



Transitioning from analogue to digital imaging: Challenges of South African analogue-trained radiographers

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ARTICLE INFO

Article history:

Received 18 April 2018

Received in revised form

7 August 2018

Accepted 4 October 2018

Available online 1 November 2018

Keywords:

Analogue imaging

Digital imaging

Technology advancement

Changing workplace

ABSTRACT

Introduction: The work of a radiographer includes using technology to produce x-ray images. The technology employed could either be analogue or digital technology. Over the last 20–25 years analogue-trained radiographers in South Africa have had to produce x-ray images using digital technology. The aim of this paper is to explore and describe the experiences of analogue-trained radiographers utilising digital imaging in projection radiography.

Methods: The study used a qualitative, exploratory, descriptive design. Purposive sampling was employed and individual, in-depth, semi-structured interviews were conducted.

Results: Two themes emanated from the data. The first concerned the evolution of the radiographer when faced with the advances in technology. The second addressed the role that the work environment played in the manner that the participants experienced the change.

Conclusion: Evidence was found of radiographer indifference towards exposure selection, dose optimisation and placement of anatomical side markers in the primary beam when using digital imaging. Further evidence emerged of interprofessional and intergenerational conflict as a result of the introduction of the new technology.

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Introduction

The professional work of a radiographer encompasses both patient care and the use of technology.¹ The technology employed could be either analogue or digital technology. The type and quality of images produced by analogue or digital technology differ but what remains the same is that the x-ray beam still passes through or is absorbed by the patient. The major differences between the two technologies are found, however, in the type of image receptor used as well as the use of computer technology when recording the x-ray image. The first recorded innovation in digital radiography was the development of a computed radiography image receptor, in 1973, that was patented by the Eastman Kodak Company in Rochester, New York.² However, it was not until the 1980s that digital technology was used in a clinical setting.³

One major advantage of analogue radiography is that it provides radiographers with an explicit response on the correctness of the selected exposure factors.⁴ However, images produced in digital

radiography may still yield images of acceptable density and brightness despite the exposure factors selected.⁴

However, analogue imaging has a number of limitations such as the use of harmful chemicals for automatic processing, the extra personnel required to perform image processing and the archiving and retrieval of x-ray films.⁵ In addition, the x-ray image produced cannot be manipulated to improve the information on the x-ray film.⁶ The fact that an x-ray film can only be in one place at any given time presents a further limitation for the management of the patient.⁷ Another drawback of analogue imaging systems is its limited response to a range of radiation exposures.⁸ This limited dynamic range means that a small degree of over or underexposure may result in an unacceptable image requiring a repeat the examination, thus adding to the radiation dose of the patient.^{5,8}

On the other hand, digital radiography has provided the radiographer with a number of advantages. The greater dynamic range of digital detectors results in improved image quality and a possible reduction in the patient radiation dose.³ The introduction of digital imaging has led to a decrease in the time a radiographer takes to complete a general radiographic examination,⁹ leading to an increase in productivity and a saving in human resource costs as well as an increase in the efficiency of the x-ray department.⁹ Digital

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images are easy to manipulate and process^{5,10} and then can be distributed via telecommunications networks.¹¹

Despite the many advantages of digital radiography there are also certain disadvantages. Radiographers are required to examine more patients in a given time because of the workflow improvements.¹² This increase in efficiency and productivity brought about by digital radiography,^{12,13} coupled with an ever increasing request for x-ray services¹⁴ has led to an increase in work-related stress for radiographers.¹⁵ Furthermore, radiographers now have to be experts in exposure parameters.¹⁵ Patient radiation dose can increase appreciably when radiographers change from using analogue to digital radiography,¹⁶ which can be ascribed to their resistance to using higher kilovoltage (kV) values and their insistence on using higher milliamperes-second (mAs) values to combat quantum mottle.¹⁷ The use of higher mAs values leads to 'dose creep' as radiographers seek to produce images of diagnostic quality.^{17,18}

Analogue radiography has served the profession since the 19th century.⁸ In South Africa, though, it has gradually been replaced by digital technology since the installation of the first digital equipment in Pretoria, South Africa in 1996.¹⁹ In the United States, there are indications that analogue technology is still being employed.²⁰ In South Africa there is a paucity of documentary evidence of the use of analogue radiography; however, there is anecdotal evidence of the use of analogue technology.

Approximately 55% of all diagnostic radiographers in the Eastern Cape Province in South Africa, obtained their undergraduate qualification before November 2007.²¹ This is the cohort of radiographers of the present research. The local university introduced studies on digital technology in one of its modules in 2007. Conversations with local radiographers revealed anecdotal evidence that the transition from analogue to digital radiography presented them with a number of difficulties, namely under preparedness and feelings of inadequacy, and the different responses of the image receptors. Such difficulties caused Hayre¹⁸ to question whether diagnostic radiographers are still the experts in acquiring images in general radiography using digital radiography. Therefore, the aim of the present study was to explore and describe the experiences of analogue-trained radiographers utilising digital imaging in projection radiography.

Method

The research study was conducted using a qualitative, exploratory-descriptive design. Gray, Grove and Sutherland²² describe this design as aiming to explore and describe a topic of interest to which a solution is required.

Participants

The target population for the present study included all analogue-trained radiographers in the local municipality who were registered with the Health Professions Council of South Africa (HPCSA) in terms of the Health Professions Act 56 of 1974. The study only probed radiographers in the local municipal area. In addition, only radiographers who obtained their undergraduate qualification before 2007 and their Bachelor of Technology in Radiography before 2005 at the local university were eligible for participation. The study was conducted in both private and public sector radiology departments and the target population comprised approximately 140 radiographers in the local municipality. Purposive sampling was used to select the group of radiographers that was representative of all radiographers in the local municipality. Furthermore, the participants had to be analogue-trained radiographers who are now utilising digital imaging for projection radiography. A list of all radiographers working in the radiology

departments was obtained from the radiographers-in-charge at the various hospitals. These lists were used in conjunction with the 2016 Register of Radiographers published by the HPCSA²¹ to select radiographers based on when they obtained their various diagnostic radiography qualifications as shown by Table 1 below. A total of ten participants were interviewed for this qualitative study as no new data transpired after the eighth interview when data saturation was reached.²³

Procedure

A pilot study was conducted to test the data-collection instrument.²³ Semi-structured individual interviews were conducted with radiographers who provided written consent. The consent of participants was requested to allow for the use of voice recording devices. The interview guide comprised a main question and a further six sub-questions. The main question was: How did you experience the move from analogue to digital imaging? The sub-questions were: What was your experience after the initial training by the application specialists? What kind of challenges are you now experiencing with the digital technology? How did you cope with the move from analogue to digital imaging? How has the introduction of the "new" technology affected staff relations in the x-ray department? How has the introduction of the "new" technology affected your experience of radiographic practice? And how can management assist you with optimising your digital imaging skills? The interviews were transcribed verbatim, by the researcher.

Analysis

Tesch's eight steps in the coding process were used to perform the data analysis process.²⁴ The data set of interviews were submitted to an independent coder for analysis. Following the analysis a consensus meeting between the researcher and independent coder was held to review and discuss the emerging themes.

Ethical approval

Ethical approval was obtained from the Nelson Mandela Metropolitan University, which issued the following reference number: H16-HEA-RAD-001. Additional permission was obtained from both the private and public sector radiology departments where the study was conducted.

Results

Two themes emanated from the data, namely: 1) the evolution of the radiographer when faced with advances in technology and 2) the role that the work environment played in the manner that the participants experienced the change.

Theme 1: The evolution of the radiographer in the face of technological advancement

The transition from analogue to digital imaging has caused radiographers to respond in diverse ways toward the technological change involved. Although some analogue-trained radiographers responded positively to the change they also experienced a number of challenges with adapting to the changeover.

Radiographers' changing skill sets in relation to technological change

Participants felt that, since the advent of digital technology, it was no longer necessary to think when making a selection of the exposure factors to be used for a particular examination. They

Table 1
Biographical information of participants.

Participant	Gender	Years of experience	Qualifications obtained and year obtained	Institution where qualification was obtained	Public or private practice
Participant 1	Female	11	National Diploma in Radiography: Diagnostic (ND: Rad (D)) – 2005	Local university	Public
Participant 2	Female	35	ND: Rad (D) - 1978 Bachelor of Technology (BTech) in Radiography (Diagnostic) (BTech: Rad (D)) – 1999	Local university	Public
Participant 3	Female	35	ND: Rad (D) – 1980	Local university	Private
Participant 4	Female	32	ND: Rad (D) – 1987 BTech: Rad (D) - 2002	Local university	Public
Participant 5	Female	11	ND: Rad (D) – 2005	Local university	Private
Participant 6	Female	23	ND: Rad (D) - 1992	Local university	Public
Participant 7	Female	21	ND: Rad (D) - 1995	Local university	Private
Participant 8	Male	36	ND: Rad (D) – 1982	Local university	Public
Participant 9	Female	25	ND: Rad (D) - 1984	Local university	Public
Participant 10	Female	20	ND: Rad (D) - 1995	Local university	Private

argued that some radiographers felt that the machine would do the thinking on their behalf.

- “So, you doing more in less time - without applying your brain. Your brain is not really needed - it still is to a certain degree, obviously. But, there is less needed, the machine does a lot more of the thinking for you” Participant 7

They also felt that radiographers no longer seemed to think about radiation dose and its effects on the patient when examining them. Radiographers no longer appeared to collimate anymore, nor utilise anatomical side markers before processing the image.

- “They not worried about the dose they're giving the patient, they worried about the EI [exposure indicator] they get on their plates.” Participant 4
- “... you know, in the old days it's compulsory your ..., your letters must show – you know, it must show. And here ..., I've put my letters on but, I've collimated too much and it's not showing so let's put on a ..., you know, those ones that's pre-set on the machine.” Participant 5

All medical exposures necessitate optimisation, which is a process where patient doses are held as low as reasonably practicable.²⁵ In moving from analogue to digital imaging, radiographers often did not explore the possibility for dose optimisation because they used the new technology in the same way that they used the old equipment, that is they continued to use the same exposure factors and imaging methods.²⁶

Perceptions and attitudes of radiographers towards technological change

Many of the participants articulated feeling resistant to the introduction of digital imaging. They felt frustrated and negative towards the new technology.

- “In the beginning it was very difficult. We were very resistant and it was quicker to do analogue radiography than it was digital.” Participant 4
- “... And there was lots of tears and tantrums and frustrations uhm ..., of course, as it is you know everybody resists change.” Participant 2

Technology, such as the digital technology used in radiography, is a force that drives change in an organisation.²⁷ One of the reasons why people are inclined to resist change, argues Booyens,²⁷ is

because it is easier to do a job in the conventional way than it is to learn a completely new way of doing the job. Hence, one participant lamented having to use the very rigid mounted flat panel detector used in digital radiography as opposed to the portable cassette used in analogue radiography.

- “With DR, I would say, the extremities was [sic] the worse to adjust to because we used to doing, you know, these patients in plaster of Paris [POP] – you're used to manoeuvring the cassette for them, now all of a sudden you have to try and force the patient into the middle of the table.” Participant 1

The experience of this participant is corroborated by Carroll¹⁷ who indicates that DR offers less adaptability for both technique and positioning.

Another participant bemoaned the slow rate of image retrieval in digital radiography and the negative effects thereof. The participant ascribes it to the restricted memory of the computers that they were using.

- “The computer's memory is only ..., the RAM is only so big. So, therefore if it's a big programme running, the computer runs slower. So, if the doctor's got a huge file like, I'm going to use a CT scan, for example, or an MRI that is trying to So, it's going to take extremely long for him to be able to ..., to download those images.” Participant 4

In a South African study by van Heerden et al.¹⁰ “slow traffic” was found to be a disadvantage of a picture archiving and communication system (PACS). Carlton and Adler²⁸ also refer to the slow movement of computed tomography (CT) images indicating that, in order to retrieve CT images, a network with adequate bandwidth is required to handle large data files.

Despite the negative sentiments articulated above, radiographers also expressed feeling positive towards certain aspects of digital imaging. For instance, they stated that digital imaging was quicker than analogue imaging and that images could be manipulated.

- “And this digital is so quick. It's like on the beat you see the picture you can see to repeat. You know, there isn't that minutes and hours of waiting and waiting for the pictures to come through a processor.” Participant 3
- “Now with modern technology you can make adjustments, you can manipulate your image.” Participant 9

A study by Andriole²⁹ comparing film-screen radiography with computed and digital radiography for chest examinations concluded that both computed and digital radiography deliver better productivity compared to analogue imaging. Furthermore, Reiner and Siegel⁹ posit that using digital imaging appreciably decreases radiographic examination times when compared to conventional film-screen radiography. In addition, images in digital imaging can be adjusted and improved during display whereas the contrast of the final image in analogue imaging cannot be changed once the image is processed.^{3,5,6}

Radiographers experienced challenges with adapting to new technology

Radiographers reported experiencing problems with information and communications technology (ICT). The major problems experienced related to images being lost and the intermittent interruption of the digital system.

- *“He [doctor] doesn't find the image. The image is on the computer but the patient was done he knows the patient was done but it's not on him” Participant 4*

Hence, at times doctors were unable to find the image that they had ordered despite the fact that the patient had had an x-ray examination. Gale and Gale³⁰ say that unreliable data can negatively influence patient care when images are labelled and stored inaccurately, rendering them inadequate, dissimilar, odd or simply missing. Storage and labelling errors may occur when patient information is manually entered and typographical errors may arise.³¹

A further challenge was the Digital Imaging and Communications in Medicine (DICOM) compatibility of the machines (equipment) used by radiographers:

- *“My machine's DICOM compatible ... But ..., that machine can only send to the other machine, it cannot receive. Now, once you talk about DICOM you must be specific and say it must be DICOM retrieve and receive, uyabona [you see].” Participant 8*
- *“So our system would intermittently switch off and the doctors would complain that your system is down - because it could not take this load.” Participant 8*

DICOM is a universal yardstick used to transmit, store and display medical imaging data.³² According to McBiles and Chacko,³³ when a PACS system fails, rapid image accessibility and prompt image reporting availability are made redundant. It explains why the doctors would complain because they would not be able to retrieve any images or reports for the patients that they care for. This problem is often intermittent and McBiles and Chacko³³ recognise PACS downtime as a challenge, even though PACS downtime is uncommon.

Apart from the difficulties experienced with the new equipment, participants also experienced challenges with the quality of the images transmitted to doctors via PACS:

- *“... the image the doctor views in trauma is really not the same quality image. And they are ..., the doctors will often turn around and say poor quality image or they can't see what they want.” Participant 9*
- *“..... but we also have a problem, for example, that the images from our fluoroscopy unit, for example, on the fluoroscopy unit it's beautiful but you send it through to the PACS - it's awful.” Participant 4*

The participants reported experiencing difficulties with using the computer during image production, the intermittent stoppages of the digital system, DICOM incompatibilities and the poor quality of digital images transmitted electronically. The digital images received by the medical doctors are viewed and interpreted on display monitors. If a sub-optimal or an inappropriate display monitor is used it will compromise the quality of the transmitted digital image.³⁴ Hence, the quality of a digital radiograph is reliant on the management of the electronic information throughout the digital imaging chain.³⁵

Theme 2: Role of radiographers' work environment on their experiences of technological change

Participants reported that the role of management had an effect on how they experienced coping with the introduction of digital imaging. Moreover, staff relations between radiographers and other members of the healthcare team were impacted upon. There were three sub-themes identified:

Hospital and or radiography/radiology management have influenced the manner in which radiographers have experienced coping with the new technology

Participants suggested that hospital and or radiography/radiology management did not adequately plan for the introduction of the new technology. They failed to implement acceptable change management strategies and did not commit sufficient funding for the change process

- *“... yes and these people with the stands and monitors were suddenly wheeled into the department. We have been told that now the time has come to convert. The darkroom was officially closing down.” Participant 2*
- *“You know, people resist change and also they need to be orientated. Change management need to be implemented, uyabona [you see] ... They did not have a separate budget for this project.” Participant 8*

The sudden change experienced by the participants is contrary to the recommendation by Bramson and Bramson³⁵ who propose that the individuals who will be utilising the new scheme should be participating in formulating the changes in the organisation. Littlejohns, Wyatt and Garvican,³⁶ in a South African study on the failed implementation of a computerised hospital information system in the Limpopo Province, warn that inadequate education of hospital staff before implementing the change may lead to the failure of the new technology. In addition, managers often do not consider the cost of change as they tend to focus on the advantages that stem from the change.³⁷

Changing technology has impacted on radiographers' staff relations in the health care environment

Participants felt that the working relationship between radiographers and medical doctors were influenced by the change in technology from analogue to digital imaging.

- *“He [the doctor] picks up the phone and craps on everybody because the patient is not on the ..., on the computer. So, those are part of the problems that we do have.” Participant 4*

From the excerpt above it is evident that there may be challenges with regard to the radiographer-doctor communication pathway and their negotiation skills for conflict resolution. Professionals have diverse skills and expertise and in order to function successfully, communication is imperative in achieving an efficiently operating team.³⁸ According to Storm,³⁹ individuals who interact with others via technology often have difficulty employing normal conversation.

The citation of the participant also highlights the conflict between the two professionals. Conflict is inexorable in interprofessional teams according to Brown, Lewis, Ellis, Stewart, Freeman and Kasperski.⁴⁰ Storm³⁹ indicates that technology forms a barrier between individuals thereby making it easier to be disrespectful and belligerent, supporting the view of the participant.

The changing technology has also impacted the relationship between the radiographer and patient as demonstrated by the following quotations:

- “... in a way, is good you don't have to re-expose the patient to radiation because you can manipulate the image.” Participant 6
- “... the speed that we can work at, the patients that we can get through and it's wonderful that we can do them and they can go.” Participant 7

Sicotte, Paré, Bini, Moreault and Laverdure⁴¹ state that digital imaging has had a direct, positive influence on the quality of patient care because of the shorter waiting times for patients. Furthermore, the dynamic nature of digital radiographic images allows for them to be manipulated.⁶ An added advantage of this image enhancement is that the image does not have to be repeated and this spares the patient an additional exposure to radiation.⁸

Changing technology has led to intergenerational differences (conflict) emerging among radiographers

Participants were of the opinion that the change of technology has led to intergenerational differences developing among them.

- “... you know we have got different generations and uhm ..., we have different outlooks in life. You've got ..., you've got your 45 to 60 year olds which have been in this job for many, many years and then you have the child that is newly qualified that thinks she knows everything” Participant 4

The participants also felt that younger radiographers, or radiographers trained in digital imaging only, were not performing to the desired standards, that they were careless and had a gap in their knowledge.

- “... the standard of work is just not what it used to be ... is it because digital has spoilt us to such an extent that we are now letting a machine do what we used to do?” Participant 2
- “And also carelessness is another problem. Uhm ..., and the young girls will just get through the work as quick as possible ... it's just a case of they become more careless.” Participant 4

Fasbender and Deller⁴² posit that age-diversity has become more prevalent in the workplace and this diversity may contribute to negative outcomes between the different age groups. The negative outcomes could include conflict, miscommunication, misunderstanding, lowered productivity and poor working relationships,⁴³ which appear to be present in the participants responses.

Older radiographers or radiographers trained in analogue imaging were particularly concerned that students have lost the art of radiography. They bemoaned the students' purported inability to select appropriate exposure factors that comply with the ALARA principle:

- “.... we used to do scaphoids and wrists and things, small images all on one film because now you saving film. And I think there was a bit of an art to it. It's gone now ... And exposures, I mean, now even as students they have no idea about ..., forming your own exposure.” Participant 6

The idea of radiography being an art form is supported by Carlton and Adler²⁸ who say “radiographers can become technically artistic”. Ricketts⁴⁴ is of the opinion that analogue imaging requires more finesse than digital imaging with regard to collimation and exposure selection, but he feels that digital imaging has not completely eradicated the artistry of radiographic imaging.

Older radiographers also felt that it was scary working with interface devices and they struggled. They felt that they were not proficient enough to work with the computer and this made them apprehensive. Many preferred to do the positioning and leave the computer work to the younger radiographers or students.

- “Also I would say with the older radiographers, who were also not computer literate, they also struggled.” Participant 1
- “So, I'm very nervous of a computer - I only do what people show me to do.” Participant 3

In another study⁴⁵ on how PACS influenced the work practice of radiologists, generational differences were apparent between junior and senior radiologists. Senior radiologists feared the technology while the junior radiologists readily adopted the new technology.⁴⁵ The junior radiologists became the tutors of their seniors when working with the new technology⁴⁵ reinforcing the view expressed by Participant 4.

Limitations

The study only probed radiographers in a single municipal area. In addition, only radiographers who obtained their undergraduate qualification before 2007 and their Bachelor of Technology in Radiography before 2005 at a local university, were eligible for participation. The experiences of all other radiographers and student radiographers were not considered. Only the narratives of the participants were used.

Conclusion

Participants revealed how their radiographic work had been changed by the introduction of digital technology. They also indicated that the introduction of digital technology caused them to have both negative and positive feelings about the technology. They also expressed experiencing various challenges with adapting to the new technology. Furthermore, the transition from analogue to digital imaging influenced the relationship between radiographers and other healthcare professionals as well as between radiographers and their patients. Finally, the relationship between younger and older radiographers saw intergenerational differences manifesting themselves.

Conflict of interest

None.

Acknowledgements

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

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