: Final Survey Interview Schedule

Department of Radiography

Canterbury Christ Church College

NHS Executive - South Thames
Funded Research Project

Hospital Questionnaire 2

Name: ..... Hospital: .....

Position: ..... Date:.....

I understand that since last time we interviewed you, a Radiographic Reporting Service has been implemented.

1. Have there been any benefits in the introduction of radiographer reporting? Yes/No

2. If yes, what are they ?

3. With regards to the introduction of reporting by radiographers;

   a) How satisfied are you with the quality of reports issued by radiographers

      1. extremely satisfied
      2. very satisfied
      3. quite satisfied
      4. not very satisfied
      5. unsatisfied

   b) How satisfied are you, overall, with the type of radiographic reporting service which has been implemented for A&E examinations (e.g. hours of service, availability, number of radiographers reporting, etc.)

      1. extremely satisfied
      2. very satisfied
      3. quite satisfied
      4. not very satisfied
      5. unsatisfied

   c) Are there any changes or improvements you would like to make?

4. Given that radiographers are now providing reports to A&E, do you feel there are any ways that these service could be developed further? Yes/No

5. If yes, how and why?

6. Do you feel there any drawbacks or pitfalls associated with a Radiographic Reporting Service? Yes/No

7. If yes, what are they ?

8. What are your feelings regarding the Audit Commission's recommendation that all departments "institute a 'hot reporting' system allowing reports of basic exams to be available before the patient leaves the department"?

9. What do you see as the obstacles to x-ray departments carrying out of the recommendation of the Audit Commission?

10. Are there any further comments you wish to make in respect to:

    a) reporting in general?

    b) radiographic reporting, specifically?

Appendix 4: Dissemination of the Work

The Implementation of a radiographic Reporting Service for Skeletal Trauma

Paterson AM, Piper KJ, Ryan CM

(proffered paper accepted and presented at the European Congress of Radiology, Vienna. March 1999. Abstract No: 535)

Preliminary Findings: The Implementation of a Radiographic reporting Service for Trauma Examinations of the Skeletal System in 4 English NHS Trusts

Piper KJ

(Invited presentation: Annual General Meeting of the Special Interest Group in Radiographic Reporting, September 1998)

The Implementation of a Radiographic Reporting Service for Trauma Examinations of the Skeletal System

Piper KJ, Paterson AM, Ryan CM

(proffered paper accepted and presented at Radiology 1998, Birmingham. May 1998. Abstract No: 1130)