



# Evidenced-based radiology? A single-institution review of imaging referral appropriateness including monetary and dose estimates for inappropriate scans

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## Abstract

**Background** There has been a year on year increase in imaging requests at our academic institution. The iRefer guidelines are produced by the Royal College of Radiologists in the UK and are designed to prevent inappropriate imaging and radiation exposure. They have been available to general practitioners and hospital physicians in Ireland since March 2015.

**Aims** Our aims were to determine the proportion of inappropriate imaging referrals pre- and post-guideline introduction and to calculate the cost and dose estimates for inappropriate scans.

**Methods** A retrospective review of 1124 radiographs was performed with reference to a validated audit template. Emergency department, in-patient, and general practitioner referrals were reviewed. Cost and cumulative dose estimates were calculated for inappropriate referrals taking into account salaries, average time spent performing/reporting radiographs, and median effective dose values.

**Results** The introduction of the iRefer guidelines has not significantly affected the proportion of inappropriate radiograph referrals at our institution, 42% pre-introduction and 43% post-introduction. We identified 784 inappropriate referrals across 6 radiograph subtypes, imparting a total median effective dose of 65.1 mSv to patients. The time spent performing inappropriate abdominal and spinal radiographs in 2017 yielded an estimated cost of €8036.40.

**Conclusion** A significant amount of inappropriate radiographs continue to be requested and performed, exposing patients to needless ionizing radiation and wasting staff members time at a financial cost. Interventions are needed to decrease inappropriate referrals.

**Keywords** Imaging appropriateness · iRefer guidelines · Patient dose · Radiology services

## Abbreviations

ESR European Society of Radiology

RCR Royal College of Radiologists  
UK United Kingdom  
HSE Health Service Executive  
GP General practitioner  
PNS Para-nasal sinus  
NB Nasal bone  
AR Abdominal radiographs  
ED Emergency department  
IP In-patient  
SR Spinal radiograph  
CDS Clinical decision support  
mSv Millisieverts

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## Introduction

The demands on clinical radiology services are increasing. Overutilization of diagnostic imaging has added “unjustifiable costs” to healthcare [1]. Prior studies have noted the increase

in public health spending that accompanies increased utilization of diagnostic imaging [2]. As such, the contemporary radiologist should be cognizant of their role in “economic gatekeeping” and patient safety [3]. Employees of state-run public healthcare systems have an obligation to ensure appropriate use of taxpayer funds [4]. In order to achieve this in radiology, we must ensure that referrals are evidence-based. The increased use of ionizing radiation in diagnostic radiology raises justifiable public health concerns [5, 6]. In recent years, the European Society of Radiology (ESR) has strongly endorsed objective justification of imaging requests using evidence-based guidelines prior to the administration of ionizing radiation [7].

Our institution has experienced a dramatic year on year increase in imaging referrals. As a result, outpatient waiting lists have steadily increased. Similar trends have been noted in the UK, Canadian, and American hospitals [8–11]. The iRefer guidelines are evidence-based imaging referral guidelines produced by the Royal College of Radiologists (RCR) in the UK [12]. The iRefer guidelines are purchased by the Irish Health Service Executive (HSE) on an annual subscription and have been available to the Irish General Practitioners (GPs) and public hospitals since March 2015. Despite the widespread availability of the iRefer guidelines, the number of imaging referrals has continued to increase at our institution.

The primary goal of this study was to assess the appropriateness of plain radiograph referrals before and after the introduction of the iRefer guidelines in March 2015. Secondary goals included carrying out a cost estimate and dose analysis of inappropriate referrals.

## Materials and methods

This single-center retrospective review was carried at a tertiary referral academic institution. The “Audit of Compliance with Imaging Referral Guidelines,” template from the RCR website was referred to during study planning [13]. A number of radiograph subtypes were included in this study: para-nasal sinus (PNS), nasal bone (NB), abdominal radiographs (AR), and spinal radiographs (SR).

### Para-nasal sinus and nasal bone radiographs

PNS and NB radiographs (from all referral sources) in the 2 years before and the 2 years after the introduction of the iRefer guidelines were reviewed. Cost and cumulative dose estimates for these radiographs were calculated.

### Abdominal radiographs

Three referral sources were assessed: general practitioner (GP), in-patient (IP), and the emergency department (ED).

For each source, 50 radiographs were reviewed from January 2015 pre-introduction of the iRefer guidelines and 50 from January 2017 post-introduction. Inappropriate requests were identified by reviewing the referral information for each radiograph and consulting the iRefer guidelines. Cost and cumulative dose estimates for inappropriate radiographs were calculated.

### Spinal radiographs

Forty-nine C-spine, 49 T-spine, and 49 L-spine GP radiograph requests were reviewed pre- and post-introduction of the iRefer guidelines. Inappropriate requests were identified by reviewing the referral information for each radiograph and consulting the iRefer guidelines. Cost and cumulative dose estimates for inappropriate radiographs were calculated.

### Cost analysis

Radiology directorate staff salary information was obtained (consultants, registrars, radiographers, porters, and administrative staff). Time taken to complete a single radiograph per profession was estimated. Radiographs acquired and reported on call were noted. Using this information, the estimated cost of inappropriate radiographs was calculated for each radiograph subtype and referral source (Table 2).

### Dose analysis

Cumulative median effective dose estimates were calculated for inappropriate radiographs using local median effective dose values. Additional radiograph views outside of the standard protocol were taken into account in the dose analysis, i.e., oblique views in a C-spine radiograph.

## Results

The referral information for 1124 radiographs was reviewed. Six hundred eight radiographs pre-iRefer guideline introduction and 559 radiographs post-iRefer guideline introduction.

### Para-nasal sinus and nasal bone radiographs

According to the iRefer guidelines, PNS and NB radiographs are never indicated [12]. Three hundred eleven PNS and NB radiographs were performed in the 2 years prior to the iRefer guideline introduction (March 2013–February 2015). Two hundred sixty-two were performed in the 2 years after the guideline introduction (March 2015–February 2017). The total estimated cost of these inappropriate radiographs over this 4-year period was €2867.70. The total cumulative effective dose to patients was 8.7 mSv.

### Abdominal radiographs

According to the iRefer guidelines, ARs are indicated under specific circumstances [12]. Comparing January 2015 to January 2017, there was an increase in the number of inappropriate AR referrals from all sources (Table 1). There was a 12% increase in inappropriate GP referrals (60–72%), a 4% increase in inappropriate IP referrals (26–30%), and a 12% increase inappropriate ED referrals (26–38%) (Table 1). The total estimated cost of inappropriate ARs from GP, ED, and IP sources in January 2015 and 2017 combined was €660.70. The cumulative effective dose to patients was estimated at 33 mSv.

### Spinal radiographs

According to the iRefer guidelines, SRs are indicated under specific circumstances [12]. The average number of inappropriate SR referrals from GPs (C-spine, T-spine, and L-spine) in January 2015 was 47.7%. This decreased to 39.3% in January 2017 (Table 1). The total estimated cost of the inappropriate GP SR referrals from January 2015 and January 2017 was €643.80. The cumulative effective dose to patients was estimated at 31.9 mSv.

### Total estimated cost of inappropriate abdominal and spinal radiographs for 2017

The estimated cost of inappropriate ARs in January 2017 was €371.90. The estimated cost of inappropriate SRs in January 2017 was €297.80. Assuming that these inappropriate referral rates remained static for the remaining 11 months of the year; the cost estimate of inappropriate AR and SR referrals in 2017 was €8036.40.

### Discussion

It is well documented in the literature that imaging overuse leads to increased radiation exposure, increased monetary cost, and increased waiting lists [1, 2, 11]. On review of 6

radiograph subtypes, we identified 784 inappropriate referrals imparting a total median effective dose of 65.1 mSv to patients, the equivalent of 21.7 years of background radiation [14]. The time spent performing inappropriate abdominal and spinal radiographs in our department in 2017 yielded an estimated cost of €8036.40. The introduction of the iRefer guidelines has not significantly affected the proportion of inappropriate radiograph referrals at our institution, 42% pre-introduction and 43% post-introduction. It is worth considering that radiographs are the quickest and cheapest imaging tests performed in a radiology department. A similar analysis of computed tomography referrals could reveal much larger cost and dose estimates.

The reasons for this poor compliance with the iRefer guidelines have not been fully elucidated in this study. At our institution, there is free access to the iRefer guidelines from hospital desktop computers and GPs are also entitled to free access. Anecdotally, we have found that knowledge of the iRefer guidelines among local GPs and hospital physicians is poor. In the future, a quantitative analysis to identify causal factors could help to target appropriate interventions.

Further efforts are needed to stem inappropriate referrals. Implementation of feedback and accountability mechanisms may help to move towards more sustainable and appropriate use of resources. A recent national audit in the UK concluded that the implementation of “meticulous vetting,” and the “return of inappropriate requests,” was associated with a high proportion of appropriate diagnostic imaging requests [15]. In keeping with this, we have since implemented more stringent vetting of GP plain film requests locally, which is carried out by radiographers with reference to the iRefer guidelines. Radiologists are consulted in certain cases and inappropriate GP referrals are now either canceled or re-triaged to a more appropriate imaging request. The turnover rate of junior doctors and a high volume of in-hospital X-ray requests make it more difficult to implement a similar vetting system for inpatient and emergency department referrals.

Clinical decision support (CDS) software has become commonplace in many North American hospitals and has reduced inappropriate referrals in many cases [16, 17]. CDS software provides evidence-based feedback to physicians regarding the

**Table 1** Referral trends pre- and post-iRefer guideline introduction

	Inappropriate radiographs Pre-iRefer (January 2015)	Inappropriate radiographs Post-iRefer (January 2017)	Change
GP abdominal radiographs	60% (30/50)	72% (36/50)	+ 12%
ED abdominal radiographs	26% (13/50)	38% (19/50)	+ 12%
IP abdominal radiographs	26% (13/50)	30% (15/50)	+ 4%
GP C-spine radiographs	27% (13/49)	18% (9/49)	– 9%
GP T-spine radiographs	55% (27/49)	47% (23/49)	– 8%
GP L-spine radiographs	61% (30/49)	53% (26/49)	– 8%
Total	42% (126/297)	43% (128/297)	+ 1%

appropriateness of their request; it may also have a role in facilitating audit and physician accountability. The success of CDS software in North America is largely been due to monetary recourse imposed on institutions performing inappropriate scans [3].

A recent study in New Zealand showed that physician feedback regarding personal referral appropriateness relative to their peers helped bring about a sustained decrease in inappropriate imaging referrals [18]. Targeted interventions such as this may help to circumvent inappropriate referrals, e.g., endorsement of the iRefer guidelines by radiology at junior doctor orientation days and GP–radiologist group meetings to help promote imaging appropriateness education.

### Limitations

This is a single center, retrospective study and may therefore be susceptible to selection bias.

The cost estimate model used was based on staff salaries and the average time taken by staff members to acquire and report radiographs. This model provides a rough estimate of the cost and time spent performing inappropriate radiographs and is not a validated model.

The validity of this study is in part dependent on the accuracy of the clinical information provided by the referrer.

Unfortunately, there is no way to determine with certainty, the proportion of requests containing inaccurate information or those missing relevant clinical details.

### Conclusion

We have used a validated audit template to demonstrate that the introduction of the iRefer guidelines has not significantly affected the proportion of inappropriate plain radiograph referrals at our institution. A significant amount of inappropriate radiographs continue to be requested and performed, exposing patients to needless ionizing radiation and wasting staff members time at a financial cost. Interventions are needed to decrease inappropriate referrals.

### Compliance with ethical standards

**Conflict of interest** The authors declare that they have no conflict of interest.

**Ethical approval** This article does not contain any studies with human or animal participants performed by any of the authors.

## Appendix

**Table 2** Cost analysis assumptions

Inpatient referrals	Emergency department referrals	General practitioner referrals
50% require porter	50% require porter	0% require porter
0% reported by registrars	90% reported by registrars	10% reported by registrars
100% reported by consultants	10% reported by consultants	90% reported by consultants
100% require radiographer	100% require radiographer	100% require radiographer
0% require administrative staff	0% require administrative staff	100% require administrative staff

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