Radiographer knowledge and practice of paediatric radiation dose protocols in digital radiography in Gauteng

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ABSTRACT
Introduction: Digital radiography (DR) poses the risk of unnoticed increases in patient dose, potentially resulting in the overexposure of paediatric patients. In some jurisdictions, there is a shortfall in the knowledge and application of safe paediatric radiation dose protocols. In such instances, radiographers can lack an understanding of the relationship between exposure index (EI) and the visual appearances of image noise, thereby resulting in under- or overexposure to the paediatric patient.

Methods: A quantitative, descriptive research study was conducted at six purposively selected diagnostic radiology departments in Gauteng, South Africa. The study was based on a 29-item questionnaire seeking to quantify the radiographers’ knowledge of paediatric radiation dose protocols and whether their knowledge translated into safe radiation dose practice.

Results: A 94% (61/65) response rate was achieved. Results show a low number of respondents (35, 57%) expressed a positive opinion of their knowledge of paediatric radiation dose protocols and EI; however, 41 (67%) participants were unaware of the function of EI.

Conclusion: The study revealed that, in Gauteng, there is an increased demand for further training in paediatric radiation dose protocols and a need for radiographers to improve awareness of exposure factors.

Implications for practice: Improving radiographers’ lack of knowledge of paediatric radiation dose protocols in Gauteng is important. It is essential that radiographers receive continuous training and education highlighting the importance of justification and optimisation of radiological examinations.

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Introduction

Diagnostic radiographers have an ongoing responsibility to ensure radiation safety during all digital diagnostic procedures.\(^1\) Radiation safety can be achieved by maintaining the consistency and accuracy of an established radiation protection programme.\(^2\) The radiation protection programme must include the management of paediatric patient dose because reducing the radiation dose to paediatric patients is of the utmost importance, since children are more susceptible to radiation-induced toxicities.\(^3,4\) However, insufficient knowledge of paediatric radiation dose protocols and practice has contributed to paediatric patients being considered as ‘small adults’, ultimately contributing to paediatrics receiving a higher radiation dose than necessary.\(^5\)

Among the factors contributing to the increased radiation dose to paediatric patients is the lack of knowledge by radiographers to factors affecting the dose from digital radiography (DR).\(^5\) Moreover, the lack of knowledge of DR dose factors can contribute to under- and overexposure to the paediatric patient.\(^6,7\) Although advancements in DR have potentially reduced the radiation dose, the exposure latitude has created an environment in which acceptable quality X-ray images can be produced at higher doses.\(^8\) The exposure latitude provides a consistent image appearance even in the presence of under- and overexposure, due to the DR detector being sensitive to a wide range of exposures.\(^9\) Therefore appropriate radiation dose protocols should be implemented and used.\(^9\)

It has been shown that the continual use of radiation awareness procedures such as justification and optimisation can ensure a higher degree of radiation safety.\(^1\) Effective paediatric doses can be obtained for any radiological examination using appropriate acquisition factors and when considering a patient’s mass.\(^10\)
In DR, the exposure index (EI) indicates the amount of ionising radiation received by the image receptor (IR) and is closely related to image quality. The selection of exposure technique factors is influenced through the availability of digital post-processing capabilities and contributes to the determination of the radiation dose and allows the radiographer to overrule preset exposure factors while still producing an image of acceptable quality.

The ALARA (as low as reasonably achievable) principle is advocated due to the potential harmful effects of ionising radiation. Knowledge of the radiation risks relating to a specific examination, patient size, gender and age is crucial due to the risk of radiation damage to radiosensitive organs, especially in children. Radiographers should therefore aim to minimise the risk by the dose of ionising radiation to the patient as low as possible.

Diagnostic radiographers are expected to improve their knowledge of EIs; however, some do not understand the relationship between EI and the visual appearance of image noise. Image noise, which is termed quantum mottle in DR, is apparent when insufficient X-ray photons reach the IR, thus producing an underexposed image. In some instances, this will require a repeat exposure and subsequently result in an overall overexposure to the patient.

According to the International Atomic Energy Agency and Goske et al., knowledge of the harmful effects of ionising radiation mandates the implementation of DR radiation dose protocols to decrease the radiation dose per image to the patient while maintaining acceptable image quality. Adequate training, education and continuing professional development (CPD) of radiographers is warranted.

The study was conducted at six radiology departments in Gauteng, South Africa (between June and August 2017) which comprised both private and public practices. Participating departments were equipped with DR units and had dedicated paediatric X-ray rooms. The purposively selected participants were all registered with the Health Professions Council of South Africa (HPCSA). Purposive sampling was used to select participants based on their availability and had to be employed at the selected radiography department as a qualified radiographer. Therefore, students were excluded. Sixty-five radiographers were considered eligible for inclusion in this study.

Data collection method was in the form of a questionnaire comprising of 25 closed ended questions and four open-ended questions. Topics included demographics, questions probing the radiographers’ knowledge of paediatric DR dose protocols and if that knowledge translated into safe radiation practice.

The content validity of the questionnaire was tested during a pilot study. The questionnaire was distributed to 11 qualified diagnostic radiographers registered with the HPCSA, working at a department in Gauteng that had fully implemented DR units. Following the pilot, the revised questionnaires were hand delivered to each participating department by the researcher, and the researcher waited for them to be completed.

The number of questionnaires distributed at each participating department varied according to the number of qualified radiographers employed at each site. Each participant was given an information letter, which explained the aims and objectives of the study and invited the participants to partake in the study on a voluntary and anonymous basis. Qualified radiographers who choose to participate in the study were asked to complete a consent form. The completed questionnaire was placed by the participant in a sealed cardboard box which was placed in an isolated corner of each radiography department. Ethical clearance for the study was received from the Research Ethics Committee of University of Johannesburg.

Statistical analysis

The data collected was analysed using SPSS Version 25 (IBM Inc, Armonk, NY). The questionnaire was subdivided into three sections, the collected data was analysed in terms of frequency. However, questions pertaining to quality of training and knowledge was analysed using inferential statistics. The Pearson chi-square test for independence was used to determine any significance between the answers to various questions in the questionnaire. Significance was accepted if the p value was .05 or smaller.

Questionnaire reliability was assessed as internal consistency using Cronbach’s alpha coefficient. Cronbach’s alpha provides an indication of the average correlation among the items that make up the scale. Cronbach’s alpha value of 0.734 was achieved; therefore, statistical reliability had been confirmed.

Results

A total of 65 questionnaires were administered and 61 were returned (94% response rate). Most of the respondents were aged between 31 and 40 years, with clinical experience ranging between 11 and 20 years.

Sixteen (28%) were aware of what the accumulative dose is for a paediatric chest X-ray (Fig. 1). Thirty-five (57%) participants indicated that they had good knowledge of ionising radiation related risks. Forty-one (67%) participants were unaware of the correct function of EI (Fig. 2). Furthermore, 25 (41%) participants were able to identify that EI can be used to determine if the noise levels are acceptable (Fig. 3). Three-quarters of participants indicated that EI is dependent on tube potential, total detector area irradiated and beam attenuation. Fifty-two (85%) participants indicated that radiation protective shielding was easily accessible within their respective working environments. Thirty-two (53%) indicated that exposure for paediatric patients should be adjusted as for a ‘smaller adult’ (Fig. 4).

However, 54 (89%) participants incorrectly stated that image processing enables the radiographer to produce an image with an acceptable grey scale. When probed about quantum mottle, 40 (66%) participants incorrectly defined it as the overexposure of an image.

Upon further analysis, 60 (98%) of the participants were able to identify that the size of the paediatric patient should be taken into account. The participants were asked to identify the acronym commonly used in radiography, i.e. the ALARA principle. Over three-quarters (51, 84%) of the participants were able to positively identify it.

Thirty (49%) respondents declared to not having received any specific training on paediatric DR dose protocols and 11 (18%) participants in this study rated their training as good, being able to
Exposure values of a paediatric PA chest X-ray

Figure 1. Participants' knowledge of radiation dose.

Exposure Index

Figure 2. Participants' knowledge of EI concept.

Can EI determine if noise levels are acceptable?

Figure 3. Participants' knowledge of EI factors and noise levels.
apply their acquired training into practice. As seen in Table 1, statistically significant differences were found between the respondents' quality of training received and radiation protection principles. Further analysis of the data concluded that there were no significant differences between public and private hospitals.

**Discussion**

Due to the participants' wide-ranging years of experience, the need for continual training and knowledge is evident. The results highlight the importance of radiographers being continually trained and educated in order to remain efficient and productive in the workplace.24

**Participants’ knowledge of paediatric DR radiation doses**

The participants were asked to identify what the accumulative dose for a paediatric chest X-ray. It was of concern that a low percentage of respondents were able to correctly identifying 0.01–0.1 mSv. Furthermore, the results show that majority of the participants were unaware of the function of EI. Over half of the participants incorrectly indicated that exposure for paediatric patients should be adjusted as for a ‘smaller adult’, therefore contributing to paediatrics receiving a potentially higher radiation dose than necessary.2

41% of the participants were able to identify that EI can be used to determine if the noise levels are acceptable. As accentuated by the results, radiographers in this study were unaware of the relationship between EI and the visual appearance of an image, leading to an increase in overexposure to the patient.13,15 Moreover, most participants positively identified the contributing factors to EI. However, the majority of participants indicated that they had good knowledge of ionising radiation related risks. For the purpose of this study knowledge was defined as the radiographers' information and understanding of DR factors affecting radiation dose, gained through education or experience.25

Over three-quarters of participants (89%) incorrectly identified that image processing enables the radiographer to produce an image with acceptable grey scale. Interestingly, more than half of the participants positively identified the functioning capabilities of quantum mottle. Additional contributing factors from literature support the mandate that DR radiation dose protocols be implemented to decrease the radiation dose per image to the patient while maintaining good image quality.12,29 Most participants were able to positively identify the commonly used acronym, i.e. the ALARA principle. That being said, a low percentage of participants were able to correctly correlate their adaption of the ALARA principle within their departments to contextualise their answers with the evidence from the literature.26 The results highlight the need to equip radiographers with a platform to acquire the information pertaining to harmful effects of radiation to paediatrics.27,2 In conjunction with literature, majority of the participants were able to distinguish that radiation used for each image is dependent on the patient size and the radiation dose delivered to the IR.13,28,29

**Conclusion**

In conclusion, within Gauteng, South Africa there is a dire need for training protocols to be implemented. With less than half the participants lacking understanding of the relationship between EI and the visual appearance of an image, therefore potentially resulting in an overexposure to the patient. Emphasis is on the majority of the participants being grossly unaware of the correct functionality of the image processing capabilities. Within Gauteng, South Africa radiographers have insufficient knowledge of ionising radiation risks. Training and re-education of radiographers would greatly influence radiographers’ knowledge of radiation dose and

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**Table 1**

<table>
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<tr>
<th>Pearson chi-square test</th>
<th>Value</th>
<th>(p)</th>
<th>Cramer’s V</th>
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<td>Quality of training compared to participants’ awareness of ionising radiation risks</td>
<td>18.141</td>
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<td>.194</td>
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<td>Years of clinical experience compared to quality of training received</td>
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<td>.001</td>
<td>.214</td>
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<td>Quality of training compared to radiation technique principles</td>
<td>66.924</td>
<td>.001</td>
<td>.304</td>
</tr>
</tbody>
</table>

Bold values indicate significance was accepted if P < 0.05.
the importance in maintaining the ALARA principle, translating in reduced overexposure of paediatric patients to ionising radiation.

Conflict of interest statement

None.

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References