‘Cranking up’, ‘whacking up’ and ‘bumping up’: X-ray exposures in contemporary radiographic practice.

# Abstract

This article explores the use of X-ray exposures following the introduction of direct digital radiography (DDR). Radiographers are central to delivering optimum levels of ionising radiation whilst maintaining sound image quality for radiological interpretation. Yet do radiographers utilise X-ray exposures appropriately? An ethnographic methodology provides insight of two general radiographic environments in the United Kingdom (UK) using participant observation and semi-structure interviews. A central theme uncovered as part of a Doctorate of Philosophy (PhD) study was the lack of autonomy concerning X-ray exposures within the general imaging environment. The findings highlight ‘how radiographers behave’. For example, some radiographers do not alter ‘pre-set’ X-ray exposures, arguably failing to produce images of optimum diagnostic quality. Secondly, radiographers acknowledge ‘whacking up’, ‘cranking up’ and ‘bumping up’ X-ray exposures ensuring image production. In conclusion this article provides an original insight into the attitudes and behaviours of radiographers regarding X-ray exposures in contemporary practices using DDR. Dose and image optimisation are central tenets of radiographic practice that may be hindered in contemporary practices.

# Introduction

This article provides insight into the use of X-ray exposures within the general imaging environment. Medicine is an ever changing field and is becoming increasingly reliant upon technical equipment and practices.1 In diagnostic radiography it is generally accepted that the introduction of direct digital radiography (DDR) has facilitated image production. For example, DDR has relieved tensions by capturing X-rays electronically, which are archived and rapidly retrievable through picture archiving communication systems (PACS). The digital detector is the key component of a DDR system consisting of pixel sizes affecting the systems resolution with typical ranges from 127-200µm providing optimal detective quantum efficiency (DQE) and established as the most suitable parameter for describing imaging performance.2 The continued improvement of image storage, ‘bit depth’, image matrix and crystal structure of DDR hardware is generally accepted to enhance the delivery of radiographic practice and radiological reporting.3 For example, the convenience of immediate image acquisition coincided with dose reducing opportunities are clear advantages of all DDR equipment: ‘exams are done easier and may result in fewer retakes and a low X-ray dose for your patients’.4 (p.3) In the United Kingdom (UK) radiographers are required to keep radiation doses ‘as low as reasonably practicable’ (ALARP) whilst ensuring optimum image quality for radiological reporting.5 This legislative practice stems from the hypothetical linear non-threshold dose response model, which maintains there is ‘no safe radiation dose’, thus informing radiation safety today.6 The importance of reducing ionising radiation is published in numerous studies demonstrating dose optimising opportunities in chest and skeletal radiography whereby 33-80% dose reduction is reportedly achieved (depending on clinical query).7-11 Whilst dose optimisation can be achieved the aim of this article explores the use of X-ray exposures within the clinical environment because it is one of the fundamental options for implementing the ALARP principle limiting ‘dose creep’, whereby radiographers may favour excellent image quality by delivering higher exposures than normal.12 Few studies have explored this phenomenon clinically,13 thus the aim of this study is to provide original insight of X-ray exposures using DDR by observing ‘what radiographers do and how they do it’. The objective is to inductively explore radiographic practices within the DDR environment supporting the National Health Service’s (NHS) continuing focus to ‘work at the limit of science – bringing the highest level of human knowledge and skill to save lives and improve health’.14 (p.2) This is important to consider because the attitudes and behaviours of radiographers arguably impact on the use of ionising radiation within the general radiography environment. Murphy15 p.170 maintains that radiography as a profession has failed to ‘critique or inquire into what is after all a technology driven environment and as a result there is inadequate consideration of radiological technology that examines its emergence or impact on both society and the profession itself’. In short, by exploring technological advances within the radiographic environment it may inform the future radiographic curriculum and facilitate student learning. It remains central to explore general radiographic practices in the UK because current estimates suggest that general radiographic examinations (combined with fluoroscopy) approximately constitutes 90% of all radiological examinations undertaken in the radiology department thus a majority of the radiographic workload undertaken clinically,16 which may resonate with other general imaging departments nationally and internationally.

# Methodology

The methodology used in this study was ethnography. Ethnography offered a valued insight into a specific culture underexplored within radiographic practice in the UK. It was first pioneered in the field of socio-cultural anthropology deriving from Greek words ‘ethnos’ (folk/people) and ‘grapho’ (to write) to learn and understand cultural phenomena which reflects the knowledge and system of means guiding the life of a cultural group.17 This holistic approach to culture is cited in the early work of the Chicago School of Sociology, creating an ethnographic mosaic using a variety of methods to better understand the social and cultural world.18 Ethnography is a qualitative and open-ended methodology, enhancing the understanding of relationships of clinical practices. Ethnography provided the tool to explore the world from the radiographers’ perspective. Hammersely19 p.35 terms this ‘practitioner ethnography’ following its recent uses in education and other professional disciplines. Social constructionism and interpretivism allowed the ethnographic fieldwork to explore the knowledge, understanding and cultural underpinnings of the imaging department.20 Crucially, the nature of this research and in particular its relationship to practice allowed the researcher to get closer to social reality uncovering radiographic practices.19 The methods included:

1) Participant observation: Observing contemporary radiographic practices using DDR exploring ‘what radiographers do’.

2) Interviews: Explored key themes derived from the clinical observations uncovering deeper meanings into ‘what had been seen and discussed informally’.

The aim of ethnography is to provide thick descriptions of patterns of behaviour belonging to individuals and groups within a particular culture.17,19 It can play a pivotal role to a professional group that seeks to understand the behaviour of its members.20 Saks and Alsop21 argue that ethnography can be more integral to professional groups that seek to yield understanding of the behaviour and practices of its members, illuminating hitherto covert patterns of behaviour and decision-making in the field. The fieldwork contexualised behaviour and decision-making in a particular work domain during a recurring but delimited time such as a normal working day seeking to understand participants actions and their experiences of the world through observing the participants by learning about people by learning from them.22 The intention of the fieldwork was to gain a rich description of radiographic practices from participant observations and interviews, tracing the process of ‘definition of the situation’ and interpret the findings.23, p.153 This supported the humanistic discovery aiming to capture and understand naturally occurring world activities in real-world settings because it was believed that radiography had its own culture in the development of DDR.23 Ethical applications were submitted to two NHS Trusts in the south of England following the installation and clinical use of DDR equipment. Applications were considered and approved at both NHS hospitals and by the University.

## Participant Observation

Empirical fieldwork began in October 2012 and finished in 2013. The choice of research sites were selected because DDR was used on a day-to-day basis by radiographers. Where informed consent was forthcoming observations were undertaken. In total approximately 30-40 operators were observed over 19 days (approximately 142 hrs.). On a typical 09:00 – 17:00 working day observations commenced at 09:00 and ended at 12:00, I would break for lunch, gather notes and then begin the second observational block from 12:30 to 17:00. Participant observation provided immersion as a ‘participant observer’ and lasted for approximately two months. Barley24 p.83 maintains that to map emergent patterns of action and interpretation requires at least partial reliance on participant observation to record interactions. The observations were vital in this process as Larsson *et al* 25 highlight; how work is done in the radiographic department depends on the individuals’ knowledge as well as on his or her openness, flexibility, service-mindedness, willingness to develop professionally, and triggers for doing certain things. Throughout the observations I observed and informally discussed the use of DDR at both research hospital sites, known as ‘site A’ and ‘site B’. Site A had used DDR since 2006 whereas site B since 2011. Field notes provided a useful tool capturing the behaviours, views and attitudes of radiographers, providing first-hand experience of action-in-process.22 The observations allowed me to ‘enter’ the radiographers’ world and discuss emerging concepts, which provided a platform for the interview transcript. Throughout the observations some participants altered their actions upon observation, for example operators became increasingly self-aware of their working behaviour illustrating the Hawthorne effect. The best evidence however to suggest that my presence did not noticeably alter all participants behaviours lies in the fact that some participants were willing to practice in a way that other radiographers may have disapproved of. This method observed and informally documented ‘what radiographers did’ in the DDR environment. This was later analysed and informed the development of the interview schedule.

## Interviews

Twenty-two interviews were undertaken. Nine interviews were undertaken at site A and thirteen interviews at site B. The radiographers observed were invited to interview, this was important in terms of theory development.22 Interviewers were ceased following data saturation hence varying sample sizes at sites A and B. Semi-structured interviews lasted between 30 minutes to 1 hour and 15 minutes and were directed by emerging themes uncovered during the observations and informal discussions thus remained sensitive to the language and concepts used by the researcher.26 The interviews explored how long radiographers had been working with DDR whilst questioning the knowledge and understanding of DDR when performing radiographic examinations. Interviews provided significant data generation. The ‘semi-structured style’ of interviewing allowed the set of topics to form questions in the course of ‘conversations with purpose’.26 p.102 Interviews were recorded using a digital audio device later transcribed verbatim by the researcher presenting participants’ in the form of quotations. Participants varied in radiographic experience. Table 1 and 2 provide details of participants in this paper highlighting job title, clinical experience and gender specific pseudonym.

### Table 1: Participants – Site ‘A’

|  |  |  |
| --- | --- | --- |
| Pseudonym | Title and Grade | Experience |
| Margaret | Band 7 Radiographer | 18 years |
| Eric | Band 6 Radiographer | 9 years |
| Bernard | Band 6 Radiographer | 8 years |
| Sebastian | Band 5 Radiographer | 2 years |
| Rosemary | Band 6 Radiographer | 7 years |
| Sharon | Band 6 Radiographer | 12 years |
| Fred | Band 6 Radiographer | 5 years |
| Harold | Band 6 Radiographer | 9 years |
| Michael | Band 5 Radiographer | 2 years |

### Table 2: Participants – Site ‘B’

|  |  |  |
| --- | --- | --- |
| Pseudonym | Title and Role | Experience |
| Geoff | Band 6 Radiographer | 5 years |
| Elizabeth | Superintendent Radiographer | 6 years |
| Terry | Band 6 Radiographer | 7 years |
| Mick | Band 6 Radiographer | 5 years |
| Victoria | Band 5 Radiographer | 1 year |
| Abigail | Band 5 Radiographer | 11 years |
| Kirsty | Band 5 Radiographer | 2 years |
| Helen | Band 5 Radiographer | 2 years |
| Danny | Band 5 Radiographer | 8 months |
| Alex | Band 5 Radiographer | 4 years |
| James | Band 6 Radiographer | 3 years |
| Annabelle | Band 7 Radiographer | 7 years |
| Emile | Band 5 Radiographer | 9 months |

Observation and interview data were analysed using thematic analysis. The study was conducted in the clinical environment(s) assuming that ‘reality is constructed, multidimensional and ever-changing and there is no such thing as a single, immutable reality waiting to be observed and measured’.27, (p.262) Glaser and Strauss 28 (p.40) support this suggesting that general relations are discovered ‘in vivo’ through participant observation, that is ‘the fieldworker literally sees them occurring’. The analysis began by gathering and comparing data and dividing it into themes highlighting the commonalities and variations. The data was transcribed into a word processing application, dated and indexed with spelling and grammatical errors searched and corrected. Themes were categorised and coded.27 Codes were assigned to overarching themes and later printed on A4 paper, ‘cut out’ and placed on A1 pieces of card, whereby theory could then be linked across the themes. Colour pencils were used to cross reference themes, which provided the basis of theory development.

# Results and Discussion

The data uncovered in this research was collected from two radiography departments therefore cannot be generalised. However radiographers in other departments may have similar experiences to the views of radiographers uncovered in this study thus important to consider. The use of ionising radiation aims to be minimised in medicine limiting the probability of stochastic effects and the occurrence of deterministic effects. The three principles; justification, optimisation and dose reference levels ensure that radiological doses arising in medicine are kept to a minimum because although it is of great value in medicine it remains the largest artificial source of ionising radiation to the human race.6 Because radiographers are ‘the last stand – the last point of protection’ the delivery of radiographic technique is paramount to dose optimisation. It is generally accepted that whilst techniques may differ from one hospital environment to another radiographers are responsible for radiation safety for all radiological procedures.5 The Health Protection Agency (HPA)16 in the UK reported a wide range (a factor of 10 for some procedures) in mean dose area product (DAP) from one hospital to another. Several reasons may account for this, including differences in patient groups, varying techniques, different complexity of procedures and different equipment quality,13 yet this article proposes an additional insight facilitating increases in ionising radiation. Radiographers should keep doses in their foremind by selecting the appropriate kilovoltage (kVp), milliamperage (mA) and exposure time (s).12,13 These selections are often subjective, based on the region under examination, its thickness, density, pathology and whether a grid is inserted or not. On observation the adjustments of kVp and mAs were often observed but this was not apparent amongst all radiographers undertaking general radiographic examinations:

Observation: *The adjustment of kVp and mAs was observed by some radiographers depending on patient size. However others failed to adjust the exposure settings and would rely on the ‘pre-set’ exposures for varying patient sizes, including children.*

This observation was explored during interviews with radiographers at sites A and B. Some radiographers acknowledged the importance of ‘adjusting’ their radiographic exposures in order to keep radiation dose to a minimum, thus suggesting that some radiographers holistically examine patients in attempts to keep radiation doses ALARP:

Michael: *I try to keep the mAs down as much as I can really… I feel that you can bring the kV up a bit, take a bit of the mAs off with DDR.*

Geoff: *But with DDR, it’s so sensitive that you would tend to alter the kV more than the mAs. And that improves image quality as much as possible.*

Rosemary: *But yes, you obviously adapt it when you need to for either children or for things that need a bit more - for a bigger gentleman, say.*

Kirsty: *I’d adjust for children, a bariatric patient, or a really, really petite patient - patients who are really, really skinny.*

The fieldwork above identifies that some radiographers aim to conform to the ALARP principle using subjective knowledge ensuring the optimum delivery of ionising radiation with DDR. By exploring the behaviours of radiographers’ within the DDR environment this can better understand ‘how radiographers perform clinically’. The avoidance of unnecessary exposure remains central to a radiographer’s practice and by understanding ‘how radiographers operate’ may allow radiographers to critically reflect on their day-to-day clinical responsibilities, grounded in UK legislation 5, p.2:

*“A health care professional who is entitled in accordance with the employer’s procedures to take responsibility for an individual medical exposure”.*

Whilst it is generally accepted that radiographers are responsible for individual exposures in their clinical environments, radiographers at both sites acknowledged their inability to subjectively assess patient size by unaltering ‘pre-set’ exposures on the DDR console regardless of patients’ size:

Bernard: *So I was told just to use the pre-set, and not actually fiddle with it.*

James: *So far I haven’t actually adjusted any exposure factors, because compared to cassette radiography they’re pretty low on exposure. So I think it’s a good… I think they’re pretty accurate, because I haven’t had any problems with them.*

Victoria: *I don’t change the exposures as much as I do in cassette radiography. I think because it is quite good image quality, and it’s a lower dose as well. So I suppose I sort of trust it more in that way.*

Abigail: *I know you can go up and down for small children and that, but unless it’s a baby or something, I don’t change them. I generally just leave them if it’s just a child.*

Seeram *et al* 3 assert that the selection of the most appropriate exposure factors is one of the fundamental options for implementing the ALARP principle. The data above shows that some radiographers are not manipulating X-ray exposures thus arguably failing to conform to the ALARP principle. This suggests that by using pre-set exposures alone operators may be unknowingly ‘over’ or ‘under-exposing’ patients as pre-set exposures are often based on a ‘medium adult’ thus not appropriate for smaller or larger patients. In support, DDR can reportedly overexpose a patient up to 500%30 providing the operator with a ‘diagnostic image’ compensating for the wrong settings 31. Uffmann and Schaefer-Prokop32 argue that dose increases due to inappropriate techniques may be unnoticed by practitioners in the digital environment. This article supports Uffmann and Schaefer-Prokop32 argument that some radiographers do fail to alter ‘pre-set’ X-ray exposures within the general imaging environment. Failure to adjust exposures for paediatric and infant patients suggests that a ‘higher than necessary dose’ may be delivered and remain unnoticed by radiographers due to DDR ability to ‘auto-correct’ overexposed images. Paediatric and infant patients are known to be more sensitive to ionising radiation due to the increase in dividing cells, yet if radiographers fail to adjust exposure factors paediatric and infant patients may be receiving unnecessarily higher does than normal. Further, radiographers were often observed increasing X-ray exposures, not decreasing them during general radiographic examinations:

Observation: *In general, radiographers using DDR would often increase X-ray exposures to produce ‘an image of diagnostic quality’. Radiographers would rarely reduce their X-ray exposures in the general imaging environment.*

This theme was explored during interviews whereby radiographers at sites A and B acknowledged their ability to ‘whack’, ‘crank’, and ‘bump up’ their X-ray exposures ensuring a diagnostic image:

Helen: *Yes, but the important thing is that you can achieve the same image by whacking the exposure factors up.*

Harold: *The one drawback of DDR that you can basically bump up the exposure factors and if anything, it will improve the image, not make it worse.*

Bernard: *The fact that you’ve got quite a large latitude in exposure factors - the adjustable nature of the images. It’s the same as cassette radiography in that respect. Of course, there’s always the danger of a certain laziness or a “I’ll make sure this image will come out, by cranking up the exposure a bit”.*

Terry: *Particularly if it’s busy and you’re under pressure, then I think there is a tendency where you think “Right, if I set this to 1.2 mAs, that might be a bit under-exposed. If I set it at 2 mAs, it’ll definitely be there.*

It is a radiographer’s responsibility to ensure that doses are kept to a minimum. The data above demonstrates that radiographers are aware and may make use of increasing exposure factors to acquire images of diagnostic quality (Harold, Bernard and Terry). Terry suggests that ‘time pressures’ limit his evaluation of sound exposure selection and that by increasing X-ray exposures reduces the possibility of ‘having to do another exposure’. This data demonstrates a potential reduction in autonomy amongst diagnostic radiographers; moreover it suggests that operators may be in danger of deliberately increasing X-ray exposures within the DDR environment due to technological advances and increasing ‘time pressures’. Caution should be taken from these findings as this may resonate culturally with other departments nationally and internationally. In the last year radiographers in the UK have been disciplined by the Health Care Professions Council (HCPC) failing to demonstrate sound ‘appropriate levels of exposure’ and sound ‘radiographic technique’. 33 p.1 This article strengthens the importance of strict X-ray exposure selection and requirement of alternative quality assurance measures within DDR environments to ensure that radiographers remain autonomous practitioners. This study highlights that some radiographers may not be employing appropriate X-ray exposures in a modality that approximately constitutes 90% of all radiological examinations. Whilst it is generally reported that the introduction of DDR can lower radiation dose to patients in the clinical environment its uses and application in practice arguably remain problematic regardless of the known phenomena ‘dose creep’. Honey and Hogg13 recently identify the lack of literature surrounding ‘dose creep’ within the clinical environment; this article provides insight of UK practices surrounding X-ray exposure selection that requires critical reflection amongst all X-ray operators.

# Conclusion

This paper has provided insight of radiographers applying X-ray exposures within the clinical environment. DDR is reported to reduce ionising radiation to patients whilst maintaining images of diagnostic quality. The recent phenomena ‘dose creep’ suggests that radiographers may increase radiation doses due to favouring superior image quality. In response, this article adds to existing knowledge by observing suboptimum techniques in action within the DDR environment. Two issues are identified. Firstly, some radiographers acknowledge their lack of exposure manipulation prior to irradiating patients thus relying on the ‘pre-set’ exposures. This suggests that radiographers may lack professional autonomy in producing images of diagnostic quality. For example, radiographers that do not provide an adequate amount of radiation may not achieve adequate penetration or image density thus impacting overall image quality for image interpretation. Secondly, radiographers in this study were observed ‘whacking’, ‘cranking’ and ‘bumping up’ exposures ensuring they achieved images of diagnostic quality. This suggests that radiographers may not be conforming to current legislative practices in the UK that informs radiation safety today. It is generally accepted that ‘no safe dose exists’ with radiographers central to ensuring the optimum delivery of ionising radiation. In short, a potential paradox may exist in the clinical environment because whilst ‘dose creep’ is reported within the literature it is important for academics and practice leaders to ‘connected theory with practice’ because the actions explored in this study do not resonate with an ‘autonomous practitioner’. This insight may help forestall poor performances nationally and internationally following the installation of DDR by ensuring optimum radiation levels are delivered in an imaging modality that approximately constitutes 90% of all radiological examinations undertaken in the UK.

# Limitations

The findings presented in this article cannot be generalised due to the limited number of radiographers observed. Further qualitative and quantitative research should be undertaken to explore whether the findings represent a greater number of radiographers nationally and/or internationally. Whilst this study explores the practices of diagnostic radiographers it does not explore educators or student radiographers’ perspectives on X-ray exposures. This additional insight would support the findings identified within this article and promote important discussions.

# Recommendations

The following recommendations are offered following the results and discussions made in this paper:

* Radiographers should remain autonomous within the general imaging environment and not rely upon ‘pre-set’ exposures on DDR equipment. Whilst ‘dose creep’ is reported within the literature radiographers should critically reflect on their own professional practices because their attitudes may still impact dose delivery to patients.
* Radiographers should reframe from knowingly increasing X-ray exposures in an attempt to ‘prevent from doing another exposure’. Radiation exposures should be holistically considered for individual patients, with special consideration to paedatric and infant patients due to their increased sensitivity.
* Because suboptimal radiographs may be sent for radiological interpretation, patients may also be receiving unnecessary exposures of ionising radiation. It is recommended that radiologists and radiographers collaborate and reflect on the production of diagnostic images in order to ensure images are of diagnostic quality.
* Because radiographers may not be conforming to the sound delivery of ionising radiation in general radiography, ‘high dose’ modalities such as computed tomography and interventional procedures should also be explored clinically.

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