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South African radiographers' radiation protection practices, a qualitative study

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ABSTRACT

Introduction: Radiation protection is multifarious, and consequently, a radiographers' application of radiation protection is multifaceted. Studies have shown varying radiation protection practices among radiographers. The first quantitative phase of this explanatory, sequential mixed-method study used the theory of planned behaviour to explore South African radiographers' radiation protection behaviour. Overall, South African radiographers' attitudes to radiation protection, subjective norm, perceived behavioural control, and radiation protection intention was high. This second phase of the study aimed to explore the reasons for South African radiographers' radiation protection practices.

Methods: This study used an exploratory and descriptive qualitative approach. Data was collected through 13 in-depth semi-structured telephone interviews. Thematic analysis was used in order to uncover original phenomena. Data saturation was achieved and the study adhered to trustworthiness and ethical measures.

Results: Thematic analysis identified two themes. The participants had the appropriate radiation protection knowledge, but radiation protection compliance remained a personal choice. Impediments such as feeling rushed during imaging of trauma and challenging patients, patients knowledge of radiation protection, resources, imaging referrals, inadequate training when transitioning from analogue to digital radiography and managerial support contributed to radiation protection compliance. Strategies such as further education, research and a change in mindset were suggested to further foster radiation protection compliance.

Conclusion: Even though participants' knowledge of radiation protection aligned with the legislated guidelines, limited internalising of the knowledge resulted in compliance being a personal choice. Participants reflected on their insouciant attitude and observed a similar attitude in their radiographer colleagues. Patient and work-related impediments were identified to contribute to radiation protection compliance. Strategies to further foster compliance were suggested.

Implications for practice: Understanding the reasons for radiographers' choice in radiation protection will allow the development of strategies that foster optimum application of radiation protection practises. Developing a radiation protection culture that enhances personal compliance supported by education and evidence should be considered.

Introduction and background

Diagnostic radiographers are tasked to ensure that risks to the patient, health care workers and the public are minimised whilst diagnostic capabilities are optimised. However, despite radiation protection inclusion throughout South African radiography education curricula[1] and being mandated, there is testament to contrary clinical practices in South Africa.[2,3] The Health Professions Act,

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1974 (act no. 56 of 1974)[4] defines radiation protection as: "*the application of radiation protection measures and techniques to minimise radiation exposure to patients, staff, self, and the public in accordance with the rules, regulations, and recommendations of the Radiation Control Directorate of the National Department of Health in South Africa and to ensure the health, safety and wellbeing of staff.*" The IAEA[5] defines radiation protection as the "*The protection of people from harmful effects of exposure to ionising radiation, and the means for achieving this*". For the purpose of this study, radiation protection considered all aspects that justify, optimise and limit exposure of ionising radiation to patients, health care workers and the public.[5,6]

This article forms part of an explanatory, sequential, mixed-method study[7] that previously added to the existing evidence base.[8] The first quantitative phase used the theory of planned behaviour to explore South African radiographers' radiation protection behaviour. The findings revealed that even though a few respondents use radiation protection, most respondents plan and intend to use radiation protection measures. Overall, radiographers' attitude towards radiation protection was positive, and their subjective norms and perceived behavioural control was high. Yet, some respondents felt that radiation protection was not worth the time and about half believed that using radiation protection is pleasant, rewarding and worth the time. About one-eighth of the respondents believed that their radiographer co-workers use radiation protection. The second phase of the study explored the reasons for these results obtained in the first phase of the study.[8]

Methods

The study followed an exploratory and descriptive qualitative design using in-depth semi-structured one-on-one telephone interviews with 13 respondents from phase one of the study, who indicated that they would like to participate in further research. Even though face-to-face interviews is preferred in qualitative research,[9–11] COVID-19 regulations would not permit face to face interviews.[12] Each participant was offered the option of Skype, Zoom, Teams, Whatsapp video and/or telephone calls; however, participants requested telephonic interaction citing availability, network signal, device challenges and time constraints against the suggested options. Participants choice of telephone interviews is echoed in the literature reported by Farooq, and De Villiers,[13] where telephone interviews were also preferred. Data saturation occurred by interview eleven; however, two more telephone interviews were conducted to confirm information redundancy.[14] The first author conducted the telephone interviews. Notes were taken during the interview detailing notable narratives, which were later reflected upon after the interview.[15,16] The audio-recorded interviews were transcribed verbatim by a professional transcriber who signed a confidentiality agreement. The transcribed data and interview notes underwent thematic analysis through the six steps advocated by Braun and Clarke[17]: data familiarisation, coding, initial theme generation, theme development and review, refining, defining and naming themes and writing up.

Measures of trustworthiness included ensuring credibility through member checking during the interviews, independent data coding to reduce bias and interview data and notes being triangulated. Dependability and transferability were ensured by a thick description of the research methodology and the path to conclusions of the study.[18] Providing direct quotations from participants together with detailed descriptions of the results further ensured transferability.[7] Confirmability was ensured by an audit trail detailing data collection, analysis and interpretation together with critical reflexivity.[19] Ethical clearance for the study was obtained from the University of Johannesburg (REC-01-28-2019). All participants were emailed with a participant information letter containing details of the study, the requirements for participation and the proposed length of the interviews. Participants emailed signed consent forms to participate in the study and for the interviews to be recorded before the interviews. An independent coder was also utilised and signed a confidentiality agreement.

Results and discussion

Participants' ages ranged from 22 to 71 years and concurrently had years of clinical experience ranging from one to 40 years. Participants represented experiences in eight of the nine South African provinces because there were no participants from the province of Mpumalanga. Participants had experience in general radiography, computed tomography (CT), mobile radiography, theatre, fluoroscopy and interventional radiography. Two themes and associated categories, as depicted in Table 1, were identified.

Theme 1: Radiation protection knowledge was appropriate, but compliance was a personal choice

Radiation protection knowledge aligned to legislation but implementing the knowledge was a radiographer's personal choice. Radiographers' personal choice was influenced by the collective insouciant attitude that led to largely poor radiation protection compliance.

Category 1: The radiation protection principles (justification, optimisation, limitation) and the application of thereof are known very well but in the end, it is a personal choice to practice

Participants described their understanding of radiation protection as a skill of using correct patient positioning, precise collimation and correct exposure factors to obtain high-quality images at the lowest possible exposure to the patient. Radiation protection requires medical imaging to be justified and the patient to be correctly identified. X-ray room doors must be closed during exposure. Radiation workers, companions and other healthcare providers need to stand as far as possible from the source of radiation. Shielding of patients, themselves, patient companions, and other staff is essential. Participants acknowledged that shielding was their immediate thought when making meaning of radiation protection. Participants described their understanding using the following expressions:

> " … *it is the patient, staff and the public …. collimate, use gonad shields … exposure selection … gives diagnostic information … no repeats.*" P9

> " … *to me it is about keeping the exposure as low as possible for the patient and making sure that the examination that you do is in fact necessary to be done …. produce an image that is of acceptable quality, but at a lower exposure*." P5

The participants' understanding of radiation protection aligns with the South African Health Professions Act, 1974 (act no. 56 of 1974),[4,20] the International atomic energy agency (IAEA)[5] and the International Commission of Radiation Protection's[6] definition. Radiation protection may be seen as the science, discipline, application and practice of protection to provide an appropriate level of protection cognisant of the benefit and harm of the exposure. Participants' stories show radiation protection's multifariousness and express that radiographers' eminent thought related to radiation protection is lead rubber shielding. In 2019, the American Association of Physicists in Medicine (AAPM)[21] released a position

Table 1
Themes and categories.

Theme	Category
1. Radiation protection knowledge was appropriate, but compliance was a personal choice.	• The radiation protection principles (justification, optimisation, limitation) and the application of thereof are known very well, but in the end, it is a personal choice to practice. • Although they had good knowledge about the basic principles of radiation protection, poor compliance was observed. (Participants knowledge of radiation protection was determined by asking participants their understanding of radiation protection. Participants observation of radiation protection practices were explored through the question: "How is radiation protection practised in your department") • They admitted that they had a lackadaisical attitude themselves and noticed the same attitude in their colleagues

2. Impediments contributed to the limited application of radiation protection, but strategies to foster compliance are suggested.	• Patient-related factors contributed to not practising radiation protection:
	  • Feeling rushed during imaging of trauma and challenging patients
	  • Patient's knowledge or radiation protection
	• Workplace impediments contributed to the poor application of radiation protection:
	  • Resources
	  • Imaging referrals
	  • Inadequate training when transitioning from analogue to digital radiography
	  • Managerial support
	• Strategies were suggested to foster radiation protection compliance:
	  • Changing radiographers' mindset
	  • Inclusion of small practice changes
	  • More research around gonad shielding
	  • Substantive training on new equipment prior to installation
	  • Motivation in the form of rewards
	  • Revision of positioning techniques not commonly performed

statement negating the use of patient gonad and foetal shielding; however, the South African legislature has not been amended and still requires that gonad and foetal shielding be used.[22]

Even though radiation protection guidelines as provided by the Health Professions Council of South Africa[20,22] are known and is a legislated requirement, participants' responses reveal that radiation protection is an individual choice and that practising radiation protection depends on the individual radiographer and their diligence.

> "*It's a choice …* " P8

> "*Honestly, we are not really worried about it*." P10

> "*I think it differs from individual to individual …. I feel that they don't even care*." P9

These findings are consistent with an observational study whereby the lack of lead-rubber shielding use was attributed to radiographers applying their own radiation protection/risks beliefs, values, and cultural norms rather than evidence-based research.[23] Radiographers expressed constraints in enforcing occupational shielding in varying power dynamic environments.[24–26]

Category 2: Although they had good knowledge about the basic principles of radiation protection, poor compliance was observed

Participants' observation of radiation protection varied from compliant to non-compliant. Lead rubber shielding compliance was most problematic, followed by collimation and exposure factors. Greater radiation protection compliance was expressed for paediatrics, pregnant and oncology patients. The radiographers' use of radiation protective equipment varied, with some participants indicating abidance, while others moved away from the radiation source, especially during mobile imaging, rather than wearing lead rubber aprons. Participants' accounts suggested that radiographers are concerned more for their own safety than for patients and the public.

> "*In our department it is being adhered to, yes*." P6

> "*They are not. They usually do that just to pass the day at the universities, at the institution. While we are students, we only exercise that precisely when we are there, but as soon as it comes to the real life here at the hospital now, we forget about that thing*." P11

Similarly, previous studies indicate poor radiation protection practices.[27–29] In contrast, a study conducted in Yobe, Nigeria, showed that radiographers had an overall high adherence to radiation protection practices[30] and more than half of radiographers responding to a study in the United Arab Emirates showed good adherence to radiation protection practices.[31] The benefits of using lead rubber shielding were reported when a lead rubber apron was used on a phantom undergoing an X-ray of the left lateral elbow, demonstrating a reduction in radiation dose to the breast and spleen.[32] Gonad shielding, however, was found to increase the dose area product when used for female pelvis X-rays.[33] Studies conducted in Yobe, Nigeria,[34] Khuzestan-Iran, Ahvaz-Iran,[35] Saudi Arabia,[36] Australia[37] and South Africa[38] show evidence of poor collimation practices. An observational study from the United Kingdom found that radiographers collimated/cropped images at the post-processing stage with collimation/cropping ranging from 1 cm to 5 cm.[39] Increasing the irradiated area outside the area of interest contributes to radiation dose and impedes image quality.[40] A contrast in responses from a participant's "*yes*" P6 to radiation protection practices being evident to an upset and emotional participant's story elucidates the spectrum of radiation protection practices in South Africa:

> "*So you see, I have seen something just here that really upset me actually …. they don't adjust exposure parameters for their patient sizes …. I was very very surprised at the factors of this senior, because I mean she used an adult chest exposure on a three year old. And it was done not in Bucky …. it is so so terrible practice. That is the attitude they give and then you just brush it off, but I mean, you know you can't give 120 and three point something exposure to a child. You can't do that. I don't know. So it is things like this that have been happening that really upsets me*." P7

Similarly, a study in Gauteng, South Africa, showed that 27% of patients received more radiation exposure than was necessary to produce a diagnostic radiograph.[41] A study in Ahvaz-Iran showed that 26% of reviewed examinations in the study used a mAs greater

than the acceptable value.[35] Studies also show that radiographers do not alter the pre-set exposure factors and used higher exposures factors to prevent repeating the X-ray.[42] There is a call for further studies to explore optimisation techniques by investigating exposure technique factors that give optimal image quality for a set radiation dose to the patient.[43]

A radiographer needs to consider the patient's body habitus, specific condition and history to set optimal exposure technique factors while considering the optimal filtration required.[44] The ICRP is explicit that one size does not fit all medical radiation exposures.[45] Radiographers, as persons responsible for taking the X-ray, make subjective radiographic technique decisions using varied mAs, kV, filtration, scatter control and image display, among other factors that significantly impact image quality and dose optimisation.[46–48] The idea of what is low and what is reasonable can be interpreted differently. Therefore radiographers need to identify and select appropriate optimisation measures while maintaining the balance between image quality and radiation dose.[49,50] Low exposures producing undiagnostic images will eventually increase the patient's radiation dose because the examination will need to be repeated. Therefore "ACHIEVABLE" is vital in understanding the ALARA principle.[6]

Category 3: They admitted that they had a lackadaisical attitude themselves and noticed the same attitude in their colleagues

Participants are of the opinion that radiographers think that radiation protection is a waste of time, a nuisance and care more about protecting themselves than others. Even though participants believe radiographers have a bad attitude to radiation protection, others believe that radiographers' attitude is positive and radiation protection is important to them.

" *with babies I do it. With the older population I must admit, I do slack, you know putting it on for every chest x ray …* " P7

"*I think a lot of people would find that it is a waste of time … Like if you would tell someone … allow someone to put a gown on if you are doing a hand X-ray for example, they would be like why? It is a hand X-ray. You are just going in, taking two images and coming out, you know? Why waste time?*" P14

"*I know some people can be quite negligent*" P4

" *… bit of a nuisance*" P5

Participants' varying radiation protection attitudes and experiences are shared in the literature. A systematic review of 41 studies, conducted from 2000 to 2019 in 22 countries, on health care workers knowledge, attitudes, and practice towards radiation protection, showed that 60% of participants had a positive attitude towards radiation protection and more than half of the participants had average knowledge and practice regarding radiation protection.[51]

Theme 2: Impediments contributed to the limited application of radiation protection, but strategies to foster compliance are suggested

Participants revealed a plethora of reasons for the current radiation protection practices and expressed these as impediments to optimal radiation protection practices. Specifically, impediments related to work and patients were mentioned. However, looking forward, participants provided suggestions to optimise radiation protection practices.

Category 1: Patient-related factors contributed to not practising radiation protection

Participants observed radiation protection non-compliance in trauma or challenging patients was higher and felt rushed in these cases leading to non-compliance. Patient knowledge of radiation protection and its influence on radiation protection practices were described.

"*not practised with difficult patients, intoxicated patients*" P12

"*it's quite busy, it becomes difficult sometimes to actually protect*" P10

"the public they don't know about radiation …. our patients they don't know about radiation. They are illiterate." P9

" … our patients do not insist on it … if our patients were a little bit more insistent, I think radiographers would think differently about it … I don't know if it has got to do with literacy levels or what of our patients." P5

Two South African studies[29,52] reported patients' knowledge of ionising radiation as sparse. These findings are confirmed by a systematic review of four studies on patients' awareness, knowledge and perception of ionising radiation in medical imaging showed that patients generally lacked awareness about radiation exposure.[53]

Category 2: Workplace impediments contributed to the poor application of radiation protection

Workplace impediments that contributed to the poor application of radiation included resources, imaging referrals, inadequate training and managerial support.

Participants shared that the availability of resources in the form of operational X-ray equipment, radiation protective equipment and human resources as reasons for the poor application of radiation protection principles. Participants described that the lack of resources engendered an increased workload. Participants explained that radiographer shortages coupled with being rushed to complete exams when limited X-ray rooms were working and increased time spent locating lead rubber aprons and shields increased the likelihood of radiation protection non-compliance.

" … volume of work … does not allow you to like carefully cone down … mass producing X-rays here …. the workload and you have to push those patients … as long as they are getting an image at the end of the day …. I think the availability of the resources, the correct devices to use. You know, like your lead aprons, your gonad strips" P13

Literature supports participants' view that resource distribution in South Africa contributes to suboptimal radiation protection practices.[54] Radiographers in South Africa may be employed in the public or private sector or work in both sectors concurrently. Financial resource allocations between the sectors are not equitable; 50% of the total health expenditure finances 16% of the population in the private sector, and the remaining 50% finances 83.5% of the population in the public sector.[55] Consequently, radiology equipment and human resources between the sectors vary. As a result, not all radiology departments, whether private or public, may physically have a radiologist present or have a radiologist's report provided.

Participant 13 describes "*defensive medicine*" as preventing optimal radiation protection since clinical indications for the exam

did not justify the examination. Participants also felt the medical team did not value their opinion.

> "…. … *So they practice defensive medicine …. everybody that comes need to be X-rayed trauma series. So you are over exposing. Secondly, I think doctors don't have much insight into viewing X -rays properly. So that is why they continuously ask for repeat X —rays … We do repeat routinely and we don't have a radiologist …. like bedside X-rays are just abused and then also the other problem is being in a so-called country hospital, you don't have a radiologist here. So we can only advise the doctor, but at the end of the day the doctor feels oh, you are just a radiographer, but if you had a radiologist here, then all that will stop. All that will stop*." P13

The South African policy on the request for medical X-ray examinations[56] states that "*A radiographer in his/her professional capacity may refuse or accede to the request provided that good and sufficient grounds exist for his/her decision*." Therefore South African legislation[20,56] advocates for justification of imaging requests and the radiographers' role in justification. Support for participants' experience when applying the justification principle is echoed in a South African study reporting that radiographers questioning imaging requests were often disregarded, and radiographers were still ordered by the healthcare professional requesting the examination to do the examination.[57] Akin to participants' stories, the same study found that imaging requests were done to mitigate litigation, uncertainly, as cautionary measures, done as a "quick-fix", prevent comebacks and because the patient demands an X-ray.[57]

Participants believe that transitioning from analogue radiography to digital radiography without adequate training has resulted in a failure to understand equipment optimally—particularly the impact of exposure factors in analogue and digital radiography. Inadequate training on new equipment resulted in radiographers being "button pushers". Participants also felt that students "*trained in this generation*" are not collimating optimally or understanding exposure factors. There is also a lack of understanding of the quality control tests and their relevance in radiation protection.

> " … *many of our radiographers come out of the older era, the conventional era … we drag those rules into this new era and that causes a whole lot of other problems. …. radiographers got what I described as perfunctory training … very shallow, low-level training were an application specialist would come in and they would talk to you for half an hour and go away and obviously not all radiographers would be present at the talk … one radiographer shared information with another radiographer and everyone just continues to press buttons without knowing exactly what is happening …. with increased mAs gives you a beautiful image and I suppose that is why people stick with it …. people are not thinking.*" P5

Participants' experience transitioning from analogue to digital radiography is analogous with South African studies were challenges with digital radiography exposure factors were reported.[58–60]

Participants disclosed a lack of support from radiology management as contributing to radiation protection practices. Established protocols were not enforced, and they felt that management was not concerned. Participants detailed being influenced by their colleague's practice, the culture in the department and radiologists.

> " *management plays an important role to establish this culture of safety*" P5

> *"I think when we work together, and you see someone else doing something, you kind of feel. I should probably do that because that person is doing it. It is the same when you are not doing it. If someone sees you not doing it, they are like okay, if she is not doing it then I don't need to do it either.*" P1

Similarly, a South African study reported that radiographers' constraint in performing quality control tests was attributed to the lack of managerial support and budget.[61] However, the Bonn Call for Action and the International Radiation Protection Association calls for strengthening radiation safety culture in healthcare by embedding radiation protection at the cultural level of an organisation.[62,63]

Category 3: Strategies were suggested to foster radiation protection compliance

Participants envisage changing radiographers' mindset and the inclusion of small practice changes may improve radiation protection compliance. Others suggest more research around gonad shielding, substantive training on new equipment prior to installation, motivation in the form of rewards and revision of positioning techniques not commonly performed as measures to ensure radiation protection compliance. While some participants indicate that more radiation protection training will be helpful, others disagree. Enforcing radiation protection during student training was also suggested. Creating a radiation dose register and greater involvement of management was also recommended to optimise radiation protection compliance.

> "*I think we should try to change our mindsets and make it necessary so that extra time is not wasted. It is part of helping that patient and giving them a proper service*." P1

> "*a lot of practical training and a lot of revision with regards to like your positioning and all of that sort of things*." P2

> "*I will say when you are changing from analogue to CR or digital I think radiographers really need to be in service before that unit is even installed in the institution to get a thorough understanding of what you are doing and even have a mini test on it, because you are just pushing buttons as we are doing and we are not realising that there are implications, you know?*" P12

> " … *but I don't think a course, because personally speaking from our department, I feel like people would again say it is just a waste of time.*" P4

Literature also provides similar suggestions to increase radiation protection awareness, attitude, and performance by including radiation protection topics in curricula, implementing periodic practical training courses in hospitals, and providing continuing education programs.[51] An integrative review of eight studies showed a positive correlation between radiation protection education and improvements in clinicians' knowledge and/or referral practices.[64] A study conducted in Ankara, Turkey, found that the training had the most significant impact on radiation protection.[65] In contrast, Shoman, Hakim, MagidTolba & Abozaid[66] study showed no statistically significant difference in the knowledge score and attending radiation safety courses. The Yobe, Nigerian study[67] showed no significant difference in adherence score with the radiographers' educational qualifications, contrary to other studies that showed a higher radiation protection awareness with higher educational levels.[68–70] Radiographers' involvement in research activities will contribute to developing their knowledge, skills and competencies in daily clinical practice.[54,71]

Limitations

Interviews were conducted telephonically. Therefore, nonverbal communication could not be assessed.

Conclusion

Participants revealed the multifariousness of radiation protection and the role radiographers play in ensuring radiation protection. Participants' knowledge of radiation protection aligned with the legislated guidelines. However, limited internalising of the knowledge resulted in compliance being a personal choice. Non-compliance was observed as more often the personal choice. Participants reflected on their insouciant attitude and observed a similar attitude in their radiographer colleagues. Patient and work-related impediments were identified to contribute to radiation protection compliance. Strategies to foster compliance were suggested.

Ethics approval

Ethics approval obtained from authors one and two institution REC-01-28-2019.

Conflict of interest statement

No conflict of interest.

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